# PRACTICAL PHARMACY.

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THE ARRANGEMENTS, APPARATUS, AND MANIPULATIONS, OF THE PHARMACEUTICAL SHOP AND LABORATORY.

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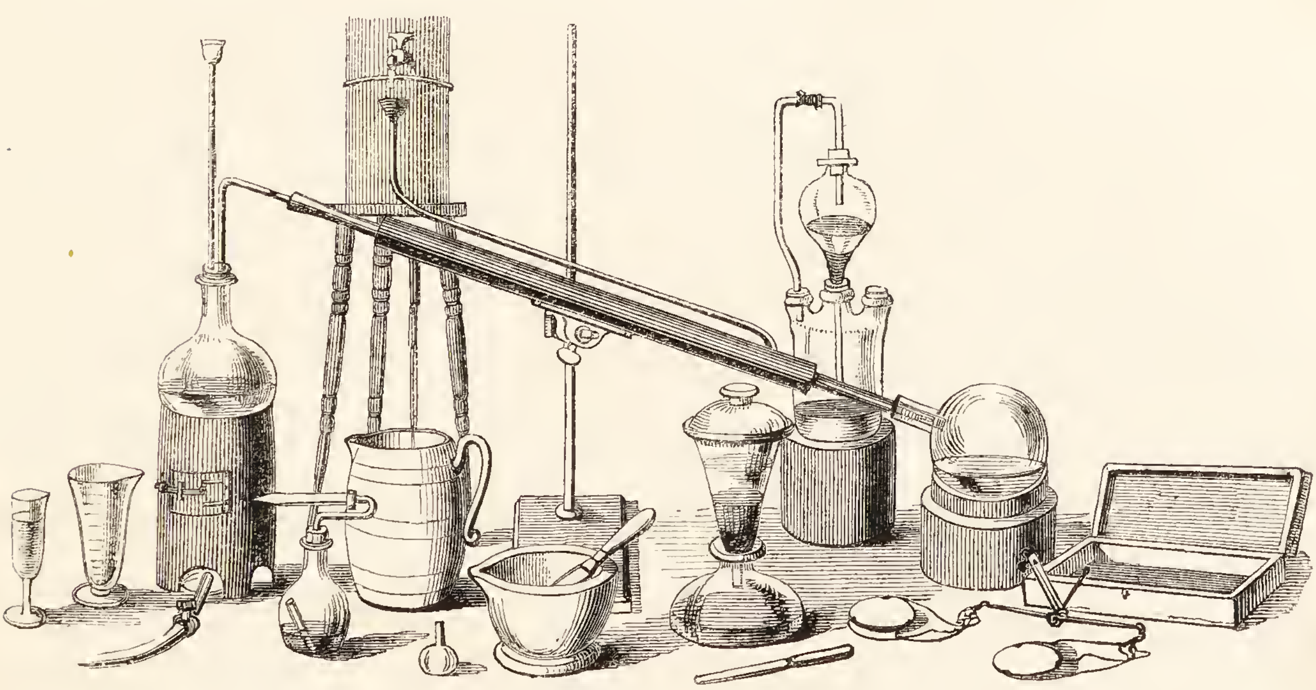
ILLUSTRATED BY FOUR HUNDRED ENGRAVINGS ON WOOD.



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# PREFACE.

A Work on Practical Pharmacy, embracing a Description of Apparatus and Manipulations, has long been considered a desideratum in this country, and I have repeatedly been urged by members of the Pharmaceutical Body to undertake the preparation of such a work. The pressure of other engagements, however, prevented my doing so, until an opportunity was presented, by the appearance of Dr. Möhr's "Manual of Pharmaceutical Technology," for laying before the English reader the "results of the personal experience" of one of the most eminent of the continental pharmaceutists. Under these circumstances, I undertook to edit a translation of those parts of Dr. Möhr's book which might be thought to convey the most practically useful information, and to make such additions as would meet the requirements of English Pharmaceutical Chemists. In proceeding with this undertaking, it was found necessary to make much more extensive additions of new matter, and alterations in that taken from the German, than had in the first instance been contemplated. This may be ascribed to the fact, that the circumstances by which the pharmaceutists are surrounded, in England and in Germany, are very different; and that, therefore, the arrangements provided and suitable in the one case, are, in many respects, inapplicable to the other. The original matter which has been introduced, including upwards of one hundred and sixty of the engravings, constitutes about two thirds of the volume, and this is enclosed within brackets, [ ], to distinguish it from that which has been translated. It is due, however, to the German author to state, that a faithful translation has not, in any part, been attempted, the paramount object having been to suit the matter to the wants of those for whom it is designed.

T. R.

19, Montague Street, Russell Square,
*December*, 1848.

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## GENERAL ARRANGEMENTS.

[The business of a Chemist and Druggist, or Pharmaceutist, involves a variety of operations and arrangements, for which several apartments are required and should be specially appropriated. A well-appointed pharmaceutical establishment ought to comprise,—

| | |
|---|---|
| The Shop or Dispensary, | Store-cellar, |
| Laboratory, | Drying-room or loft, and |
| Store-room, | Powdering-room. |

The Shop or Dispensary.—This is the most essential and important apartment in the establishment,—that in which the Pharmaceutist must contemplate spending a great part of his time, and where he hopes to be often actively engaged in the bustle of business. The success of his undertaking as a man of business cannot fail to depend, in some measure, on the adaptation of this apartment to the purposes for which it is intended.

In selecting, arranging, and fitting up the shop, provision should be made, to the greatest extent practicable, for promoting the health, comfort, and convenience of its daily occupants, and the preservation from injury of the drugs and preparations intended to be kept in it.

The form that appears to be best suited for the shop of a Pharmaceutical Chemist is an oblong, one of the short sides of which forms the front, as it is desirable to have long, straight walls, giving depth rather than width to the apartment. It should be dry and well lighted, yet not too much exposed to the direct rays of the sun. Large windows, therefore, are objectionable; they are not required for the display of pharmaceutical wares, while they occasion a great deal of trouble in keeping them clean, and admit more direct sunlight than is beneficial.]

The opinion very generally prevails among Pharmaceutists, that the shop should have a north aspect, or at least that direct sunshine should be entirely excluded; but I have no hesitation in expressing my dissent from this opinion.

The entrance to the shop ought not to be directly from the street, but from the passage to the house. There are several objections to having the entrance directly from the street: it occasions the admission of wind, dust, and wet, when the door is opened, and renders it difficult to regulate the temperature of the room, and ensure the comfort and freedom from unnecessary disturbance of those engaged in conducting the business.

[In free-trade England, however, it is generally considered desirable to make the access to the shop as easy and obvious as possible. I have heard calculations made, by some approved economists, to shew the loss a tradesman sustains in consequence of his shop-floor being elevated too much above the level of the street, thus rendering it necessary for customers to ascend two or three steps on entering. One step, if it be a low and easy one, is considered beneficial, the advantage resulting from the exclusion of wet and dirt being more than equivalent to the obstruction it imposes on the facility of admission; but every step beyond this is calculated to involve a loss to the owner of the shop. A good economist will also be careful to provide easy means for opening and shutting the shop-door: an imperfect latch or inconvenient handle to the door, by occasioning annoyance to the customer, becomes a source of injury to the tradesman.

Among the arrangements connected with the fitting of the shop, there are none more important in their influences on the health and comfort of the inmates, than those by which provision is made for *heating*, *lighting*, and *ventilating* the apartment. No pains should be spared in rendering the means for effecting these objects as complete and perfect as possible. The expense incurred will be a profitable investment, if it ensures the complete fulfilment of the objects proposed, by making the place of business a fit place for healthful recreation, instead of being, as it too often is, an imperfectly-heated and badly-ventilated apartment, where body and mind are benumbed with cold or oppressed with vitiated air. Are there not many, both employers and employed, whose longings to be released from the restraints of business occupations may be traced, at least in part, to these atmospheric influences?

One of the first questions to be settled, therefore, in connection with the fitting of the shop, should be,—what are the best means for regulating the heat, light, and ventilation of the apartment? It is desirable that these means should be planned and finally arranged in connection with the other fittings of the shop, so that they may be made subservient to each other. No plan that could be proposed for effecting these objects would be equally applicable in all cases, differences in the size and construction of apartments rendering that which may be suitable in one case inapplicable in another. The following suggestions, however, may probably prove useful under a variety of circumstances.

*Arrangements for Heating the Shop.*—It is desirable that the means adopted for this purpose should be economical and efficient when used, and that their disuse should involve no inconvenience; for there are only a few months in the year during which artificial heat is required in the shop.

The most common arrangement for warming shops consists in the use of a stove fixed near the centre of the room. In these cases the flue is sometimes made to descend, and is then carried underneath the ceiling of the room below until it reaches the chimney. The heat is communicated to the atmosphere both by radiation, and by conduction from the contact of air with the heated surface of the stove. If the stove be much heated, as is the case with common stoves of this kind, a disagreeable flavour is sometimes communicated to the air, in consequence of the decomposition or volatilization of organic matter, either floating in the atmosphere or otherwise brought in contact with the hot metal. Dr. Arnott's stoves, which never become heated to a very high temperature, are not subject to this objection, and are at the same time economical and efficient.

Gas stoves are occasionally used for warming shops. A patent has been taken out by Mr. Rickets for a stove of this kind which requires no chimney. It consists of an external cylindrical case, within which gas jets are ignited, and these are made to heat a number of tubes fixed within the stove, through which air passes. The heat, however, is principally diffused by radiation.

These stoves are objectionable if used without a chimney, on account of their adding the carbonic acid, and other noxious products of the combustion of the gas, to the atmosphere of the room.

There is another kind of gas-stove or furnace, fitted up by Mr. Rickets and other gas-fitters, which although not generally used expressly for heating rooms, may, in some cases, in addition to its application to other useful purposes, be made available for warming a small shop.

Fig. 1, represents a section of one of these furnaces. A, is an iron tube, about two feet long and two, three, or four inches in diameter, open at both ends. At C, about two inches from the top, a disk of

Fig. 1.

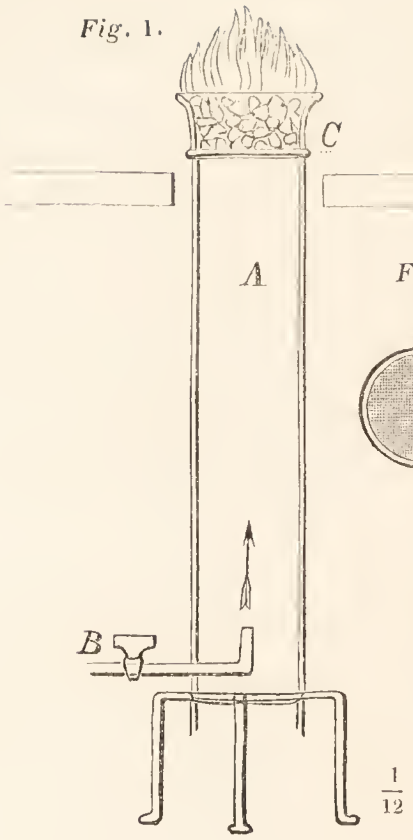
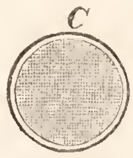


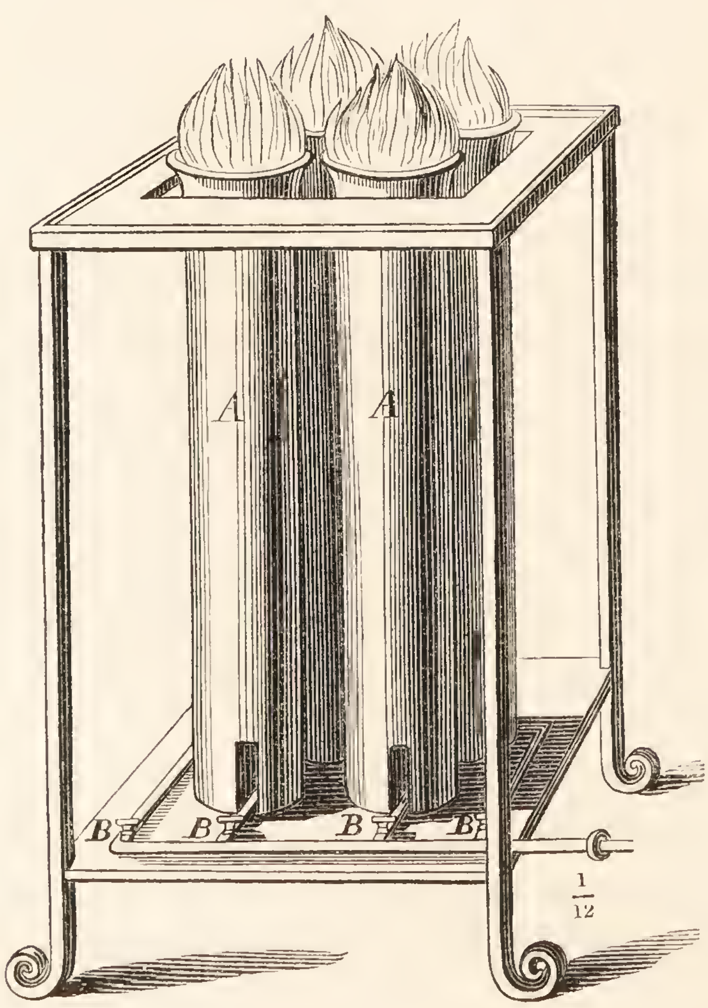

Fig. 2.




Mixed-gas Furnace.

fine wire gauze (fig. 2) is securely fixed, so as to form a diaphragm, on which are put some pieces of broken pumice-stone to fill the upper part of the tube. B, is a gas-pipe from which gas is allowed to escape into the tube A, where, on ascending, it mixes with the atmospheric air, which has free ingress at the bottom. This mixture of gas and air, passing through the wire gauze, is ignited on the surface of the pumice-stone. The wire gauze is used to prevent the communication of the ignition to the combustible mixture below it, while the pumice-stone, becoming red-hot, forms a good radiating surface. The quantity of gas admitted into the tube A, should be such, that the gaseous mixture shall burn with a pale blue flame *perfectly free* from smoke.

Fig. 3.



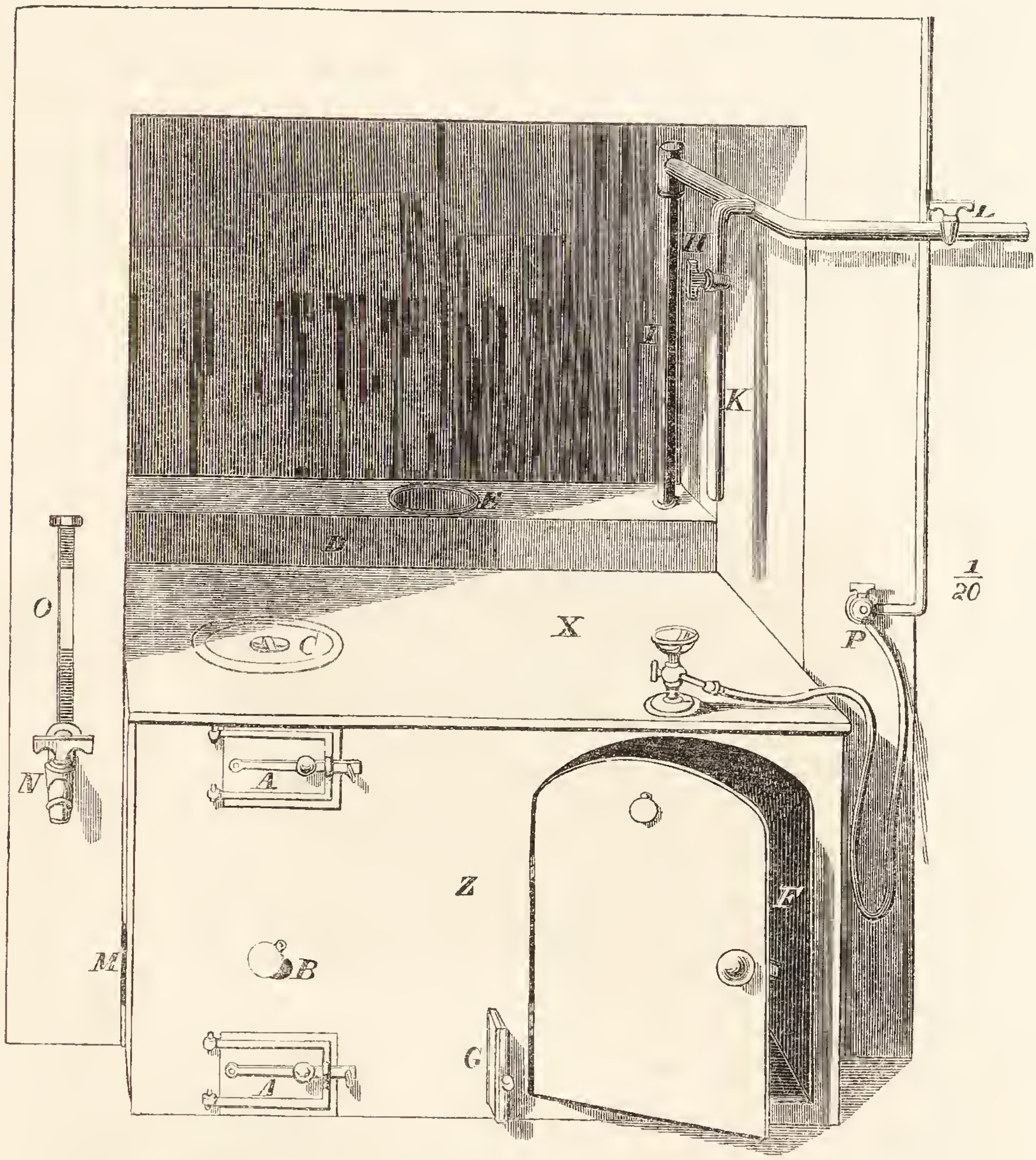

Mixed-gas Furnace.

A furnace of this kind may be lighted in an instant; it affords sufficient heat for making a decoction, heating a plaster spatula, or for any other similar purpose; and it occasions no annoyance from dust or smoke. Several of them may be fixed contiguously to each other, as shewn in fig. 3, so that two or more may be lighted at the same time, when required, and a great amount of heat may in this way be produced.

Means ought to be provided for conveying away the products of combustion from this, in common with every other, kind of stove or furnace, instead of allowing them to contaminate the air of the apartment; yet the effects of using either of the gas-stoves above described without a chimney, would not be more injurious than those resulting from the ordinary combustion of the same quantity of gas in lamps.

In some cases a fire-place, already existing in the shop, may be advantageously retained as such, and may have fitted into it, either a common stove, or a close stove having several useful applications, besides that of warming the apartment. Fig. 4, represents a useful

*Fig.* 4.



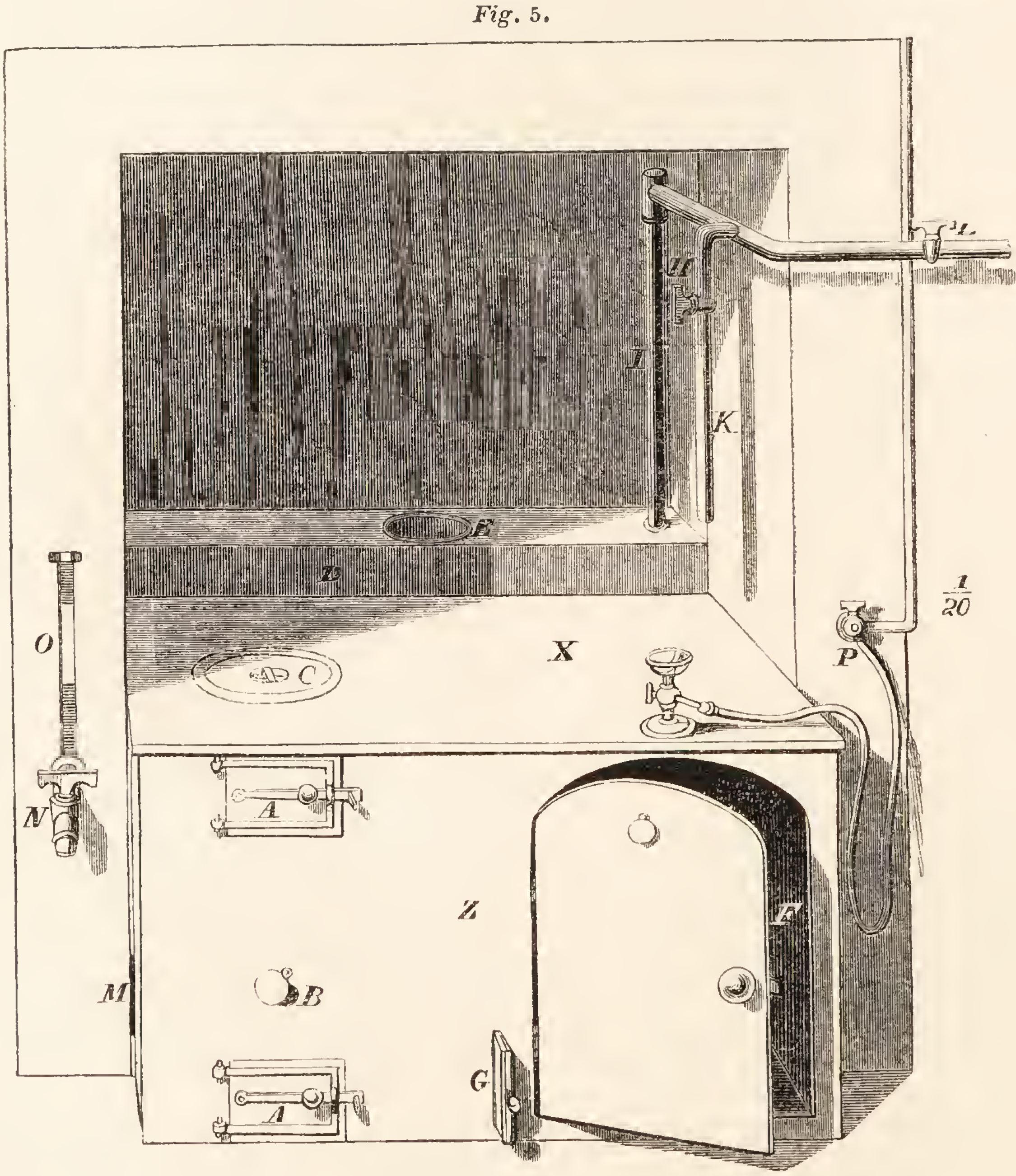

PHARMACEUTICAL STOVE.

A A. The furnace and ash-pit doors.
B. Circular opening into the fire, for clearing the bars, inserting a tube, &c.
C. Circular opening to the top of the furnace.
D. The boiler.
E. Circular opening into the boiler, with a dished cover, and water-joint. See fig. 7.
F. The drying closet.
G. A sliding door or damper, for opening or closing a communication between the drying closet and ash-pit.
H. The flue from the furnace fire.
I. The steam pipe.
K. L. Two branches from the steam pipe.
M. Channel for conveying air round the back of the fire into the drying closet.
N. The tap for drawing water from the boiler.
O. Tube for indicating the height of the water in the boiler.
P. Gas pipe, with flexible tube, and burner.
X. Z. Cast iron front and top to furnace.

kind of stove, which may be fixed in the fire-place either of the shop, or more conveniently of a room adjoining to the shop. It consists of a chemical furnace, drying closet, and boiler for the supply of hot water and steam, with provision for carrying steam or noxious vapours, from any process, up the chimney.

I have arranged this furnace with a view to its being economically and easily constructed. The top plate X, and the front with doors and return ends Z, should be of cast iron, half an inch in thickness. It would be necessary to have patterns made in wood from which to make these castings, but if it be a consideration to construct it at the least possible cost, the front may be made of brick, thus dispensing with the outer cast iron case; and the doors for the furnace, ash-pit, and drying closet, may be bought, ready made, at any ironmongers. The drying closet door in such as is commonly used for the oven fixed in kitchen ranges. The boiler D, is also kept by most ironmongers. The drawing is made from one of those manufactured by the Carron Company of Thames Street, London; it is three feet six inches in length. The pipes for supplying and drawing off the water, and also the steam pipes are attached in the usual manner. The supply of water to the boiler

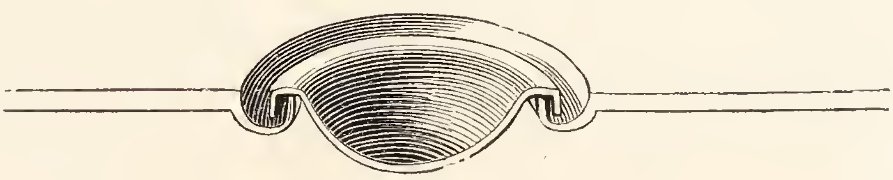
*Fig.* 5.




PHARMACEUTICAL STOVE.

may be regulated by a cistern with a ball-cock, similar to those adopted for kitchen ranges, or by a ball or stone float in the boiler itself, similar to those generally used with steam boilers. The former of these plans is perhaps the least expensive, and most easily effected in country places; it is, however, subject to this objection, that in using the steam, a certain amount of pressure is required in the boiler, which will force the water into the supply cistern, and sometimes cause it to overflow there. This result may be obviated by having a stop-cock between the supply cistern and the boiler, so that, when pressure is required, this communication may be cut off. In this case, and indeed under any circumstances, it would be desirable to have a glass tube O, for indicating the height of the water in the boiler. One end of this tube is inserted into the pipe of the tap N, and the other end communicates by a piece of metallic tube with the upper part of the boiler. The opening E, in the top of the boiler, may have a dished cover fitting on with a water-joint, as shewn in fig. 6. This would prevent the escape

*Fig.* 6.

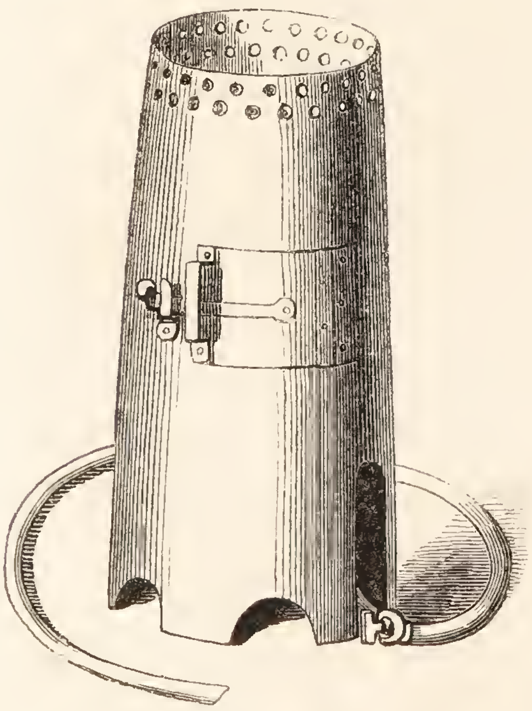


WATER-JOINT.

of steam under ordinary circumstances, and would act as a safety valve by allowing it to escape, if unusual pressure were applied, while at the same time it might be used as a water bath for the reception of an evaporating dish. The water-joint would be inapplicable, however, if the steam were required to be used under more than a very slight pressure. It would be the most simple and inexpensive way of fitting the boiler, but tight joints and a proper safety-valve would render it more complete and generally useful, and would be necessary for some of the applications we are about to notice. The ash-pit door should be made to fit as close as possible, so that the admission of air here may be shut off at pleasure. The furnace door should be close to the top plate, as shewn in the drawing; and there should be a small opening, B, immediately over the furnace bars, to admit of the clearing of the bars with a poker, of sending a blast of air into the fire from a bellows or blowing machine, of introducing a tube into the fire, warming a plaster spatula, &c. Between the drying closet and the ash-pit, there is a communication which may be opened or closed by means of the sliding door or damper G, and at M, there is an air-channel passing round the back of the fire and under the boiler to the drying closet. The course of this air-channel is further shewn in fig. 9 at F. When the furnace is in action, if the ash-pit door be shut, and the damper G, drawn out, the air supplied to the fire will be necessarily drawn from the drying closet, while fresh air, warmed by its proximity to the fire, will at the same time enter the closet through the channel M. A constant current of warm dry air will thus be maintained through the drying closet, which will render it very efficient for the purposes to which it is applied. The circular opening C, in the top of the furnace, will receive a pan, small still, or other similar vessel. Decoctions may be boiled in flat bottomed saucepans merely placed on the hot plate over the flue, a little further back than the opening C. The top of the boiler may be used for any process to which it is applicable, requiring the heat of boiling water.

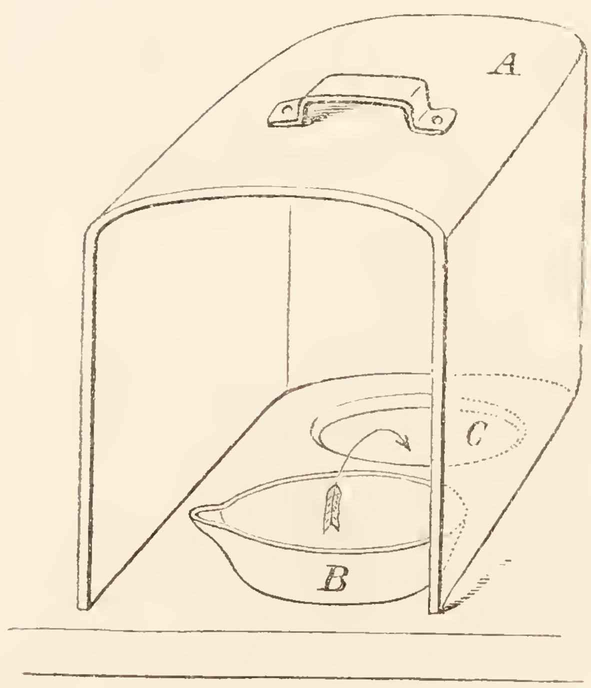
The iron plate forming the top of the drying closet at X, will have only the slight heat which it acquires by conduction from the fire. Processes involving the liberation of noxious vapours, may be conveniently conducted here, as the vapours will pass up the chimney. The gas-burner and flexible tube, as shewn in the drawing, may be required in some processes of this description, also the gas-furnace (fig. 7), which is placed over the gas-burner, and forms a support for a dish, flask, or other vessel. In some cases, however, the furnace-hood, (fig. 8,) will be found to form a better arrangement for getting rid of noxious vapours. It is

*Fig. 7.*



Gas Furnace.

*Fig. 8.*

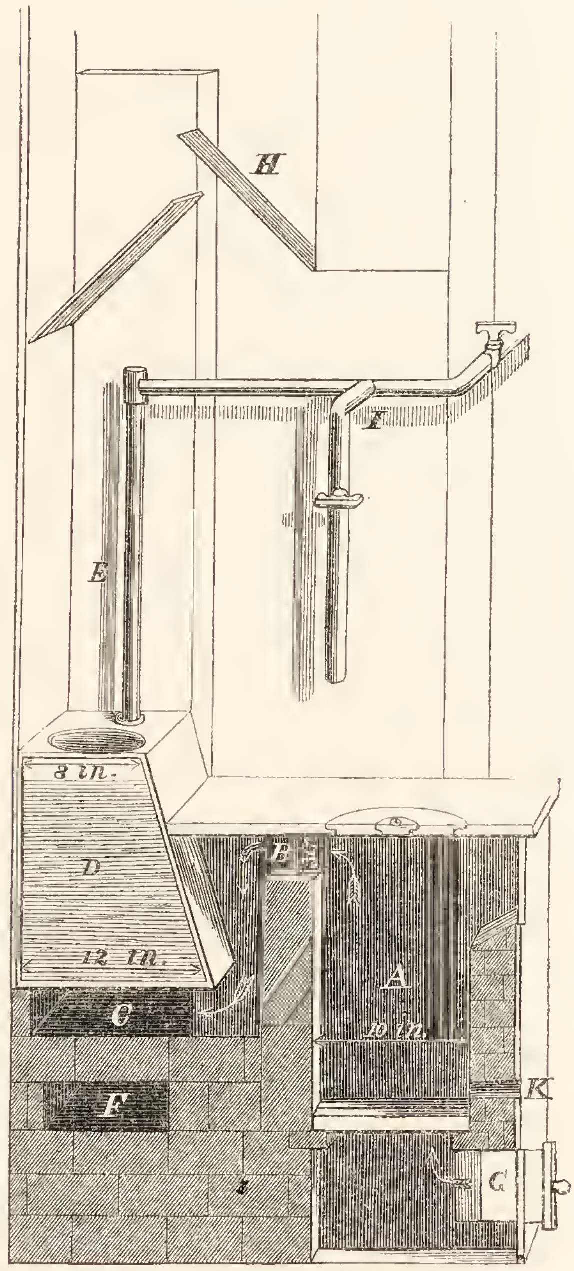



Furnace Hood.

made of tin-plate, and is placed, as represented, on the top of the furnace over the circular opening C, while the vessel from which vapours are disengaged stands a little in front of the opening.

Under these circumstances, the vapours rising from the dish will be drawn into the furnace as indicated by the arrow. If the furnace be well constructed, this effect will be complete; but, should there be any defect in the draught, it may be necessary to close the ash-pit door, in order to ensure the desired result.

*Fig. 9.*




Section of Pharmaceutical Stove.

A. The fire-place.
B The flue passing under the top plate of the furnace.
C. The flue passing under the boiler.
D. The boiler.
E. The steam pipe with the branch I.
F. The air channel leading to the drying closet.
G. The communication between the drying closet and the ash-pit.
H. The chimney-plates for preventing the soot from falling on to the furnace.

Fig. 9, represents a section of the pharmaceutical stove, through the fire place and boiler. It shows the arrangement by which steam and other vapours are allowed to pass up the chimney, while the soot is prevented from falling down. This arrangement consists of two plates of iron, fixed as represented at H, one against the back, and the other against the front wall of the chimney.

This pharmaceutical stove will thus admit of many useful applications, even when constructed in the most simple and inexpensive manner, with the water-joint valve. If, however, the joints be all made tight, and a safety-valve, capable of sustaining a pressure of three or four pounds to the inch, be attached to it, it would be susceptible of still further appliances. The steam generated in the boiler, which cannot be forced through pipes, so as to be fully available for use, unless exposed to some pressure, might, under the arrangements now contemplated, be used for making decoctions, warming a drying closet, supplying distilled water, and finally for warming the shop. The means of applying it for the three first-named purposes, will be described under the head of Steam Apparatus for the Laboratory; the last is that alone which will require special notice here.

If the pharmaceutical stove be fixed in the shop, there would perhaps be sufficient heat radiated from the stove itself to impart the required warmth to the atmosphere of the room; but, should this be the case in cold weather, it is obvious that the same diffusion of heat in warm weather would become oppressive and injurious. Yet the stove, if rendered serviceable to the fullest extent of which it is susceptible, should be in daily operation throughout the year. It would be found more convenient, therefore, to have the stove in a separate apartment, contiguous to the shop; or, if this cannot be done, efficient means must be provided for carrying off the heated air, when this is required.

The use of a steam-heating-pipe presents a most unobjectionable method of communicating heat to an apartment. In the case now under consideration, it would only be necessary to have a pipe about three or four inches in diameter, running the entire length of the shop, and fixed in, on, or near to, the floor, with a branch from the pipe L, fig. 4, to supply it with steam from the boiler. This steam-pipe may be made of cast iron, but if one of a suitable size could be obtained, coated on the inside with the enamel now so extensively applied to iron utensils, it would possess this advantage, that the water which would be condensed in it would be available for use as distilled water. The steam pipe should have a little inclination towards the end furthest from the boiler, so that the condensed water may run off from that end into a suitable vessel, fixed for its collection.

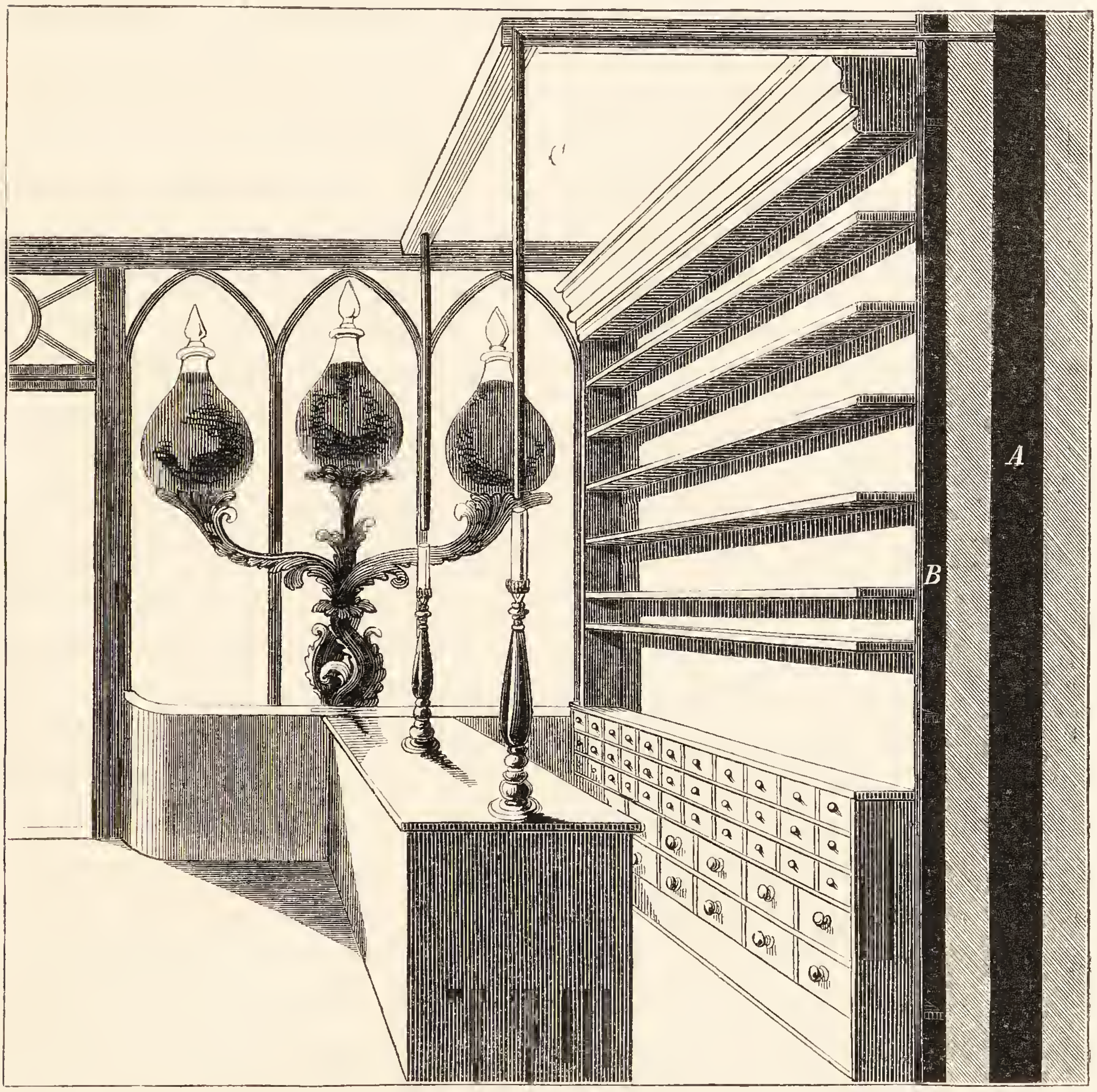
The best position for the steam-heating-pipe would be the space between the floor and the ceiling below, with an iron grating placed over it, or the interior of the counter, with openings to admit of the circulation of air around it. It is calculated that the steam-pipe for heating a room should have one square foot of surface exposed, for every 200 cubic feet of space to be warmed.

*Arrangements for Lighting the Shop.*—Gas is now almost universally adopted for artificial illumination in our towns. As compared with other means of lighting, it is found to be economical and generally convenient. In the combustion of coal-gas, however, there is a very large amount of heat generated; and, in addition to carbonic acid, there is usually a small quantity of sulphuric or sulphurous acid formed; so that the atmosphere of an apartment, lighted with gas, becomes oppressively hot and injurious to health, unless efficient ventilation, or means for carrying away the products of combustion, be adopted. A plan has been proposed* for conveying the heated and contaminated air from each gas burner into a chimney, by means of iron tubes, about $1\frac{1}{4}$ or $1\frac{1}{2}$ inch in diameter,

* On the Importance of Ventilation. By Mr. Squire. Pharmaceutical Journal, vol. iv. p. 258.

extending from the top of the lamp-glass to a horizontal tube, running either between the ceiling and the floor above, or immediately under the ceiling, and communicating with the chimney. This arrangement is shewn in fig. 10. Professor Faraday has contrived a very ingenious gas-lamp, by which the same object is effected.

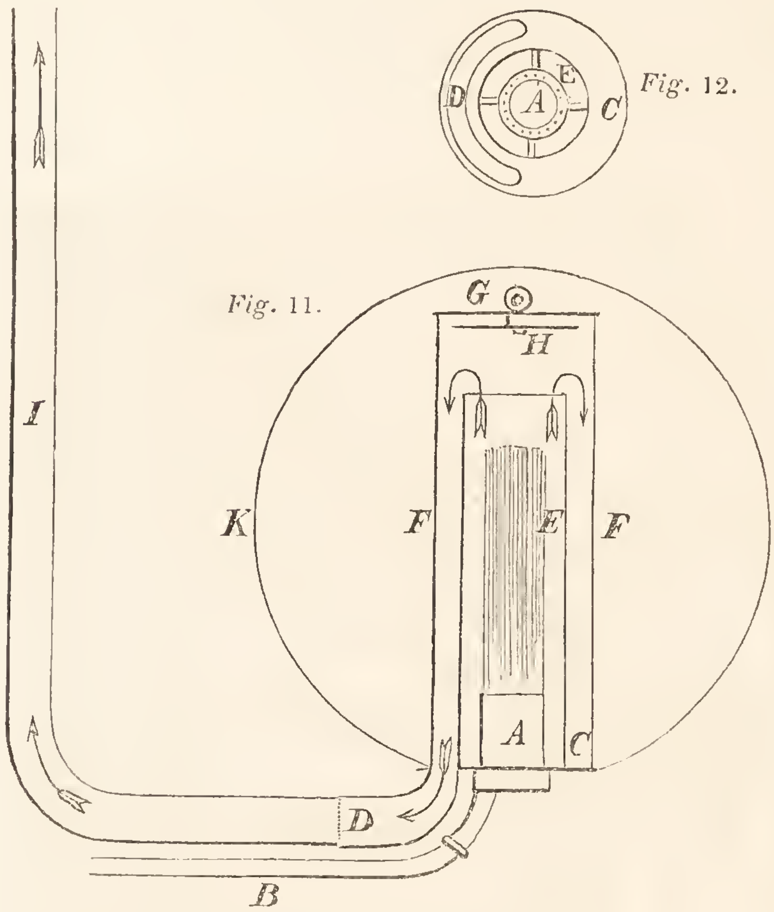
*Fig.* 10.




Arrangements for Gas-lighting and Ventilation.

A. The chimney in the wall of the shop.
B. The space between the wall and the boarding or wainscot, against which the shelves and drawers are fixed.
C. Tube conveying products of combustion from the gas-lamp into the chimney.

Figs. 11 and 12, represent Faraday's gas-lamp; A, is the burner; B, the gas-pipe leading to the burner; C, the glass-holder, which is best shewn in fig. 12; the inner glass E, is a common lamp-glass, which stands on the bars *e;* over this is placed another glass F, of larger dimensions, the top of which is closed by a plate of mica G, or a double plate, as shown in the drawing G, H. From one side of the outer rim of the glass-holder there is an opening D, communicating with the tube I, by which the products of combustion are conveyed away and discharged into a chimney. A glass globe K, having no opening at the top, may be placed over the lamp. The air for supporting the combustion of the gas enters through the openings in the centre of the burner and surrounding it, while the products of combustion pass off as shewn by the arrows.




Faraday's Gas-Lamp.

A. The burner.
B. The gas-pipe.
C. The glass-holder.
D. I. The opening and tube for carrying off the products of combustion.
E. The inner lamp-glass.
F. The outer lamp-glass, with the mica top, G. H.
K. The external glass-shade.

It is necessary, on first lighting this lamp, to determine a draught through the tube I, by heating the ascending branch, before the second glass F, is put on; it is also necessary to regulate very carefully the supply of gas, so as to prevent its smoking and blackening the glass.

A patent has been taken out for this contrivance by Mr. Faraday, of Wardour Street.

*Arrangements for Ventilating the Shop.*—Ventilation consists in the constant removal of that portion of the atmosphere of the apartment which has been rendered impure or unwholesome by respiration, or in any other way, and the substitution of fresh and wholesome air from without. It is obvious that under ordinary circumstances no portion of air can be removed from a room without an equal quantity being at the same time introduced to supply its place. All means of ventilation, therefore, must provide for the introduction of pure air and the displacement of that which has been contaminated. The principal causes of the contamination of the air in the cases now contemplated, are, respiration and combustion. Air thus contaminated becomes specifically lighter than that by which it is surrounded, and it therefore ascends to the upper part of the room, where provision should be made for its removal. If this be done, fresh air from without will gain admission through the doors and other openings. These, indeed, are the means generally adopted for ventilating apartments; but there is found to be a great impediment to the efficient adoption of these means, arising from the fear of exposure to draughts of cold air, and the difficulty of guarding against this evil.

The two principal points to be considered, therefore, in reference to ventilation, are; 1st, the means by which the vitiated air may be rapidly removed from the upper part of the room; and 2ndly, the means for introducing fresh air, which shall be so diffused or previously warmed, as not to occasion the sensation of cold draughts or currents of air.

Dr. Arnott's ventilator affords good and efficient means for the removal of the hot and vitiated air of a room, by allowing it to pass into the chimney. Fig. 13, represents this ventilator, which consists of an oblong metallic frame, A, to be fixed in the wall of the chimney, near the ceiling, as shown in fig. 14.

*Fig.* 13.

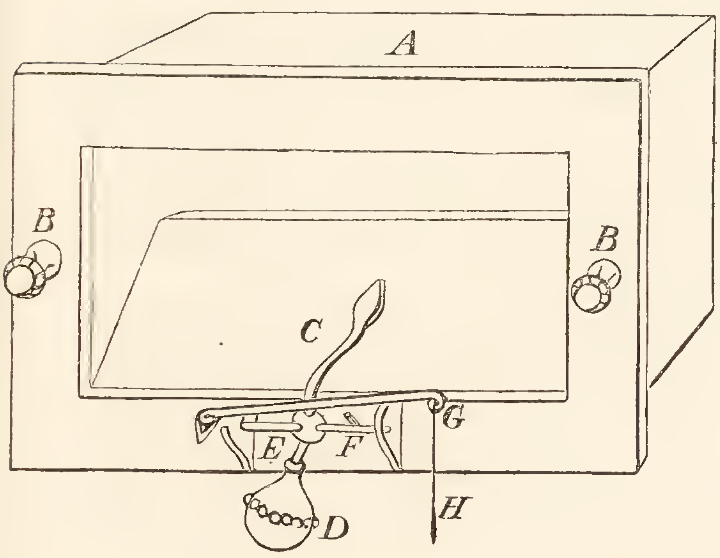
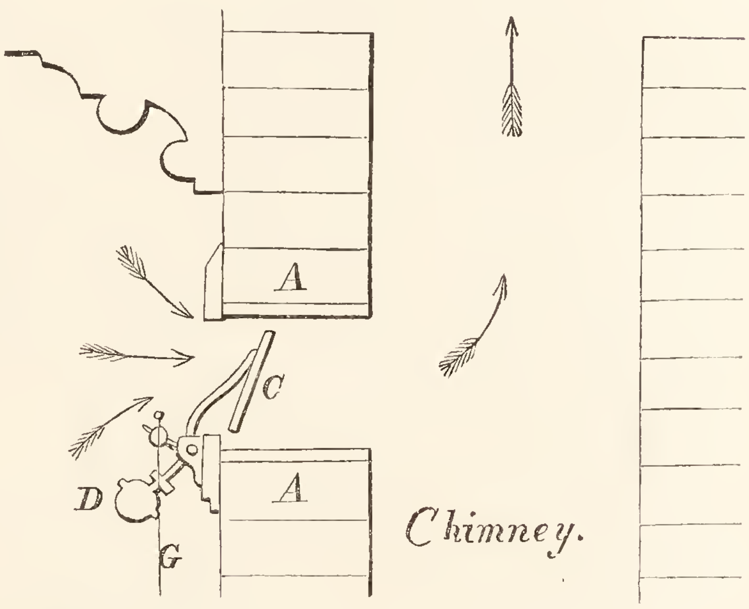



*Fig.* 14.




Dr. Arnott's Ventilating-valve.

B, B, (fig. 13,) are two screws by which the front frame, carrying the valve, is fixed to A. C, is the valve, consisting of a metallic plate, turning on the axles E, F, and balanced by the weight D, so that the opening into the chimney shall be completely closed by C, when there is no draught into the chimney, and especially when there is a tendency for the air of the chimney to return into the room. The action of the valve in allowing the air of the upper part of the room to pass into the chimney is shewn in fig. 14. G, is a wire, the lower end of which is fixed to the wall within reach of the hand, and by shortening or lengthening this by means of a screw, the extent to which the valve can open is regulated.

But the great difficulty in connection with ventilation, is not so much in withdrawing the foul air as in substituting that which is pure in an unobjectionable way. If the external air be allowed to enter the apartment at only a few points, it will almost inevitably occasion cold currents that will prove sources of annoyance. Means have been tried for causing a mechanical diffusion of the cold air as it enters, but none of these have completely answered. A patent has been taken out for a ventilator to be fixed in the window, which consists of a number of slips of glass fitted into one of the squares, in the same way as louver board ventilators are constructed. The object of this is to divide the air, as it enters, into several strata, and to give to these an upward direction, so that the cold air may pass along the ceiling, and thus become to some extent warmed and diffused before its descent. But the objection still applies to this method, that the air is admitted at a few points only, and if there be much difference between the temperatures of the external air and of that within the room, there will frequently be complaints of cold currents.

It has recently occurred to me, that a druggist's shop offers admirable facilities for effecting a very complete system of ventilation in an unobjectionable and inexpensive way. In fitting the shop, it is customary to commence by wainscoting the walls, so as to facilitate the fixing of the shelves and drawers, which are screwed to the boards of the wainscot. The way in which this is done is represented in fig. 10, where it will be seen that there is a vacant space B, between the wall and the wainscot, occasioned by the battens to which the latter is fixed. Now, as this space extends to the window, it would be easy to make an opening of suitable size from this to the external air. This being effected, the air may be allowed to pass through an infinite number of small apertures in the wainscot, and thus be very widely diffused. Moreover, the air may be warmed before diffusing itself into the apartment, by means of a steam pipe carried through the space B.

*Division of the Shop into Compartments.*—The arrangement and fitting of the shop will, of course, depend on the kind of business for which it is designed. In this country the business of a chemist and druggist is often of a very mixed character; even in those establishments where the business is purely pharmaceutical, it will admit of being classified; and the shop is sometimes divided into compartments, each of which is fitted up expressly for a particular class of business. In these cases there are frequently separate compartments for *retail*, *wholesale*, and *dispensing* business; and there may be a fourth compartment, in which the junior apprentice or assistant is engaged in putting up articles, such as Epsom salts, soda and seidlitz powders, &c., ready for sale, with the view of facilitating the dispatch of business.

If it be intended to adopt this plan of dividing the shop into compartments, it will be necessary to consider, in the distribution of the bottles and drawers, what articles would be most conveniently placed in each compartment. Thus, the syrups, pills, extracts, tinctures, powders, distilled waters, and essential oils, are, with few exceptions, required in the dispensing compartment; lozenges, articles of perfumery, most whole or unpowdered drugs, together with some of the distilled waters, tinctures, &c., should be in the retail compartment; the junior apprentice's compartment may contain those articles that are the least frequently required; while the fitting of the wholesale compartment must depend on the character of this class of business.

There are three kinds of receptacles, namely, *drawers*, *jars*, and *bottles*, that are required for containing the several substances which are arranged against the walls. In some old establishments a much larger number of drawers were used than is generally the case in those of the present day. The Pharmaceutist now uses, with advantage, a larger number of bottles, and not so many drawers.

It will be found to conduce much to the symmetrical appearance of the shop, if the fittings be so arranged that the lines formed by the drawers, shelves, &c., shall run uniformly round the apartment. The cases of drawers, which will form the first or lowest part of the fittings, ought not to be high; about thirty-nine or forty inches will be found to be a good height from the ground to the top of the drawers. If they extend higher, it will necessarily cause a great part of the bottles to be placed so high up against the wall as to be beyond reach of the arm, without the aid of a step-ladder. This is an inconvenience that ought to be avoided as much as possible; and with this view it will be well to have a deep cornice, above the shelves (as shewn in fig. 10,) whenever the size of the apartment will admit of it.]

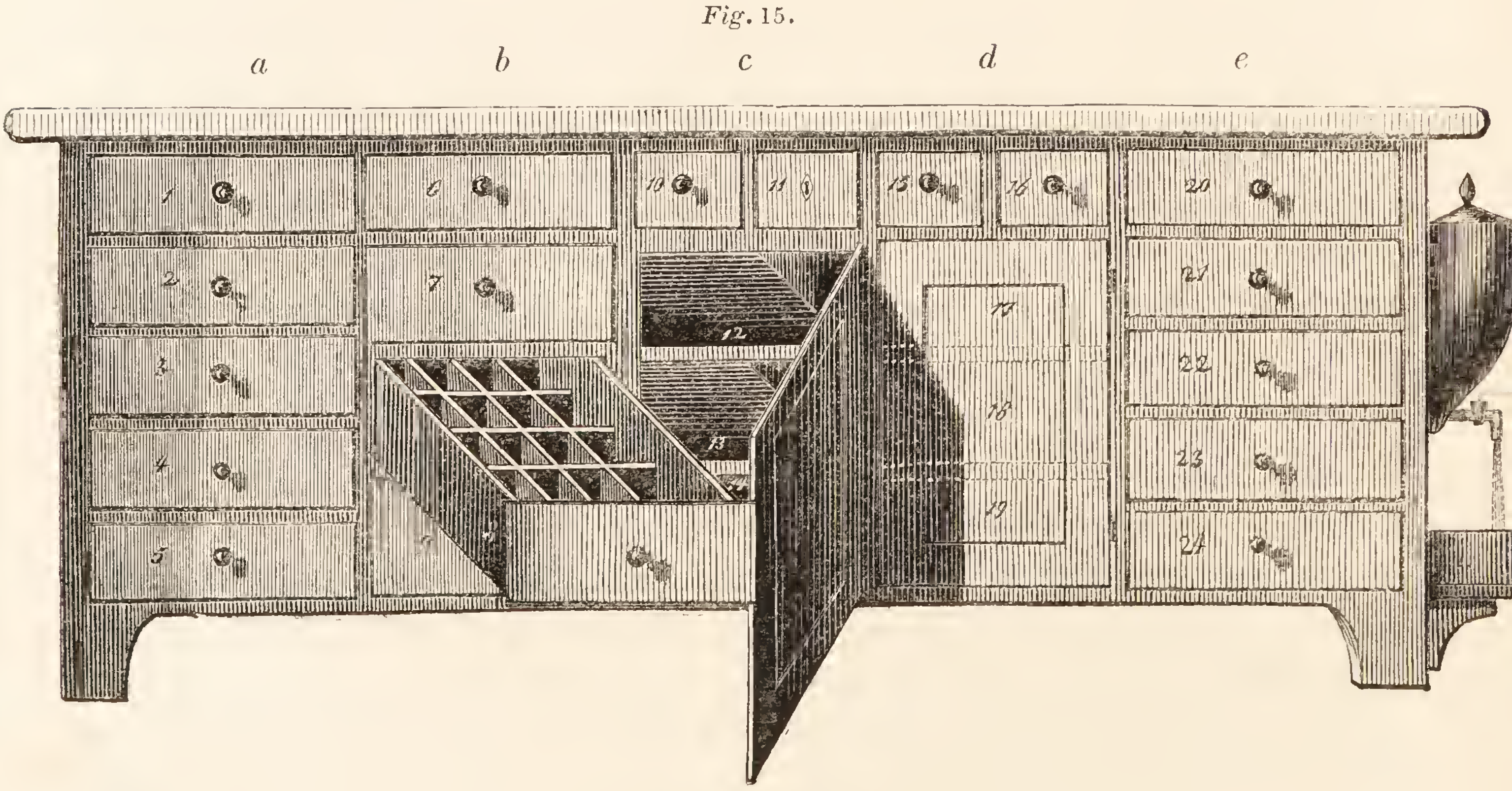
*The Dispensing Counter.*—The construction of the dispensing counter is deserving of special and minute consideration. The ease, accuracy, and expedition, with which the dispenser performs his work, will, in great measure, depend upon the arrangement of this part of the fittings. It is a very inconvenient mode of proceeding to have the drawers fitted into the counter without any reference to their particular applications, and then to appropriate them as they are required; for it is much easier to plan a well-arranged counter on paper, than to make the required alterations in one that has been imperfectly constructed.

The first point to be considered is, what part of the shop shall be appropriated to this department? It is desirable that the dispensing counter should be so placed that it shall command good light, and that those engaged at it may not be exposed to unnecessary interruptions. A question may arise, as to what is the best direction for the light to fall? When this can be made a matter of choice, it will be found advantageous to have the window to the left hand of the dispenser, so that his right hand may not cast a shadow over his work.

The height of the dispensing counter is a matter of some importance; if it be too low, it will affect injuriously the health and stature of the dispenser, by causing him to stoop, and this, from constant habit, has been found to occasion a slight curvature of the spine, which has been called the dispensers' hump. Thirty-six inches will be found to be a good height for the counter. The top should be of hard wood, and should be at least two inches in thickness.

The arrangement of the drawers, however, is the most important consideration in reference to the construction of the dispensing counter. A difference of opinion appears to exist, as to whether it is most convenient to have a great number of small drawers, or a smaller number of large ones, with internal divisions in them. I think there are several reasons for preferring the latter. The following arrangement of a dispensing counter is given as one that has been found practically convenient.

*Fig.* 15.




Dispensing Counter.

Fig. 15, gives a view of the working side of this counter, shewing the distribution of the drawers and cupboards in it. It has five divisions over which the letters *a*, *b*, *c*, *d*, *e*, are placed. The drawers, &c., are intended to be appropriated in the following manner :—

Division *a*.

1. Contains all the requisites for the preparation and dispensing of powders, such as boxes, capsules, cards, horn spoons, wrappers, spatulas, &c.

2. Paper bags of various sizes, for containing herbs, &c.

3. Pill-boxes, and wide-mouth bottles, with corks fitted to them.

4. Covered pots, for ointments, &c.

5. Empty, for any miscellaneous or forgotten articles.

Division *b*.

6. All the requisites for dispensing mixtures, draughts, &c., such as corks, caps for the bottles, labels, twine, &c. (See fig. 16.)

7, 8, and 9. Drawers, with divisions within, for containing bottles, from the smallest size up to eight or ten ounces.

Division *c*.

10. Contains the price-book, directory, paper for copying prescriptions on, &c.

11. The till or cash-drawer, with lock and key.

12. Recipe book, for copying prescriptions into.

13. Bell-metal and iron mortars.

14. Three shelves, for pill machines.

Division *d*.

15. Small slips of paper.

16. Knives, plaster irons, capsules for melting plasters in, &c.

17. Graduated measure glasses, strainers, and small dishes.

18. Porcelain or wedgwood mortars, for mixtures.

19. Ditto ditto, for powders.

Division *e*.

20. Towel, duster, scissors, knives, &c.

21. Paper, cut to different sizes.

22. Green glass bottles, from ten to sixteen or twenty ounces capacity.

23 and 24. For miscellaneous or forgotten articles.

To facilitate the opening and shutting of the drawers in the counter, and obviate the inconvenience frequently experienced from their moving difficultly and irregularly, I have had small wooden rollers (fig. 18) fixed in the frames, and can strongly recommend this addition.

I will now describe, more particularly, the internal arrangement of the drawer No. 6, containing the requisites for dispensing mixtures, &c. This is represented in fig. 16. It is $20\frac{1}{2}$ inches long, $15\frac{1}{2}$ inches wide, and four inches deep, and is divided into thirteen compartments, which are severally numbered in the drawing.

*Fig.* 16.

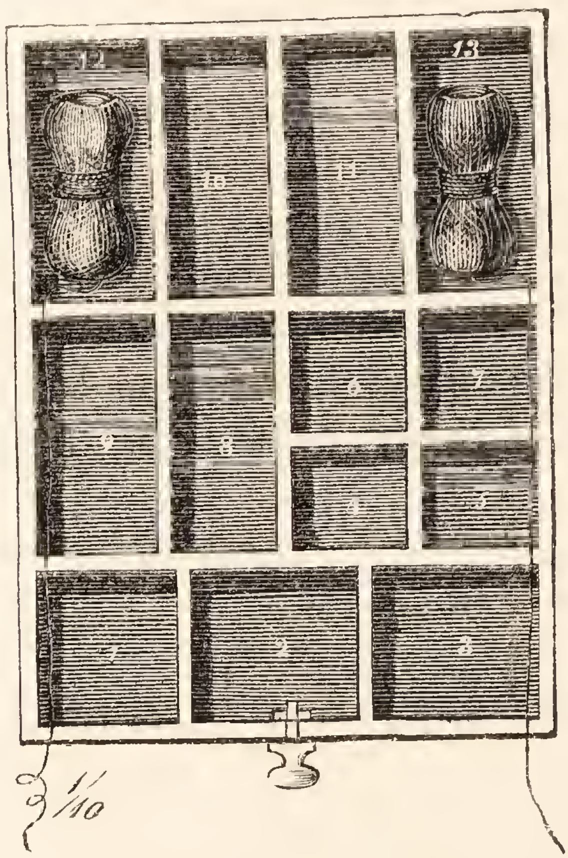
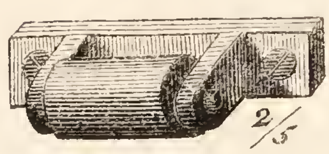


*Fig.* 17.

*Fig.* 18.

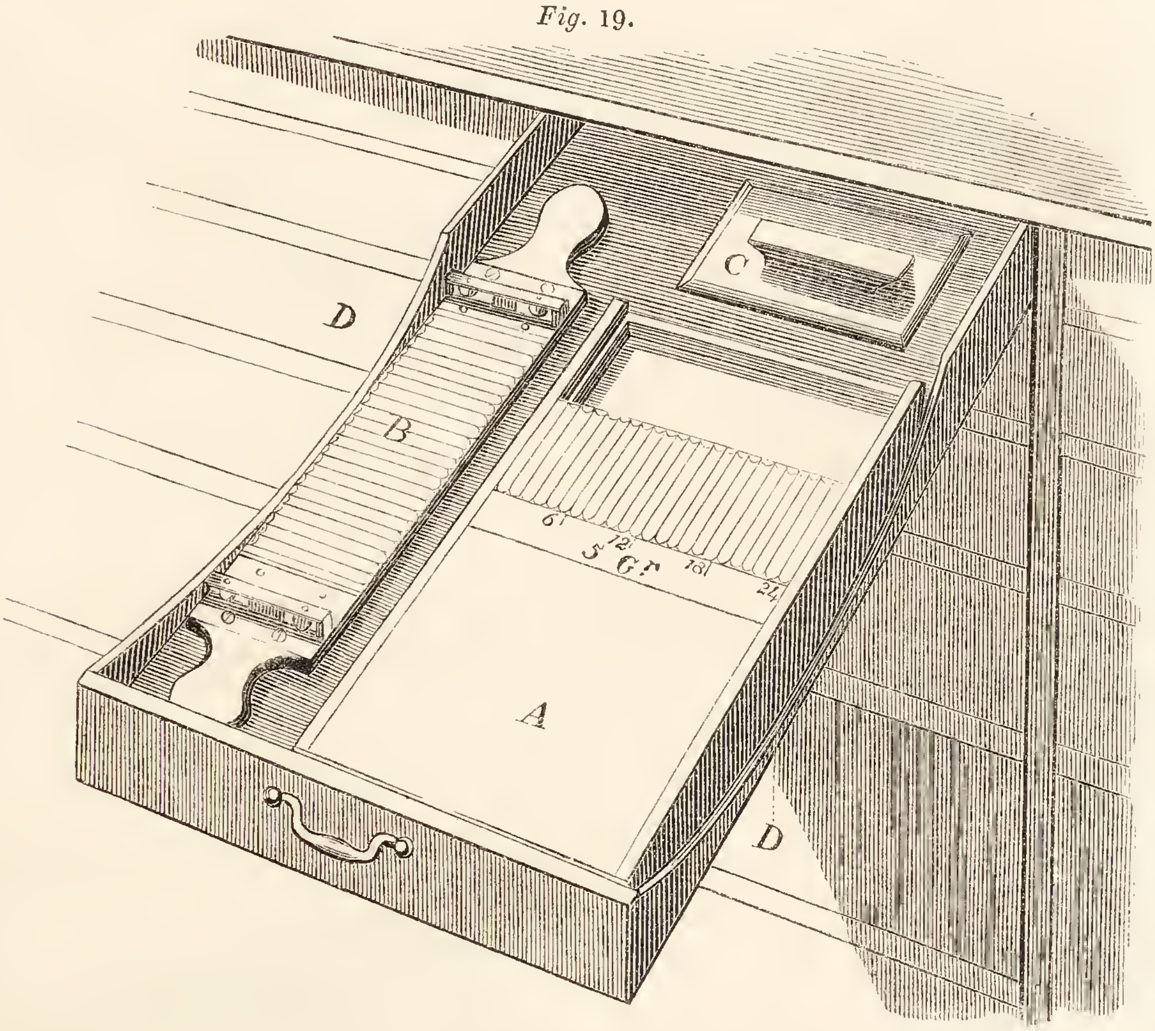


Divisions 1, 2, and 3, contain corks of different sizes, and the pincers fig. 17, for compressing and softening the corks when they are used. The insertion of the cork being the first operation to be performed after making the mixture, the front compartments are occupied with the requisites for performing it. Immediately behind these are other implements, which are subsequently required. Division 4 contains the first papers for putting over the corks; division 5, the coloured caps; and division 6, embossed and ornamented caps. Division 7 contains waxed paper, and tin-foil, for covering ointments; and 8, 9, 10, and 11, are occupied with labels of different kinds, both plain and ornamented. Lastly, 12 and 13 contain white and coloured string.

[Some difficulty is frequently experienced in determining the best place for keeping and using the pill-machines. Where there is much dispensing business done, the pill-machine is in almost constant use, so that, having to take it out of a cupboard, when required, and return it again, with its several parts, when done with, would be troublesome, and would occupy time unnecessarily. Moreover, under such an arrangement, a place would be required, on the counter, for using the machine, which, in many instances, could not be conveniently spared, and the powder employed for rolling out the pills, would occasion dust, which, together with the machine itself, would interfere with the neatness and cleanliness which ought to characterize the dispensing counter.

Some years ago, my attention was directed to this subject, and I adopted the arrangement which is represented in fig. 19. The pill machine A, is fixed in a shallow drawer, immediately under the top

*Fig.* 19.




Pill-machine.

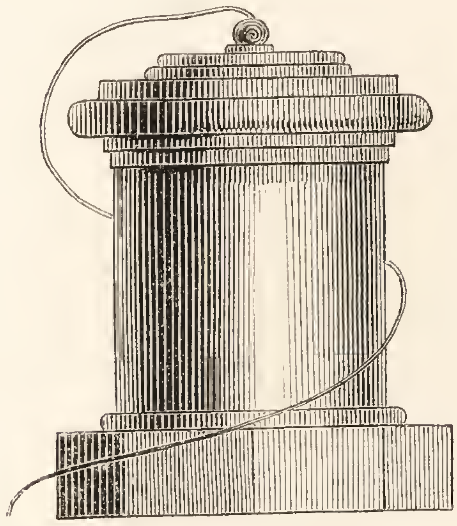
of the counter, a place being left on one side for the cutter B, to lie in when not in use, and another place at the back for the roller C. The two sides of the drawer, at D, D, are cut down, as shewn in the drawing, to make room for the lateral guides of the cutter. There is, also, a stop fixed in the top rail of the frame in which the drawer runs, so that, when pulled out, as shewn in the drawing, the front of the drawer, from its weight, falling a little below the horizontal plane, and the back edge coming in contact with the stop, a check is put to the return of the drawer when pushed. The operator, therefore, leans against it, and thus keeps it fixed while he cuts the pills with the cutter, and as soon as the process is completed, on slightly elevating the front of the drawer, so that the back edge shall clear the stop, it is pushed in, and the whole apparatus removed from sight.

This arrangement has been adopted in one of the largest dispensing establishments in London, and has been found practically convenient.

The ointment slab might be disposed of in a similar way.

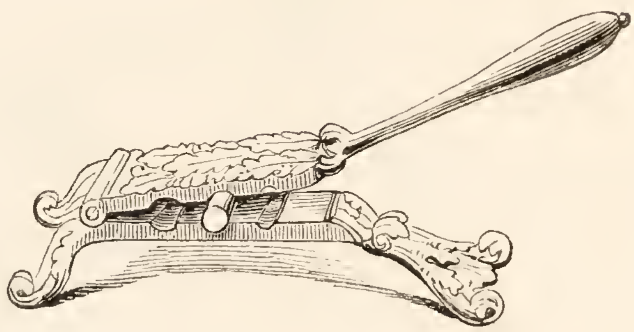
The string-box, fig. 20, and cork-squeezer, fig. 21, are frequently employed by English Pharmaceutists, instead of those delineated in figs. 16 and 17.

*Fig.* 20.



STRING-BOX.

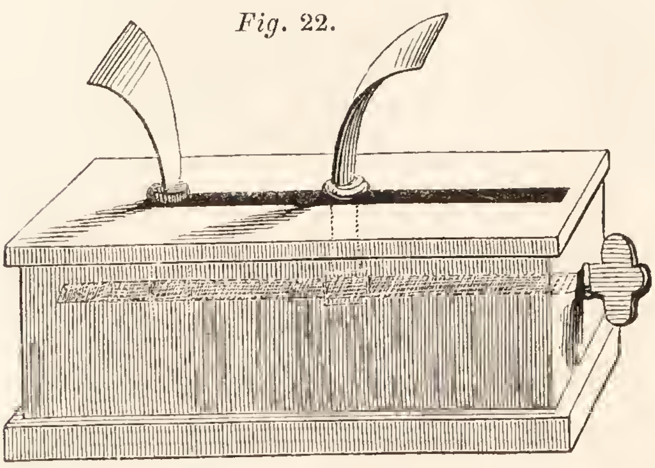
*Fig.* 21.



CORK-SQUEEZER.

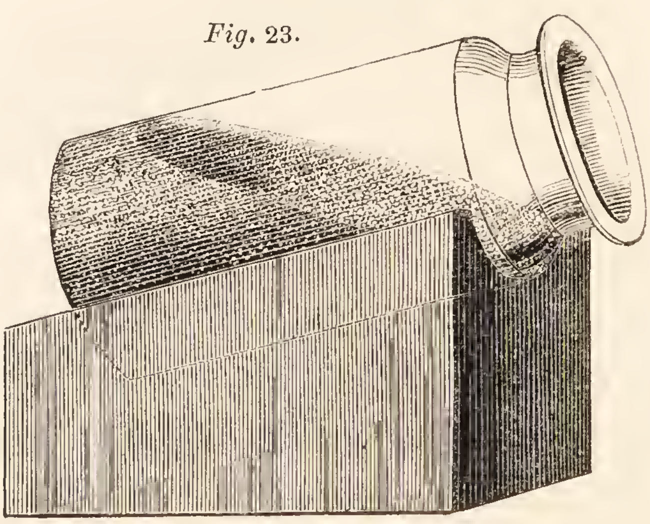
The powder-folder is a necessary appendage to the fittings of the dispensing counter. There are several forms of this implement, of which fig. 22 is one of the most approved.

*Fig.* 22.



POWDER-FOLDER.

*Fig.* 23.



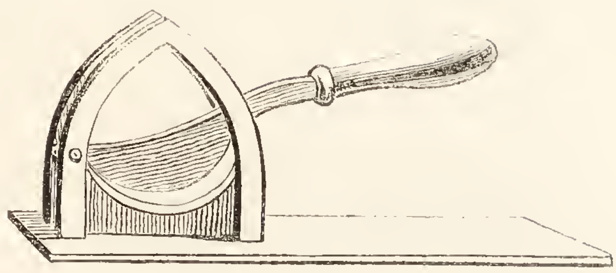
BOTTLE-STOOP.

The bottle-stoop, fig. 23, is used for giving the proper inclination to a bottle containing any powder, so as to admit of some of the contents being taken out on the point of a knife, for use in dispensing. It consists of a block of wood, of the form shewn in the drawing, with a groove in the upper surface, for the reception of a bottle in an oblique position.

The sink with supply of water, for washing measures, &c., should be conveniently situated for the use of those engaged at the dispensing counter.

The root-cutting knife, fig. 24, will be found useful, especially at the retail counter.

*Fig.* 24.

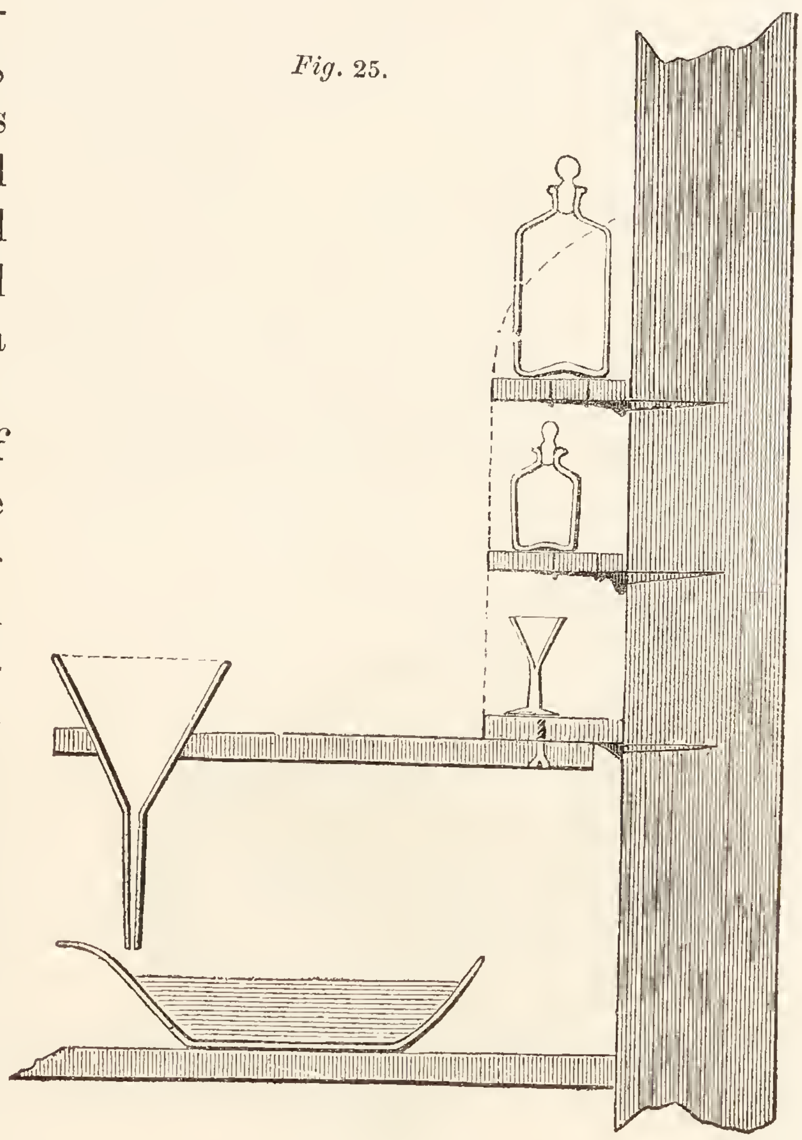


Root-cutting Knife.

A good clock must be mentioned, among the fittings, indispensable to the shop. If possible, it should be so fixed, that it can be seen by those engaged in the business, as well as by the customers.

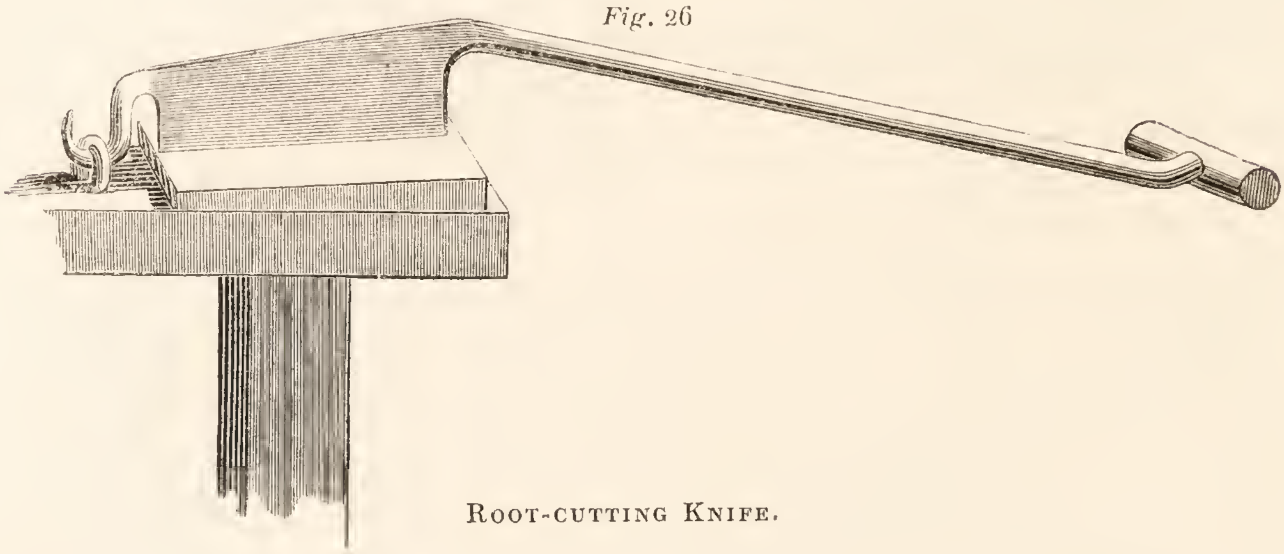
The Laboratory.—In most cases, the situation of the laboratory will not be altogether a matter of choice, as there is, generally, only one part of the premises that can with any propriety be appropriated to this purpose. It ought always to be on the ground floor, as the weight of the requisite furnaces, presses, and other apparatus, and the large quantities of water used in many of the processes, and for washing and cleaning, would soon destroy the rafters and ceiling below them, to any room above this floor. It should be well lighted, ventilated, and drained, and, above all things, it should have a plentiful supply of water.

*Fig.* 25.



The essential fittings of the laboratory are,—the furnaces, stills, steam apparatus, refrigerators, and presses, which will be hereafter described; a capacious sink, with water laid on, and perforated shelves fixed over it, for draining bottles; a fixed side table, for performing the smaller operations upon, and, above this, a set of tests, test glasses, funnels, glass measures, and a perforated shelf, for supporting funnels, as shewn in the drawing (fig. 25); a strong moveable table, which may be placed in any part of the laboratory; a druggist's root-cutting or slicing knife (fig. 26); a large marble mortar, and an iron or bell-metal mortar. There should also be a desk, on which to keep the journal of the operations of the laboratory, and, above it, a glass-case, containing the Pharmacopœias and a few other books. These,

*Fig.* 26



Root-cutting Knife.

together with some moveable apparatus, which will vary according to circumstances, will form the principal features in the laboratory. In some cases, however, the drying closet may be fixed here.]

Store-room.—In the store-room, the stock of the greater part of the drugs is kept, to be supplied from time to time, as wanted, to the shop and laboratory. It should be a dry and easily accessible room. The stock of roots, woods, barks, seeds, fruits, resins, gums, extracts, powders, salts, and mineral productions, are, with few exceptions, to be kept here. Many of these substances may be conveniently preserved in wooden boxes, such as that represented in fig. 27; or in tin boxes, such as fig. 28; which may be placed on

*Fig.* 27.

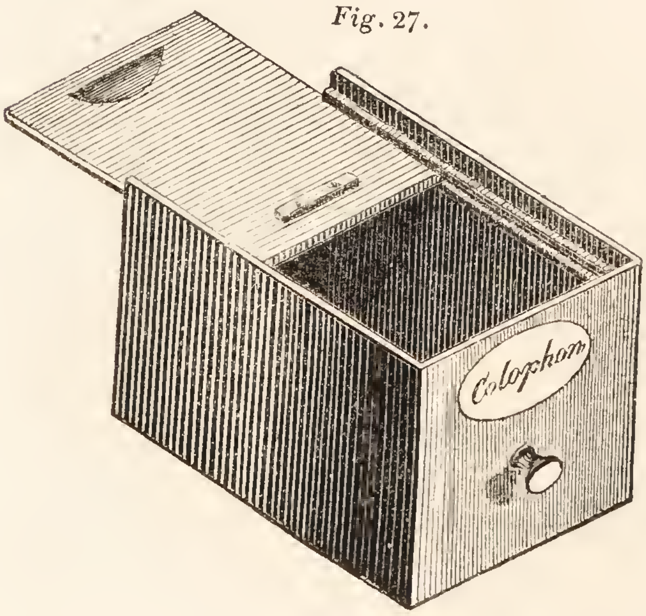
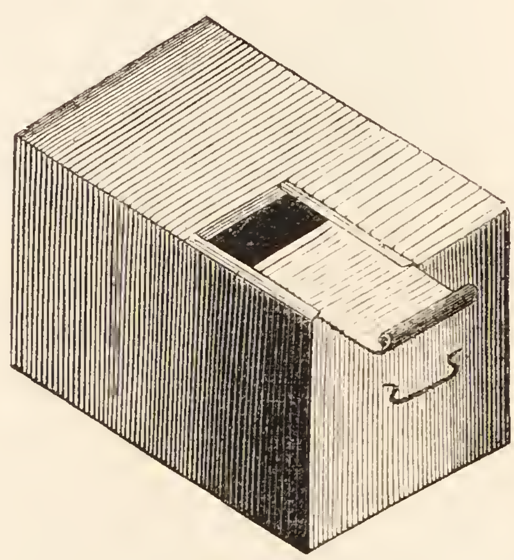



*Fig.* 28.



shelves round the room. [The fittings and arrangement of the store-room must, however, depend very much upon the character of the business to which it is attached.]

With the view of facilitating the finding of the different articles kept in the store-room, there ought to be a catalogue in which they are all entered, with references to letters and numbers, indicating in what part of the room they may be found. This catalogue should be hung against the wall, near to the door, so that reference might be made to it on entering.

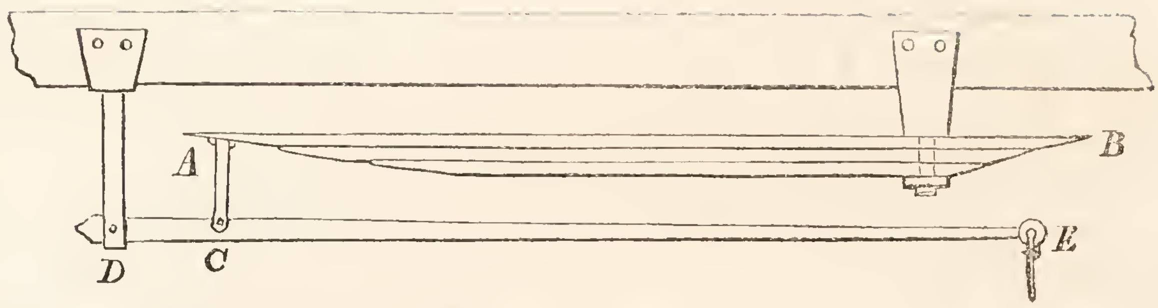
Store-cellar.—It is desirable to have a good underground room or cellar for keeping the store of those substances which are injured by variations of temperature, or are best preserved in a cold place. The syrups, ethers, distilled waters, and some of the acids, belong to this class of substances. The oils and fats, including ointments; in fact, most liquids, especially volatile liquids, and some solids, such as efflorescent salts, may with propriety be kept here.

[The same conditions which render a cellar suitable for the preservation of wines, will constitute the essential requisites in a good store-cellar. It should be as dry as possible, free from vibrations to which other parts of the house are often subject, and as airy as is compatible with the maintenance of a uniform temperature. There should also be a catalogue of the articles kept here.

Drying-room or Loft.—In Germany every druggist dries the indigenous herbs, flowers, roots, &c., which he keeps in stock. In this country this practice is not general, at least in large towns, where there are herbalists from whom, or from the wholesale druggists, such substances are usually obtained ready for use. It is, however, desirable in all cases to have a good *drying-room*, in which the Pharmaceutist may conduct any processes of spontaneous desiccation. A loft at the top of the house (the space immediately under the roof) is generally appropriated for this purpose: it has the advantage of being exposed to the influence of the sun and wind, while at the same time dust and vapours, which gain access to other parts of the house, may be excluded. Sufficient air will frequently be admitted between the slates of the roof, or, should this not be the case, provision must be made by a kind of louver boarding that will admit air but not wet. If it should be found inconvenient to use the loft in this way, a room in another part of the house may be selected to answer the same purpose; in which case it will be desirable that it should have two windows having different aspects, so that there may be a current of air through the room.

Powdering-room.—In this apartment the processes for the reduction of drugs to powder are conducted. It should be on the ground-floor, so that the mortars may have a solid foundation; and, above all, it should be a perfectly dry room, to which steam and damp has no access. It is desirable that the drying-closet should be

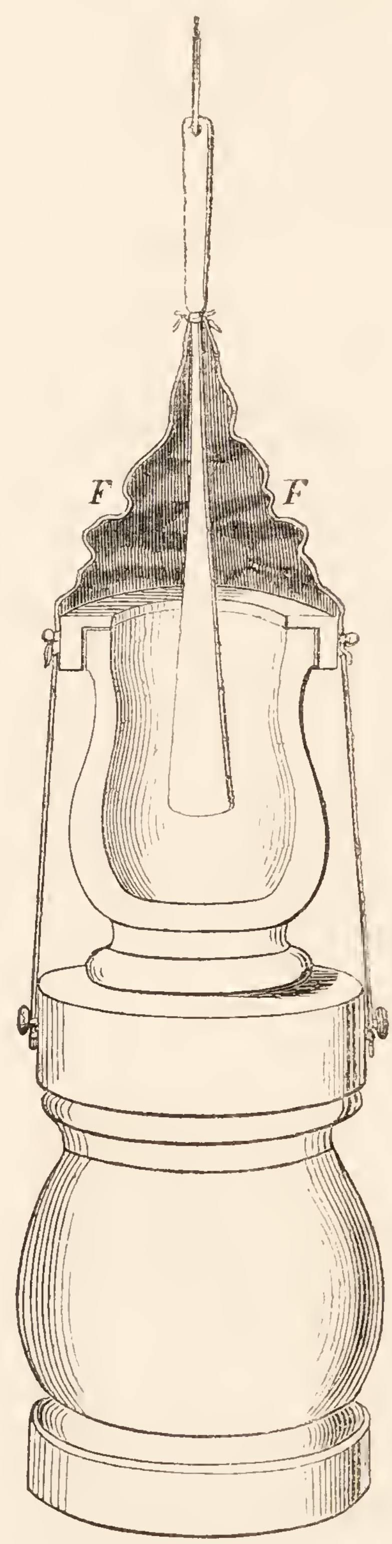
*Fig. 29.*




contiguous to, or at least easy of access from, this room, as it is often necessary in powdering drugs that they, as well as the sieves, should be put into the closet several times during the process.

The only fittings required in the powdering-room are, the mortars with spring-pestles; the sieves, which should be kept in drawers or boxes; and a strong table on which to use the sieves. There may also be added to the fittings of this room, if the space will admit, a porphyry slab and muller, and the root-cutting knife (fig. 26), which would otherwise be in the laboratory.

It will be well to have one mortar of iron and one of bell-metal, as there are some cases in which the former and others in which the latter metal, will least contaminate the substances to be pounded in them. The pestles should be attached to springs, so as to lessen the labour of pounding. The kind of spring represented in fig. 29 will be found to answer very well, and to possess some advantages over the long wooden spring frequently used.




Mortar and Spring-pestle.

It consists of a carriage-spring, A, B, one end of which is fixed to a beam in the ceiling, while the other end is connected by a rod A, C, with the bar D, E, from which the pestle is suspended, as shewn in the drawing. F, F, is a leather cover, by which the contents of the mortar are confined during the process of powdering.]

## Special Arrangements, Apparatus, and Operations.

*Drying-closet.*—A good, efficient drying-closet is an important desideratum to the Pharmaceutical Chemist. Not only is it required for drying herbs, flowers, &c., so as to fit them for preservation, but in many operations of the shop and laboratory, and in all those of the powdering-room, its services are called into requisition.

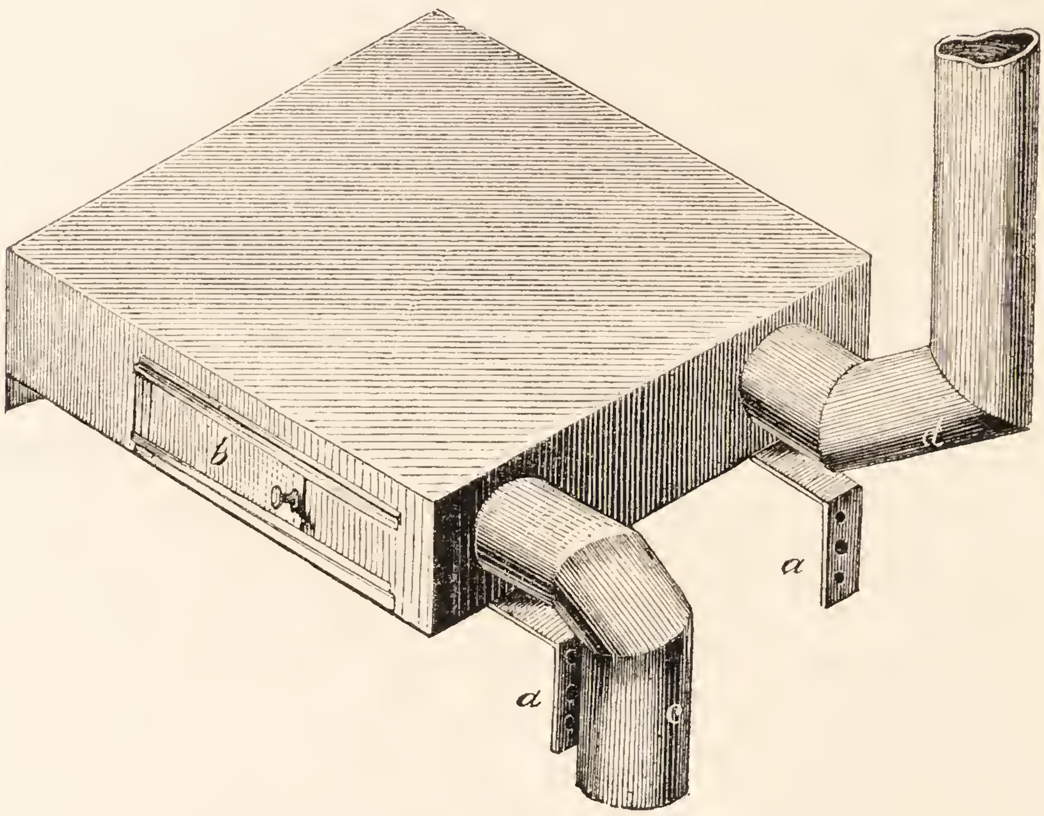
In constructing a drying-closet, the method of heating it should be a primary consideration. It ought always to be ready for use, however trifling the purpose may be for which it is required. It is therefore desirable that it should not be heated by a fire appropriated expressly to that purpose, but should borrow heat from some source where a continual supply is necessarily maintained. The expense of an exclusive fire would frequently cause the closet to be left inoperative ; or even if put into operation, the fire may be neglected from forgetfulness, and the closet thus rendered inefficient.

From these considerations, and principally from those of economy, it has long been attempted to attach the drying-closet to a fire-place in constant use, the spare heat of which may be thus appropriated. It is sometimes attached to the *Beindorf apparatus*, but this is not always found to be a convenient arrangement, at least in the way in which it is usually effected, which consists in carrying the flue of the furnace underneath the floor and then through the closet. The heat thus derived from this furnace is insufficient for the purpose required, and the method of applying it causes an obstruction to the draught of the furnace, especially on first lighting the fire.

I have found it a better plan to transfer the drying-closet to the kitchen, by which means the space it would otherwise occupy in the laboratory is saved, and the use of a constant and powerful fire is obtained, without additional expense or exclusive attention.

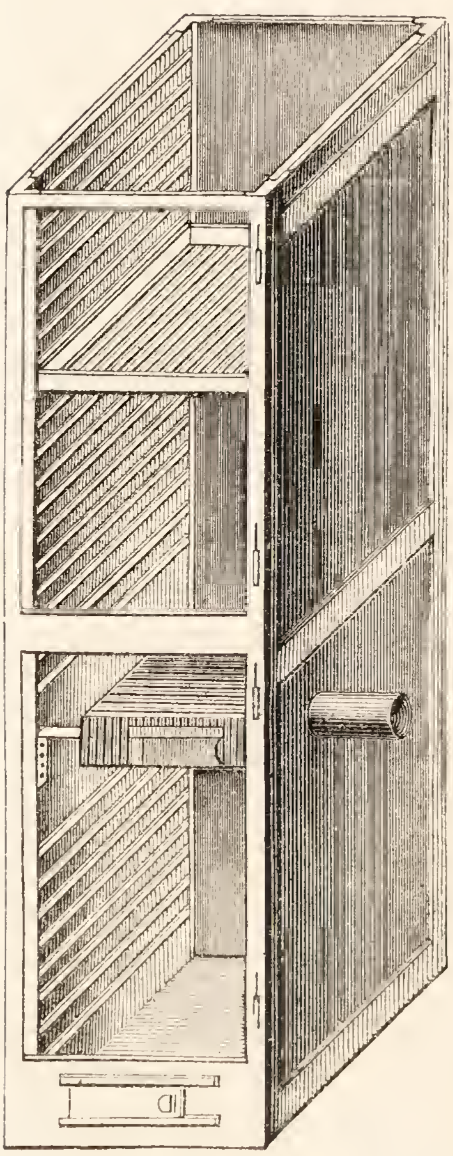
The closet is heated by means of a box made of tin-plate or sheet-iron (fig. 30), which is fixed within it, and communicates by the pipe *c*, with the flue that heats the boiler or oven of the range ; or in the absence of these, the pipe may be made to terminate at the side or back of the fireplace, so that part of the hot air of the fire may pass through it into the box, and subsequently through the pipe *d* into the chimney. The heating box is made with a flat surface, as represented in the drawing, so that any vessels may be placed upon it, and thus receive the strongest heat of the closet. The diameter of the box is about seven inches less than that of the closet, so that there is an intervening space of $3\frac{1}{2}$ inches on every side between the box and the side walls of the closet. The box rests on two iron bars, *a*, *a*, which are attached to the sides of the closet, the box itself being moveable, so that it may at any time be

*Fig.* 30.




taken out for the purpose of removing the soot that collects in it, through the door *b*. The closet may be made of wood, the crevices between the boards being closed by pasting paper over them. Laths are nailed against the sides of the closet, at a distance of four or five inches apart, as shewn in fig. 31, to receive the trays on which the substances to be dried are placed. The trays are made by first forming a square frame the size of the closet, and about two inches deep, and thin laths or bars are then nailed across the bottom at about half an inch distance from each other, leaving, however, an open space of about $2\frac{1}{2}$ inches at one end. A sheet of blotting-paper is put over these bars, and on this another sheet of paper containing the substance to be dried. The open space, over which the bars are not fixed, is left uncovered, so that the hot air in traversing the closet may pass up here; and in putting the trays into their places, they should be so placed that the openings shall be alternately on the right

*Fig.* 31.



DRYING-CLOSET.

and the left hand side, thus causing the current of air to pass in a serpentine direction over the surface of all the trays.

The following are the dimensions of a closet of the above description, which I have found, from use, to be generally convenient:—From side to side, and from front to back, it measures twenty-eight inches, while the height is $8\frac{1}{2}$ feet. It would, perhaps, be better to have it not quite so high as this, as the top trays are beyond the reach of the arm. The distance from the bottom of the closet to that of the heating-box is three feet. The heating-box is $5\frac{1}{2}$ inches high, and its lateral dimensions are $21\frac{1}{2}$ inches in each direction. The flue pipes are $4\frac{3}{4}$ inches in diameter. There are fifteen trays above the heating-box, and five below it. Fig. 31 represents this closet in perspective; it shews the heating-box, and one of the trays in the upper part of the closet. One of the flue-pipes is seen passing out at the side,—the other is not seen, as it enters on the opposite side of the closet. The doors and top are supposed to be removed, to shew the interior of the closet. No express provision is made for the entrance or exit of air, as the crevices between the door and frame, and in other parts, are generally found to be sufficient for this purpose; but a few holes may be made in the bottom and top, if thought desirable. In practice it is found better to keep the temperature of the closet pretty high by having few openings, than by rapid changes of the atmosphere to cause a reduction of the temperature.

## STEAM APPARATUS.

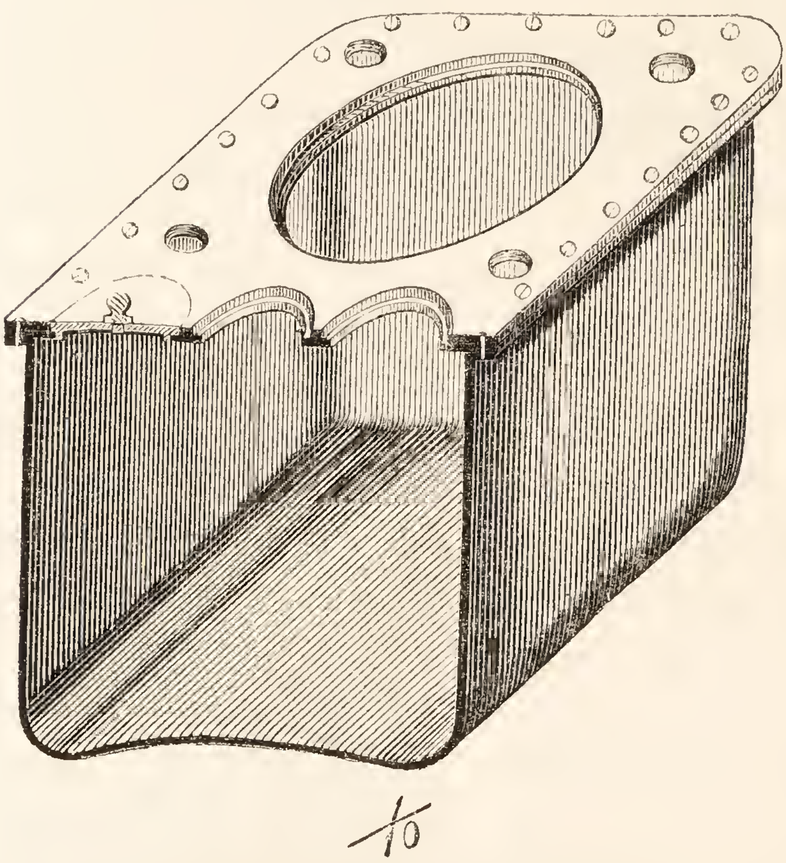
The introduction of steam as a means of communicating heat in pharmaceutical processes, has caused a complete revolution in the general arrangements of the laboratory. Where efficient steam apparatus is introduced, the necessity for other means of heating, by the use of furnaces, is almost entirely superseded. But the full extent of the convenience and advantage of the employment of steam can only be fully appreciated in those cases where the daily work of the laboratory is such as to keep the apparatus in constant use.

Several efforts have from time to time been made, especially on the continent, to contrive a steam apparatus that should be applicable to small pharmaceutical laboratories; but none has appeared to have given so much general satisfaction as that for which we are indebted to the late John Beindorf, of Frankfort. This apparatus is used throughout Germany and other parts of the continent, where it is distinguished by the name of *Beindorf's apparatus*, and in many cases *the apparatus*.

Beindorf himself, previous to his death, which occurred in 1833, had supplied the apparatus to a great many persons, and was in the habit of making them of two different sizes. The manufacture of them is still continued by his widow, who now conducts the business: but other manufacturers have adopted the form, or at least the principle, of the original apparatus, and they are now, therefore, made in many of the large towns.

The following description of the apparatus, including improvements or alterations introduced by myself, applies to that of the smaller size.

*Fig. 32.*



Boiler of Beindorf Apparatus.

The boiler, fig. 32, is 18 inches long, $13\frac{3}{4}$ inches wide, and 13 inches deep. It is made of copper, the edges to the ends and bottom being somewhat truncated, and the bottom itself slightly arched, as shewn in the drawing. The sides are perpendicular, and have a flat flanch or shoulder, to which the top is either soldered or screwed.

In the top there are four large circular openings,—one 11 inches in diameter, intended to receive the still and the evaporating vessels; two of $3\frac{1}{2}$ inches, and one of 3 inches diameter, for receiving vessels for maceration, &c.; there are also four small openings for attaching steam pipes. The top has been made, sometimes of copper with rings of tin surrounding the openings; sometimes of polished iron or steel, with brass mountings; but I prefer having the top cast entirely of brass.

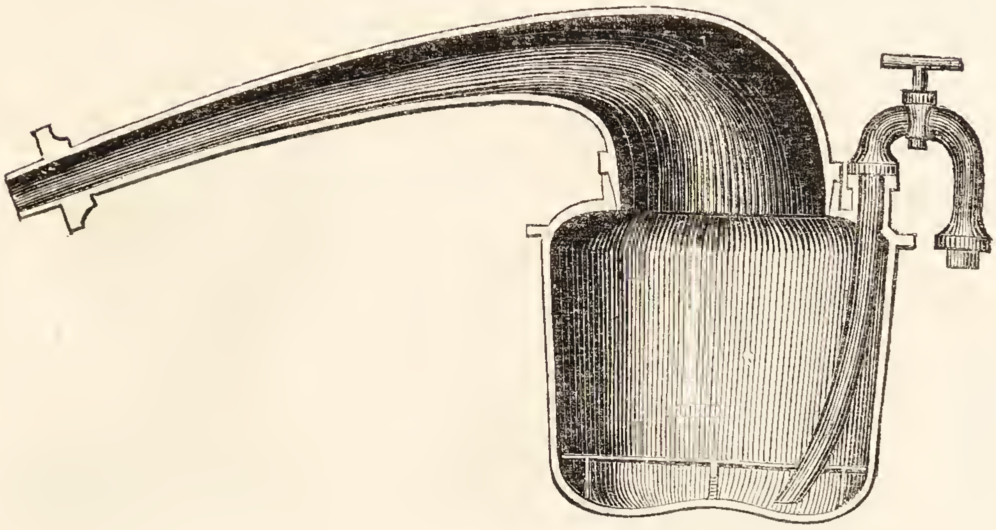
Fig. 32, represents a perspective view of the boiler cut transversely across three of the openings to shew the interior.

The following vessels and apparatus are used with the boiler in different operations:—

1. *The cucurbit and head* (fig. 33) for distillation. This fits into the large opening in the top of the boiler, and the steam-pipe, represented in the drawing, is fixed to one of the small openings of the boiler, and carries steam to the bottom of the cucurbit, to be dis-

charged underneath a perforated false-bottom, which is separately shewn in fig. 34.

*Fig.* 33.



CUCURBIT AND HEAD.

*Fig.* 34.

PERFORATED FALSE-BOTTOM.

2. *A tin dish or pan* for evaporating extracts or neutral solutions.

3. *A porcelain or Wedgewood-ware dish*, for solutions that would act on the tin, mounted with a ring of tin fitting into the opening in the boiler.

4. *A deep copper pan*, (fig. 35,) which dips into the boiler as far as the rim by which it is fitted to the opening. This is sometimes made larger and more shallow, with an external jacket, as represented in fig. 36: in this case the pan stands above the boiler,

*Fig.* 35.

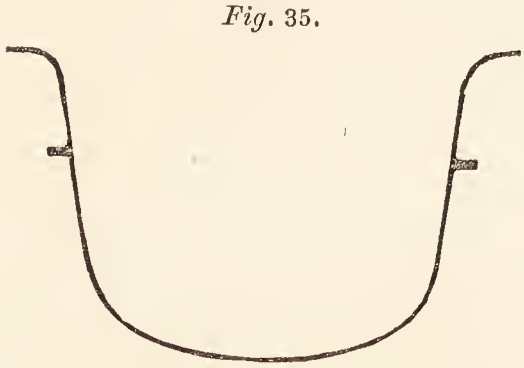
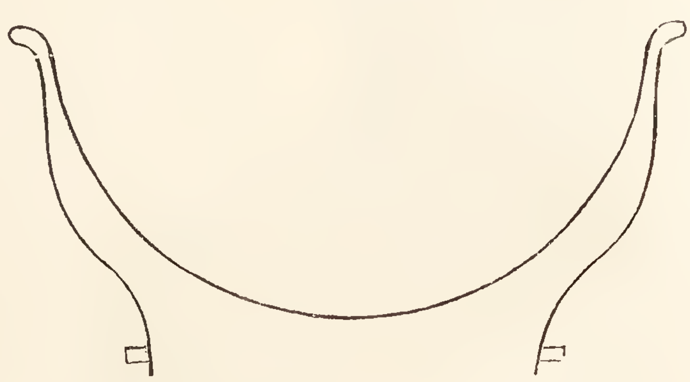


*Fig.* 36.



EVAPORATING PANS.

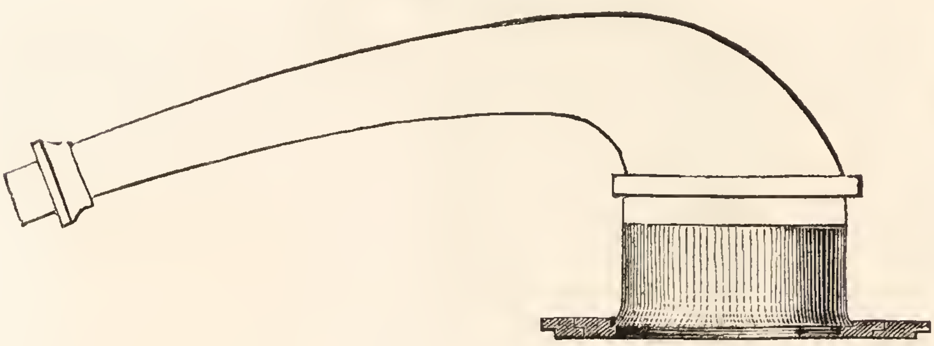
and the steam surrounds it in the space enclosed by the jacket. These are used for larger quantities of extract, for making lead plaster, &c.

5. *A set of brass rings* fitting one within the other, with a circular piece in the centre, the whole forming a lid or cover for the large opening of the boiler. These are intended for contracting the size of the opening, so as to suit any dish or vessel of smaller diameter. The two largest of these rings with the still-head fitted in the

centre, as used for distilling water without the cucurbit, are shewn in fig. 37.

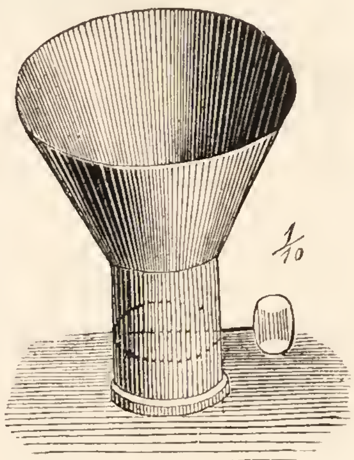
6. *A funnel-shaped apparatus* (fig. 38). It is full eight inches in diameter at the top or mouth of the funnel, and the lower end or

*Fig.* 37.



Still-head.

*Fig.* 38.

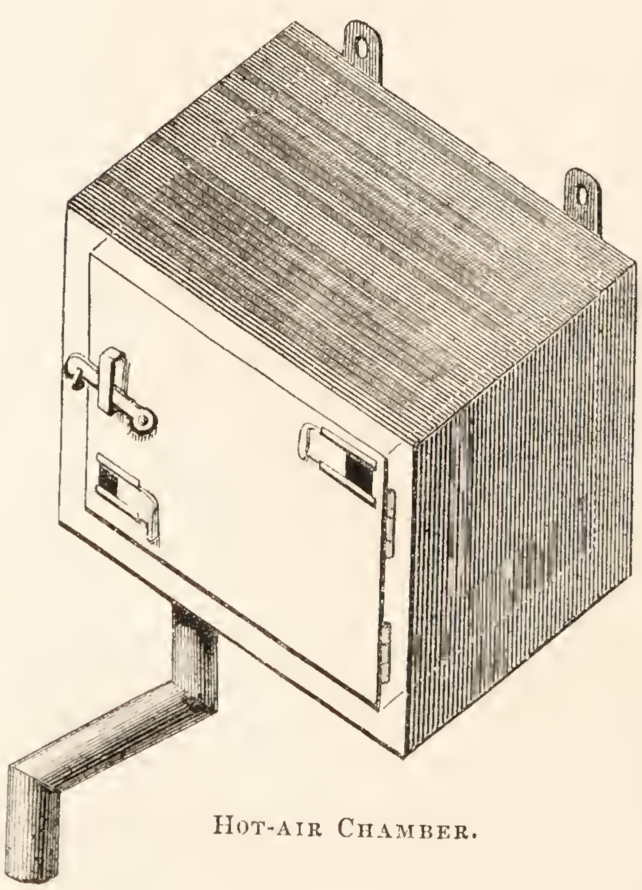


Steam-funnel.

neck is made to fit into one of the second-sized openings in the boiler. In the neck of this funnel-shaped appendage there is a valve formed of a disk of metal, across the diameter of which a wire is fixed, so that it may be turned to prevent or admit the admission of steam into the funnel. This appendage to the boiler is of great and frequent use; it affords a ready means of adapting retorts, dishes, and other vessels, of different sizes, so as to expose them to the heat of the steam.

7. *A small hot-air chamber*, made of zinc or other suitable metal (fig. 39). This is a double or jacketted box, with a door in one side, and a tube for conveying steam from the boiler to the space enclosed by the jacket. There are two openings at the opposite corners of the door, furnished with sliding shutters, by which air is allowed to pass through when required. This box or chamber may be attached to a wall contiguous to the apparatus.

*Fig.* 39.



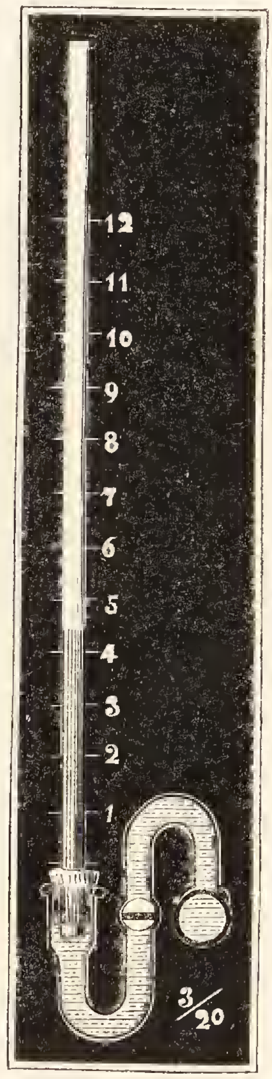
Hot-air Chamber.

If an elevated rim be fixed round the top of the box, this may be filled with sand, so as to form a small sand-bath for processes in which little heat is required.

The Beindorf apparatus is not calculated for sending a strong jet of steam through pipes, as the least opposing pressure would cause the escape of the steam through the imperfect joints by which the several appendages are fitted into the top of the boiler.

*An indicator* of the height of the water in the boiler is a very necessary part of the apparatus. That which I have found to answer the purpose best consists of a glass tube fixed to a bent brass pipe, which is attached to the cock, by which water is drawn from the boiler. This is shewn in the drawing (fig. 49,) and the tube itself is more minutely represented by fig. 40. A scale of inches is fixed to the glass tube, which thus indicates the depth of the water in the boiler. There is a stop-cock in the bent brass pipe, by which the communication between the boiler and the glass tube can at any time be shut off, in case of any accident to the latter.

*Fig. 40.*

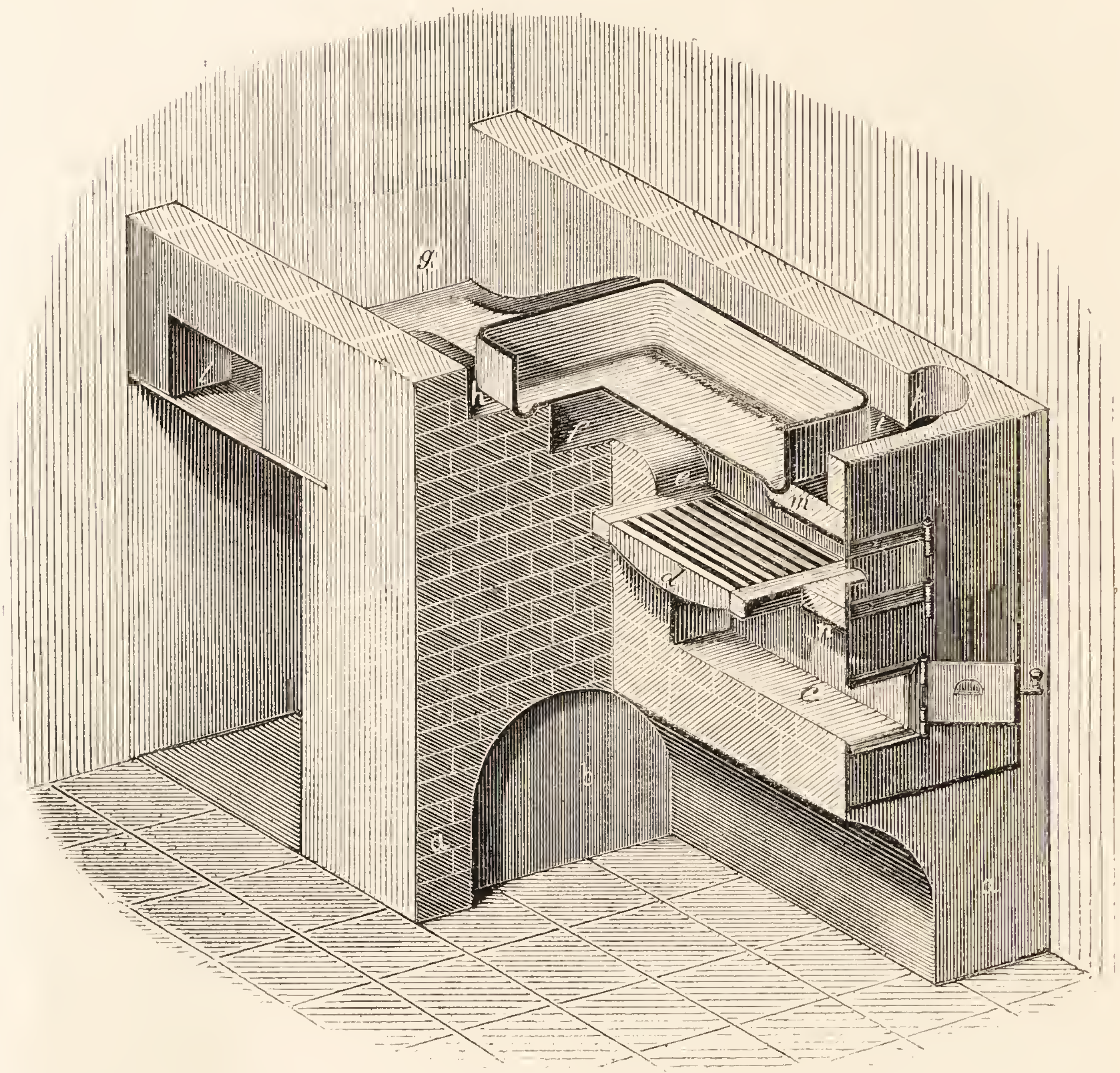



We have now to describe the construction of the stove or furnace by which the boiler is heated. The first question is, what will be the proper or most convenient height for the top of the boiler? It is necessary to have it so high that, in conducting the process of distillation, there shall be sufficient space, between the beak of the still-head and the ground, for the worm-tub or refrigerator and the receiver below it. A pit or hole in the ground is sometimes provided for the latter to stand in, but this is subject to several objections, and ought, therefore, to be avoided, if possible.

Allowing 27 inches for the height of the worm-tub, and 14 inches for that of the stand on which it is placed, it would be found that 43 inches would be sufficient height for the top of the boiler, and this would not be too high to admit of the various required operations being conveniently conducted on it.

If the apparatus be fixed at this height, there will be found to be sufficient space to have an arched receptacle for keeping the fuel in underneath the ash-pit. Fig. 41, represents the apparatus laid open so as to shew the manner in which it is arranged and put together. The walls *a a* are first erected and arched over with bricks or covered with an iron plate. The end *b* is closed with brickwork. The top of the arch is now made level, and bricked up to the proper height for the bottom of the ash-pit door, which, as well as the fire-place door, is fixed to a cast-iron plate forming the front of the stove. The ash-pit extends the whole depth of the grate *d*. Immedi-

*Fig.* 41.



BEINDORF APPARATUS.

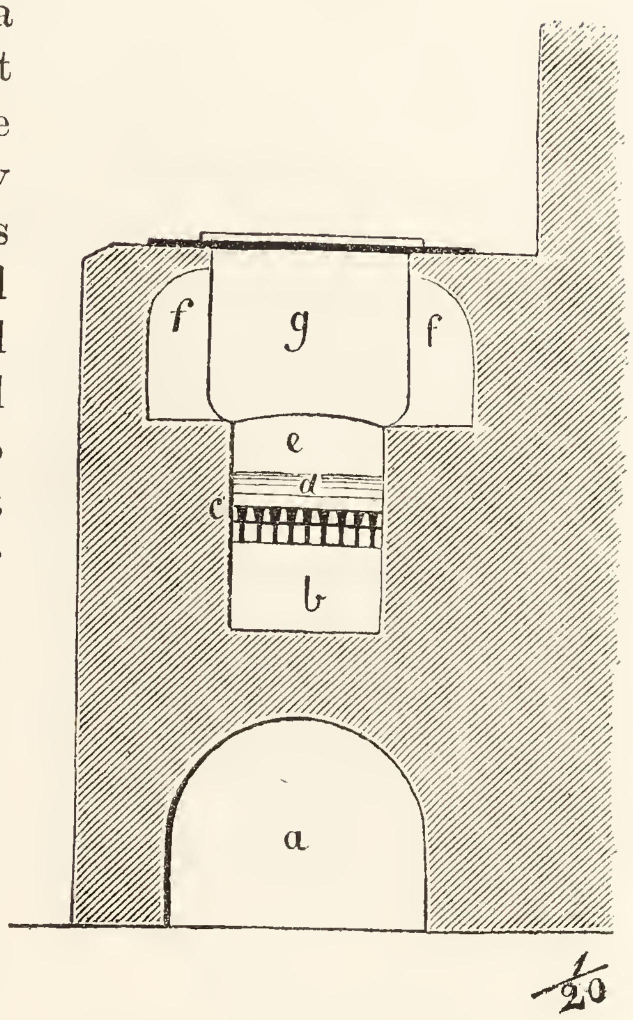
ately behind the grate rises the arched fire-bridge *e*, a portion of which is shewn in the drawing. Beyond this is the opening *f*, by which the fire passes off, which is commonly called the *fox*. The boiler rests with its edges all round on the brickwork, excepting at the *fox*. The fire passing through the fox-hole and underneath the sand-bath, returns by two channels *h* and *i* along the sides of the boiler to the chimney-flue *k*. At *l* there is an opening, stopped with a loose stone or brick, for cleaning out the space underneath the sand-bath.

It will be found advantageous to have the front, in which are, the furnace and ash-pit doors, entirely covered by a cast-iron plate. The doors should be 8 inches wide by $5\frac{1}{4}$ inches high. Twelve inches will be found to be a good length for the furnace bars.

Fig. 43 represents a transverse section of the apparatus.

*The Sand-bath*, consists of a strong piece of sheet iron, with a rim turned up on every side, about $1\frac{1}{2}$ inch deep. It will be of the full width of the furnace, and may be about fifteen or twenty inches in length. This is nearly filled with coarse, but properly sifted and clean, river sand. The sand should be passed through two sieves,—one for removing the dust and fine particles,—the other for separating small stones and coarse impurities. When properly purified by thus treating and washing it, the sand will not adhere to any vessels that may be placed in it. This sand-bath will be found to be very useful for a variety of purposes.

*Fig.* 43.



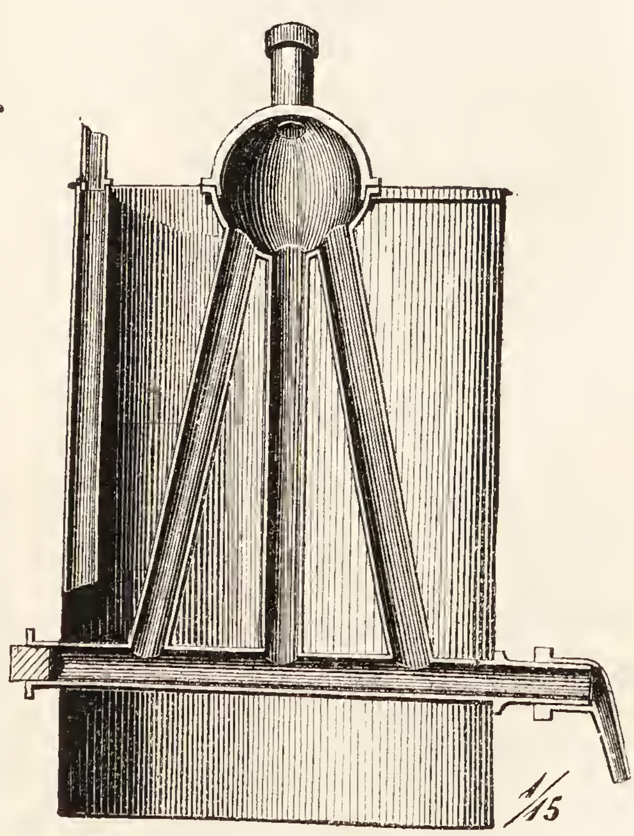

SECTION OF BEINDORF'S APPARATUS.

*a.* The receptacle for the fuel.
*b.* The ash-pit.
*c.* The grate.
*d.* The fire-bridge.
*e.* The fox-hole.
*f, f.* The two flues passing along the sides of the boiler.
*g.* The boiler.

*The cooling or condensing tub*, should stand close to the apparatus, the distance being suited to the length of the neck of the still-head. The tub should always be kept filled with water, and ready for use. I would recommend that the pipes of the condenser should be rubbed over on the outside with a mixture of tallow and black lead, to prevent the adhesion of carbonate of lime, which is often deposited in considerable quantity from the water contained in the tub.

*Beindorf's cooling or condensing tub*, is represented by fig. 44, where a vertical section of it is shewn. All parts of this condenser may be easily cleaned, which is not the case with the common worm-tub. Where there is only one condenser used, it is

*Fig.* 44.



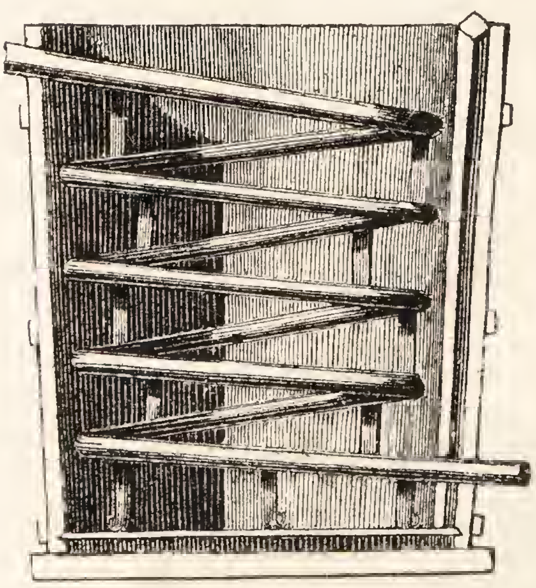

BEINDORF'S CONDENSING TUB.

quite indispensable that it should admit of being perfectly cleaned, otherwise the product of each process will be contaminated with some part of that which preceded it.

*The common worm-tub*, is shewn in fig. 45. The worm is made of tin pipe [and too much care cannot be taken to ensure the purity of the metal employed in this, in common with all other metallic condensers.] The principal objection to the common worm-tub arises from the difficulty there is in properly cleaning out the pipe. The means sometimes adopted for this purpose consists in letting a leaden ball, attached to a string, run through the worm, then fastening a sponge or bottle-brush to one end of the string and drawing it through, at the same time pouring some water in. [If there be many coils to the worm, however, this method will be found impracticable, and the only available means will be to close the lower end of the pipe, then fill it with a solution of caustic alkali, and allow this to remain in for some hours, then, having removed this and the condensing water from the tub, to pass a strong jet of steam through the worm for some time.]

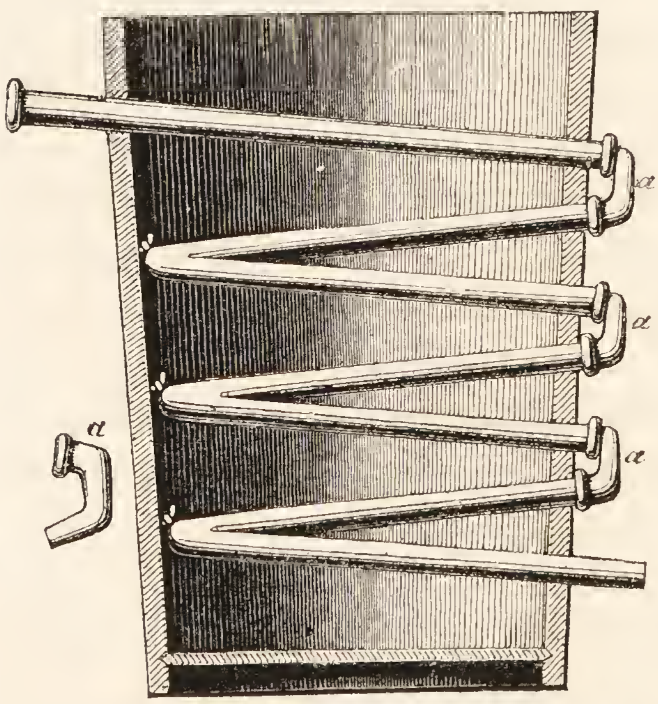
Another form of condenser has been proposed by Kolle. This is represented by fig. 46. The pipe is not bent circularly as that of the common worm is, but in the form of a zig-zag, running to

*Fig. 45.*



COMMON WORM-TUB.

*Fig. 46.*

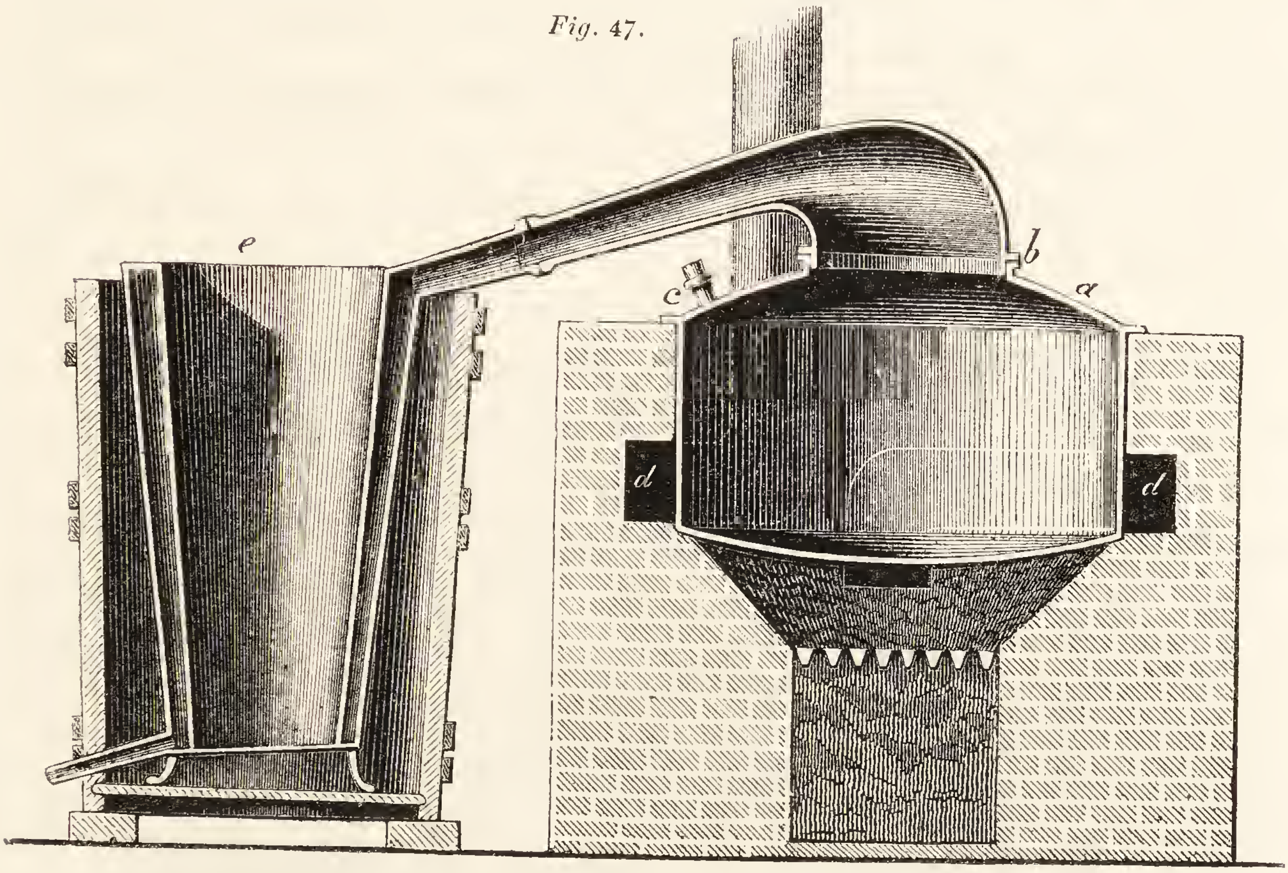



KOLLE'S CONDENSER.

and fro in a vertical plane. On removing the pieces of bent tube *a* the whole of the interior of the pipe may be cleaned by means of a stick or long brush. There is, however, a difficulty in keeping so many joints water-tight, especially when the tub is made of wood, for the joints can only in such case be stopped with cement. If the tub be made of zinc or copper, the projecting ends of the tube may be soldered to it, and the liability to leakage entirely removed.

*Gadda's Condensing Apparatus*, is represented in fig. 47. It consists of two conical vessels of metal, of unequal size, the

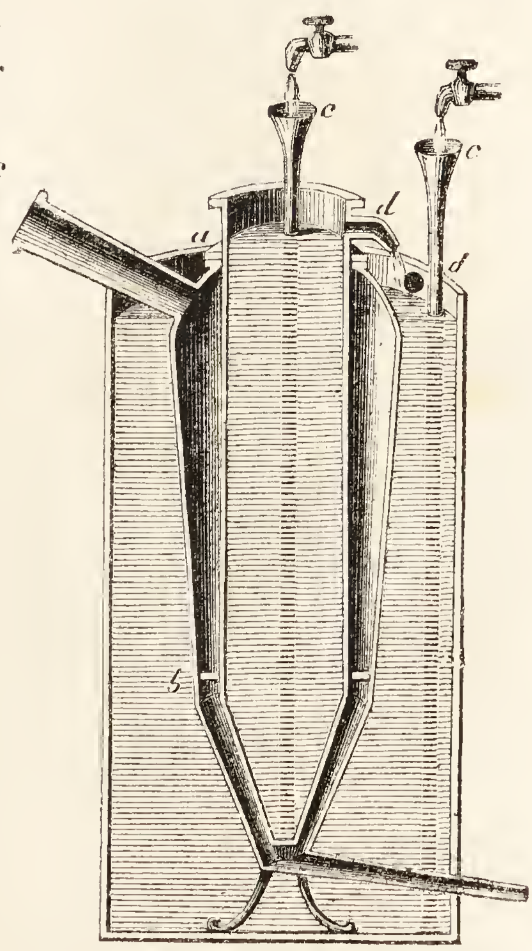
*Fig.* 47.




GADDA'S CONDENSER AND STILL.

smaller being fixed within the other, and the space between them closed at the top and bottom. These are placed in a tub filled with cold water which comes in contact with the inner and outer surface of the cones, while the space between is occupied by the vapour to be condensed. The drawing also represents a common still set in brickwork, shewing the construction of the fireplace and flues. Gadda's condenser is subject to the objection which applies to the common worm, that it cannot be easily and efficiently cleaned out. To obviate this objection, Mitscherlich has given to it another form which is represented in fig. 48. In this the inner part of the cone is made cylindrical, and may be taken out, so as to admit of the interior of the apparatus being cleaned. The inner and outer pieces of the cone are united at the top by a joint *a*. There is also a perforated ring *b* near the bottom which keeps the inner cylinder in its proper

*Fig.* 48.

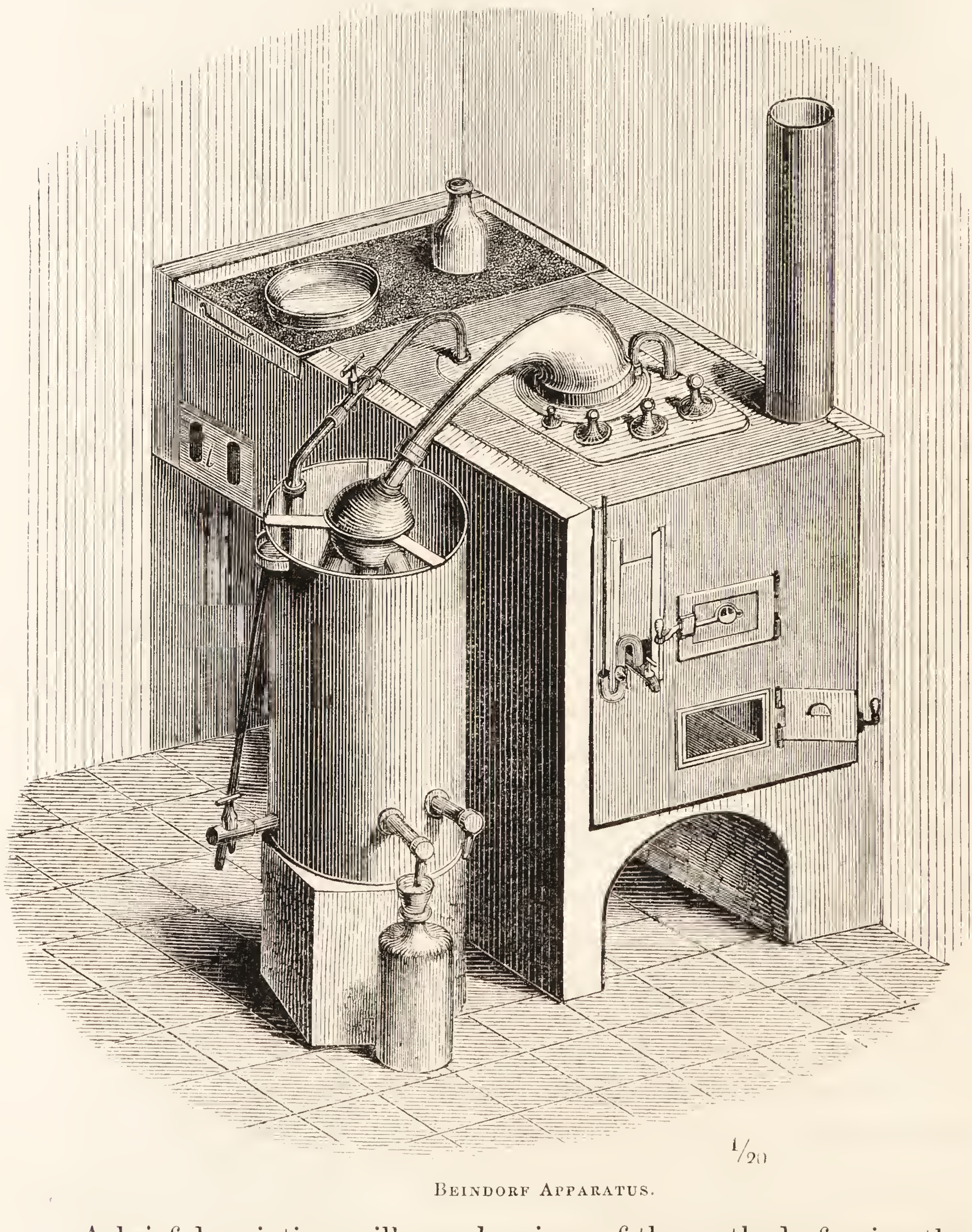



MITSCHERLICH'S CONDENSER.

place. Cold water is supplied by two jets *c*, *c*, and the heated water is carried off by the pipes *d*, *d*. In using this apparatus it is necessary to have a constant supply of cold water, which can be drawn from a reservoir situated above the condenser, unless the tub containing the condenser be itself large enough to hold the required quantity of water.

Fig. 49 represents the Beindorf apparatus and condenser in operation.

*Fig.* 49.



BEINDORF APPARATUS.

A brief description will now be given of the method of using the apparatus for the several purposes to which it is applicable.

Distillation. In the pharmaceutical laboratory, distillation generally has reference to the preparation of distilled waters. For this purpose the boiler is charged with rather more water than usual, so that two or three gallons may be distilled without recharging it. The cucurbit (fig. 33,) is then fitted into its place in the top of the boiler, and the steam pipe being fixed as represented, and the herbs, flowers, &c., to be operated upon, put over the perforated false bottom of the cucurbit, the distillation is conducted by causing a jet of steam to pass through and become charged with the volatile constituents of the solid ingredients. If essential oils be substituted for the vegetable substances which yield them, the former may be dropped on to bibulous paper, and this placed on the false bottom of the cucurbit. This mode of operating is certainly subject to one objection, that the attachments of the several parts of the apparatus being loose, any obstruction to the free passage of the steam causes it to escape at the joints; and such an obstruction is sometimes occasioned by the condensation of steam in the cucurbit and the accumulation of water there so as to cover the end of the steam pipe.

To obviate this difficulty, without the necessity of having recourse to a common still, I have had the still-head made to fit on to the opening in the boiler, by means of moveable rings as shewn in fig. 37. The boiler itself is thus converted into a still, and the substances to be operated upon are put in with the water and distilled in the usual way. There are some cases in which this, which is the old method of distilling, answers better than that which consists in passing steam through the materials to be operated upon, contained in a separate vessel. Thus, for instance, in rectifying oil of turpentine, it is found that the oil passes over more rapidly when it is put into the still with the water, than is the case when steam is passed through the turpentine contained in a separate vessel. In the former instance, *small* bubbles of steam being generated in every part of the boiling water pass through and become charged with the turpentine which floats on the surface; while in the latter, *large* bubbles of steam being discharged from the steam pipe in one place, the diffusion of the vapour of turpentine into this is less complete. By the former process, the products of the distillation will consist of about equal volumes of oil and water, while by the latter process there would be a much larger proportion of water. A similar result also occurs in distilling the oil from Copaiba. Again, in the distillation of bitter almond water, it is necessary to introduce the almond cake into the still with the water, as these must be allowed to digest together at a gentle heat for several hours before commencing the distillation.

This method of converting the boiler into a still is certainly subject to the inconvenience of its becoming contaminated with some of the substances operated upon, which may communicate a disagreeable taste or smell to the water afterwards, and it is, therefore, necessary to adopt some efficient means of cleansing the boiler after such operations.

Alcohol, and spirits generally, may be distilled by putting them into the alembic immersed in the water of the boiler, the heat communicated in this way being sufficient for the purpose. In distilling small quantities of spirituous or ethereal liquids, a retort put into the funnel-shaped apparatus fig. 38, as shewn in fig. 50, may be used.

*Fig.* 50.

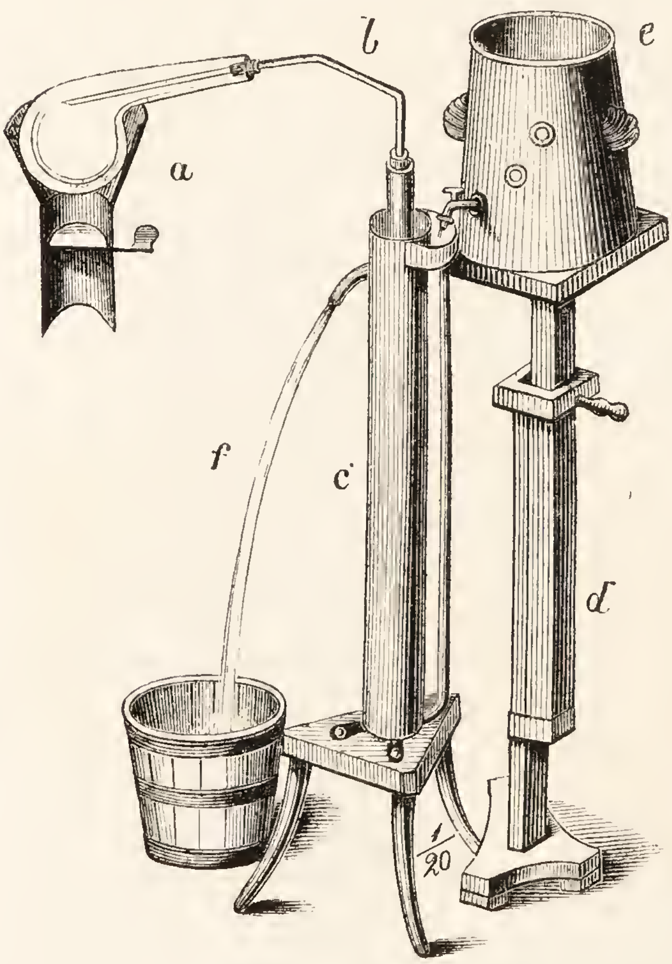
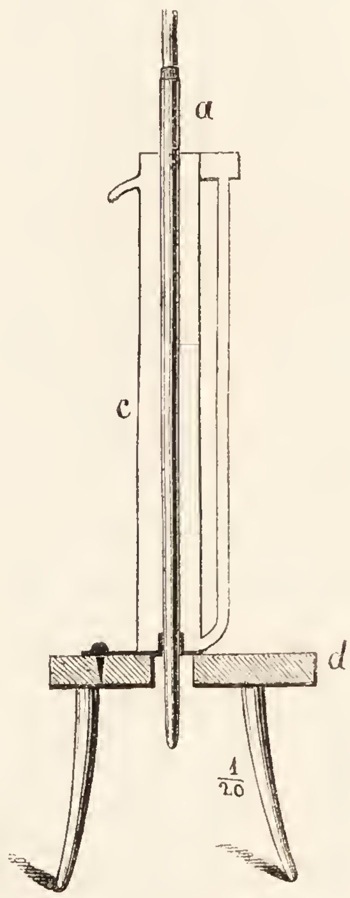



*Fig.* 51.




Distillation of Spirits.

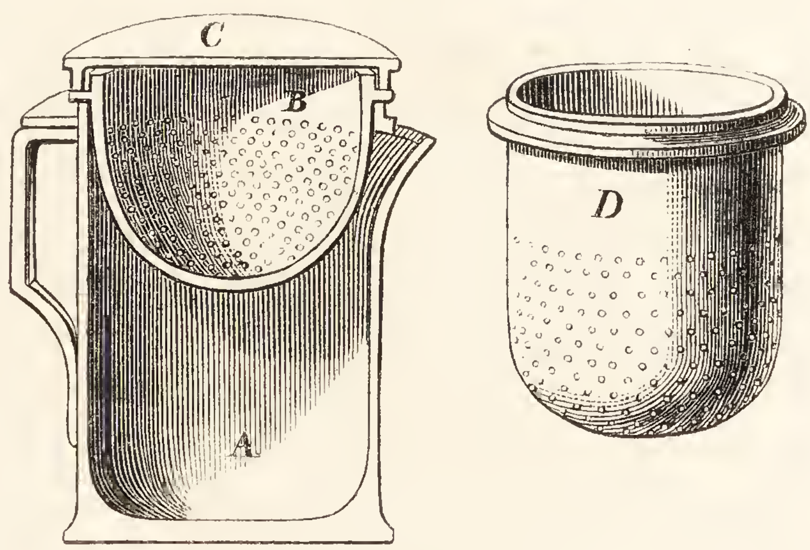
Fig. 51 represents the condenser which I am accustomed to employ for these volatile liquids. It consists of a glass tube *a*, one inch in diameter and thirty-eight inches in length, which is fitted by means of two perforated corks into the brass cylinder *c*, of four inches diameter, and about thirty inches in length. There is a small tube as shewn in the drawing, for conveying a stream of cold water to the bottom, and another near the top for carrying off the heated water. This apparatus is fixed vertically to a stool *d*, under which the receiver is placed.

In fig. 50 this apparatus is represented in operation. *a* the retort placed in the funnel, with the bent tube *b* connecting it with the condenser *c*, in the manner recommended by Liebig. The object of this arrangement is to prevent condensation within the conducting tube, which passes some distance into the retort, and to cause none but the most volatile vapours to pass the highest angle of the tube. *e* is the tub for holding the supply of cold water which runs in a continuous stream through the condenser.

Digestion and Infusion.—In making some infusions, such as *Infusum Lini compositum*, and generally in the process of digestion in the sense in which that term is usually employed, the continued application of heat is required; and this is conveniently effected by the Beindorf apparatus, the intermediate sized openings in the boiler being intended to receive vessels for this purpose.

[As the apparatus is designed to be in daily operation, it will always have a supply of boiling water for making the infusions which are required to be prepared every day, so as to be in readiness for use in dispensing. The infusion pots ought therefore to be placed near to the apparatus, and also to the sink where they are cleaned on every occasion before being used.

*Fig.* 52.




Infusion Pot.

Fig. 52 represents a very good form of *infusion pot*, which has been introduced by Mr. Squire, of Oxford Street. It is constructed on the principle originally suggested by Mr. Alsop, which consists in retaining the solid substances to be infused in the upper part of the vessel, instead of allowing them to subside to the bottom. Mr. Alsop observed that when infusions were made in the latter, which is the usual way, the water in contact with the solid ingredients became saturated or highly charged with soluble matter, and thus formed a dense stratum at the bottom, which had little tendency to diffuse itself into the less saturated liquor above, and thus prevented complete extraction by cutting off the contact of the upper stratum of liquid with the substance to be acted upon.

Mr. Alsop proposed having a perforated diaphragm, about halfway between the top and bottom of the pot, on which to place the solid ingredients. For this Mr. Squire has substituted the perforated dish B, or D, fig. 52, which answers the twofold purpose of supporting the solid substances in the upper part of the liquid, and of straining the infusion when it has stood long enough, by merely lifting this out. The angles within and without the pot are rounded off wherever this is practicable, so that the vessel may be the more easily kept clean.]

Solution, Liquefaction, Saponification, &c.—The solution of salts, of gum, of extracts, the liquefaction of fats, ointments, and plasters, and other processes of this description, are performed in round-bottomed vessels of tin, copper, or Wedgewood-ware, placed over one of the openings in the boiler. Lead plaster may also be made in the large pan by the heat of the boiler, and by conducting the process in this way, the liability of spoiling the product by the application of too strong a heat, which is always incurred when the ingredients are heated over the naked fire, is entirely avoided. But the time required for effecting the complete saponification of the oil by the water-bath heat, is much more than it would be if a stronger heat were applied, two or three days being occupied in the former case to complete what might be made in little more than as many hours in the latter.

Vaporization. This process is of very frequent occurrence in the pharmaceutical laboratory. Extracts, solutions of salts, purified honey, and a variety of other substances, require in the course of their preparation, to be deprived of a part of their water. There are two ways in which this is effected; first, by generating steam at the bottom of the vessel, and throughout the liquid, which is called *ebullition* or *boiling*, and secondly, by generating steam only from the surface of the liquid, which is sometimes distinguished as *evaporation* or *surface evaporation*. By the former process the concentration is effected most rapidly, but it is subject to some objections. In the first place there is a greater dissipation and loss of any aromatic or volatile constituents that the liquid may originally have contained, than would occur from surface evaporation. There is also a danger of decomposing or burning any organic matter that may be present, and the liability to this increases as the inspissation proceeds. Extracts made in this way, if incautiously inspissated, frequently become to a great extent insoluble in water; whereas, had they been otherwise prepared, they would have been entirely, or almost entirely, soluble.

As the Beindorf apparatus will not admit of the steam being exposed to more than a very slight pressure, it will never attain a temperature sufficient to cause the ebullition of an aqueous liquor contained in one of the evaporating pans; for even should the steam in the boiler be a few degrees above the boiling point, the obstruction to the free transmission of the heat in its passage through the metal pan, and still more if the pan be of earthenware, will cause the contents of the pan to be four or five degrees lower.

*Surface evaporation*, however, as it takes place at a temperature below the boiling point of the liquid, may be effected with this apparatus in either of the pans, figs. 35 and 36. This kind of evaporation depends upon the diffusion of the vapour into the superincumbent air, and therefore the rapidity of the evaporation is greatly increased by maintaining a constant change of atmosphere, that which is charged with vapour being replaced by dry air into which diffusion can take place freely. Indeed, if the liquid were contained in a close or covered vessel, such as a still, evaporation from the surface would not proceed at all after the air in the still had become charged with vapour, unless some mechanical means were adopted by which a change or current of air may be effected through the vessel. It is also desirable, with the view of promoting this kind of evaporation, that as large a surface as possible of the liquid should be exposed to the air, and that this should be constantly changed so as rapidly to substitute the warmer particles from below for those which have been cooled by the influence of evaporation.

In the inspissation of extracts and other similar preparations, and especially where this is effected by surface evaporation, it is necessary to keep the substance constantly agitated by stirring it. The process of stirring not only causes a new surface, and a more extended surface to be exposed to the air, but at the same time it occasions a change of the atmosphere in contact with the liquid.

But how is this very essential, yet tedious and insignificant process of stirring, to be effected? If, as is usually the case, it be done by manual labour, the whole time of an assistant will be occupied in doing that which one of his fingers could accomplish; while at the same time from the very tediousness and insignificance of the work, it is often neglected.

The Stirrer.—Having experienced these inconveniences, I have provided a remedy for them, by constructing a mechanical stirrer. This is a machine which, when wound up, will keep the contents of a pan continually, and regularly stirred for about three hours, without any personal attention. Fig. 55, represents this apparatus. It consists of three spindles or pivots set in an iron frame. The first, or principal pivot, *a* fig. 55, carries a wooden barrel two inches and a quarter in diameter, and four inches and a half long. At the front or outer end, there is a projecting rim to prevent the cord from slipping off, and to occasion the return of the coil. This pivot passes through the frame, and carries at the end a double winch *k, k*, the handles of which are of unequal distance from the spindle, so as to admit of the coil being wound up by a quicker or slower motion. The double winch also serves to balance one handle against the other, and prevent any irregularity in the motion of the machine when in action. At the opposite end of the spindle there is a toothed wheel *b*, and immediately beyond it another *c*. The wheel *b* is provided with a click, as shewn in fig. 53, so that if it be turned in the direction indicated by the arrow, as is the case in winding up the machine, the

*Fig* 53.


*Fig.* 54.

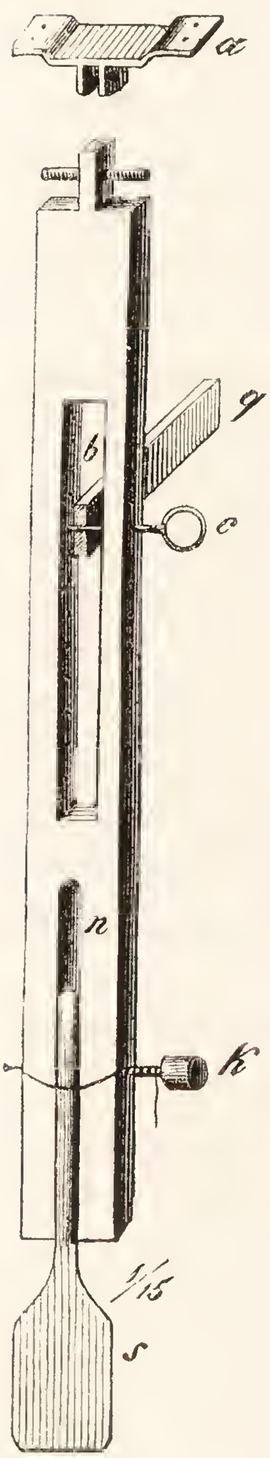
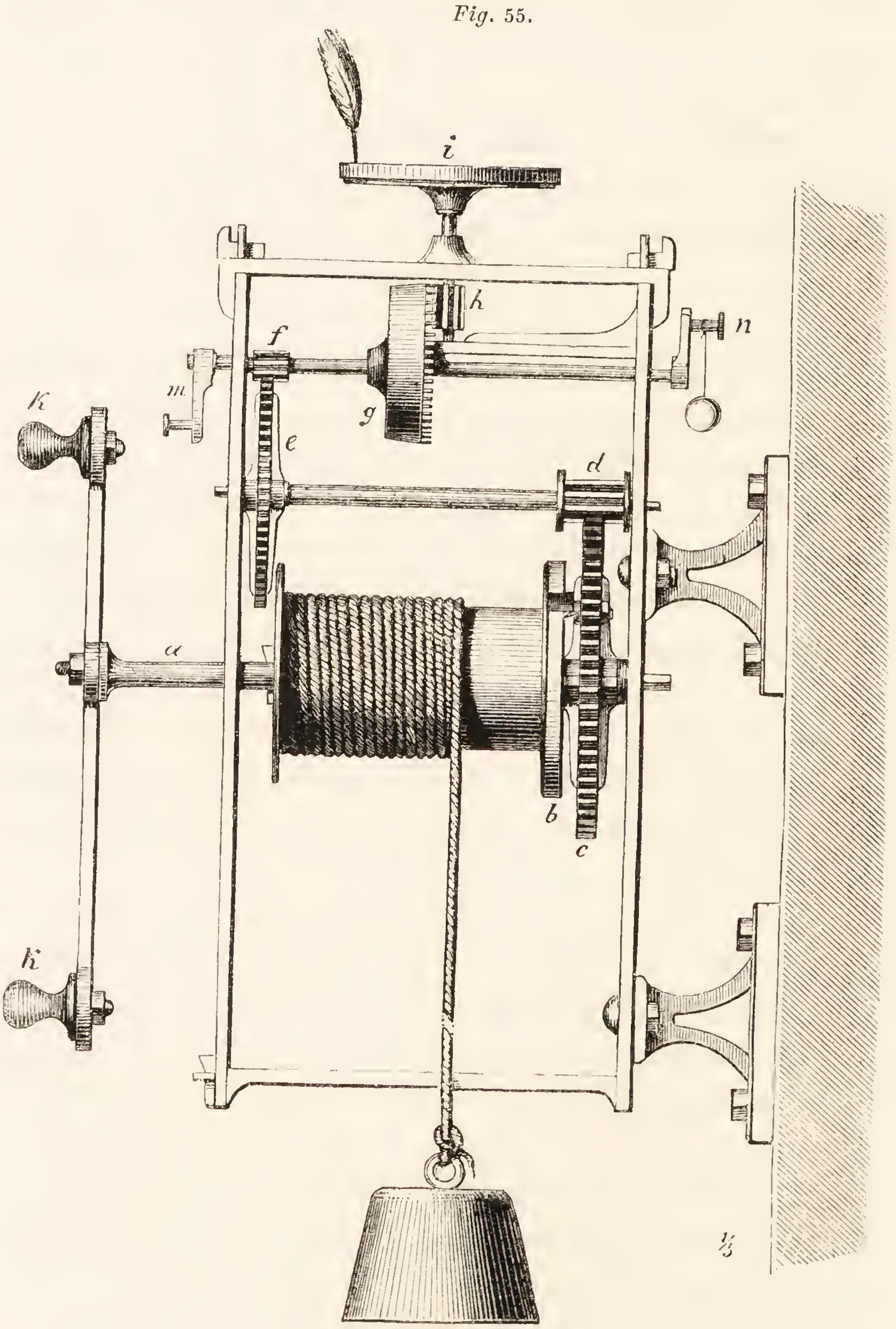



*Fig.* 55.




Apparatus for Stirring Extracts.

spindle will turn without carrying the wheel *c* with it; but when drawn in the other direction by the weight, as is the case when the machine is in action, the wheel *c* is carried with it in consequence of the detent, and all parts of the apparatus are thus put into motion.

The wheel *c* bites with sixty teeth in the pinion *d* of the second pivot. This pivot carries the wheel *e* which bites with sixty teeth into the pinion *f* on the third pivot, to which is also attached the contrate wheel *g*, giving motion through the pinion *h* to the fly-wheel *i*. This fly-wheel consists of a disk of wood with a feather stuck in it, which serves as a balance-wheel or regulator to the machine. Thus, if the feather be placed edgeways with reference to the direction of the movement, it will offer little resistance to the rapidity of the motion, and as a slower action is required, the feather is turned so as to impede the motion by the opposing force of the air.

On the third pivot, which carries *f* and *g*, there are at the opposite extremities two small winches *m* and *n*. The latch *q* (fig. 54,) is made to fit with a notch on to the projecting pin of *m*, and in this way motion is communicated from the machine to the spatula *s*, of the stirrer. A counterpoise weight is suspended from the winch *n*, which equalizes the accelerating and retarding influence of the weight of the latch.

*The stirring bar* (fig. 54,) is suspended vertically over the centre of the large opening in the boiler on which the pan is placed. An iron bracket *a* is fixed to the ceiling, and from this the stirring-bar is suspended by means of a pin, so as to admit of its motion to and fro. The length of the spatula is regulated by the pin *k*, while the extent of its motion is regulated by the pin *o*, which by elevating or lowering this end of the latch lengthens or shortens the stroke of the stirring bar.

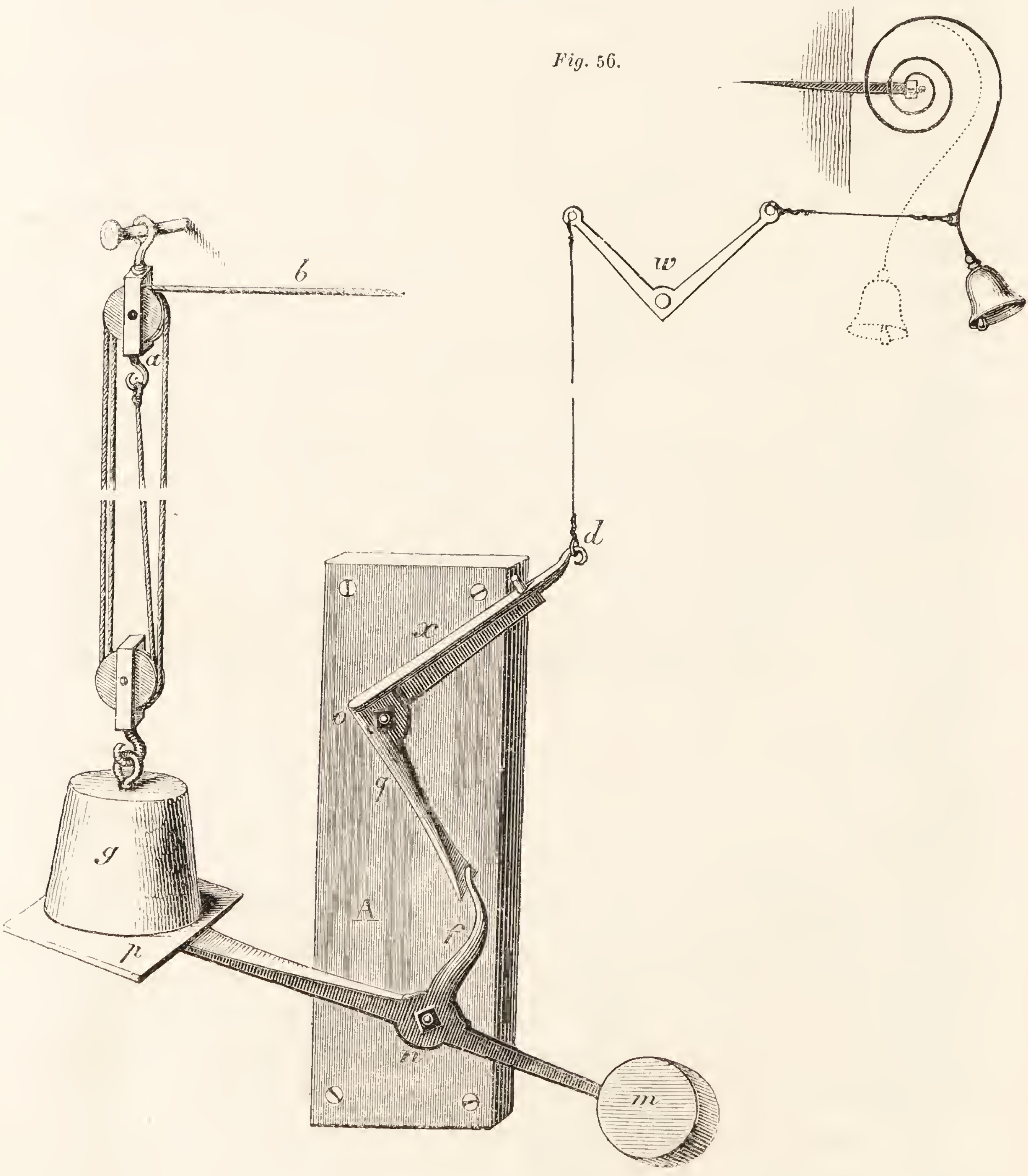
*The spatula s* may be changed to suit the substances operated upon. Thus, for extracts, a wooden spatula may be used; for solutions of salts, one of glass or porcelain should be substituted; and for alkaline solutions, an iron or silver one.

The length of time during which this stirring-machine will continue in motion without rewinding, will of course depend on the length of the line as compared with the circumference of the barrel on which it is wound. The weight may either hang vertically from the barrel as shewn in the drawing, or it may be suspended by a single or double tackle from a more elevated position.

The weight attached to the stirrer I have in use is 40 ℔., and this is suspended by a compound tackle from a height of twelve feet. With this arrangement the machine continues in motion for three hours. When my apparatus was first fixed, the cord being shorter, the motion was maintained for only one hour, and it was frequently found that the machine ran down, and the liquid remained unstirred for some time before the attention of the laboratory man was attracted to it. Even when the continuance of the action was extended to three hours, the cessation of motion was occasionally found to escape observation, so that I was led to contrive an alarum that should always indicate in a manner that could not fail to be noticed, when the machine required rewinding.

*The alarum* is represented in fig. 56. It is fixed close to the

*Fig.* 56.




LABORATORY ALARUM.

floor, immediately under the descending weight. The principal parts of the mechanism of the alarum are attached to a board A, which is fixed against the wall. The weight *g* as it descends comes on to the plate *p* fixed to one end of a bar of iron working on a pivot *n*, and having a counterpoise *m* at the other end. The plate *p* being pressed downward by the weight, the arm of the lever *f* communicates motion to the cranks, *q*, *o*, *x*, and *w*, and on its passing the end *q* of the first crank, the spring of the bell is thrown into active motion and the alarm sounded.

This alarum has been found to be efficient; it works well, and is audible throughout the house; and if there be but one assistant engaged, he will immediately be informed, even if he be at the counter, that the stirrer requires re-winding.

When the apparatus is not in use, the lower end of the stirring-bar may be fixed up against the ceiling, so as to be out of the way, and indeed the whole of the mechanism should be fixed at such a height as not to interfere with any other operation that may have to be performed.

The mechanism of an old clock or a roasting jack, may be used for constructing a stirring machine.

The effect of agitation in promoting the evaporation of a liquid is very marked. I have calculated, that, in making extracts with the apparatus here described, the evaporation will be at the rate of about one pound of water in an hour; so that, if the process be commenced at eight o'clock in the morning, about fourteen pounds of water may be evaporated by ten o'clock at night.

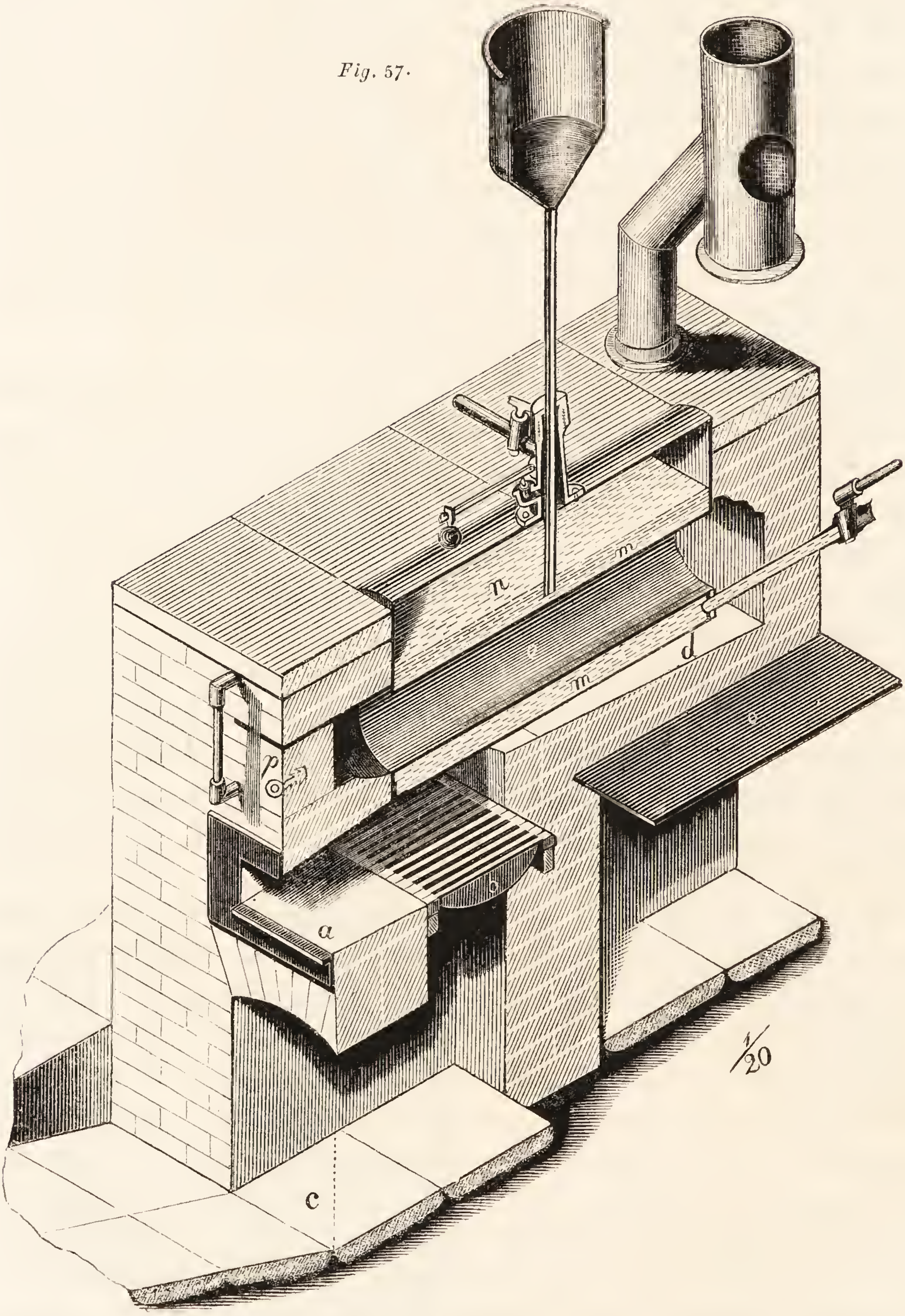
The Beindorf apparatus possesses advantages in its cheapness, the small space it occupies, the numerous purposes to which it is applicable, and the facility with which the several parts are put together or disconnected. But, on the other hand, it is subject to some objections, the most serious of which is, that the steam cannot be put under sufficient pressure to admit of its use for some purposes to which it might otherwise be advantageously applied. The size of this apparatus is also, in some cases, found insufficient to enable it to meet the requirements of the laboratory, [and this would certainly be the case where there is much work to be done]. With the view of meeting the latter objection, a double apparatus is sometimes used; but instead of resorting to this expedient, I would rather recommend the adoption of an entirely different arrangement, and the substitution of a proper steam boiler to which the different apparatus may be attached by pipes.

Figs. 57, 58, and 59 represent a cylindrical boiler, with the fire-flue passing through it, which is the form most frequently adopted.

on the large scale, as it ensures strength to the boiler, and economy of heat.

Fig. 57, shews the manner of setting this boiler.

Fig. 57.



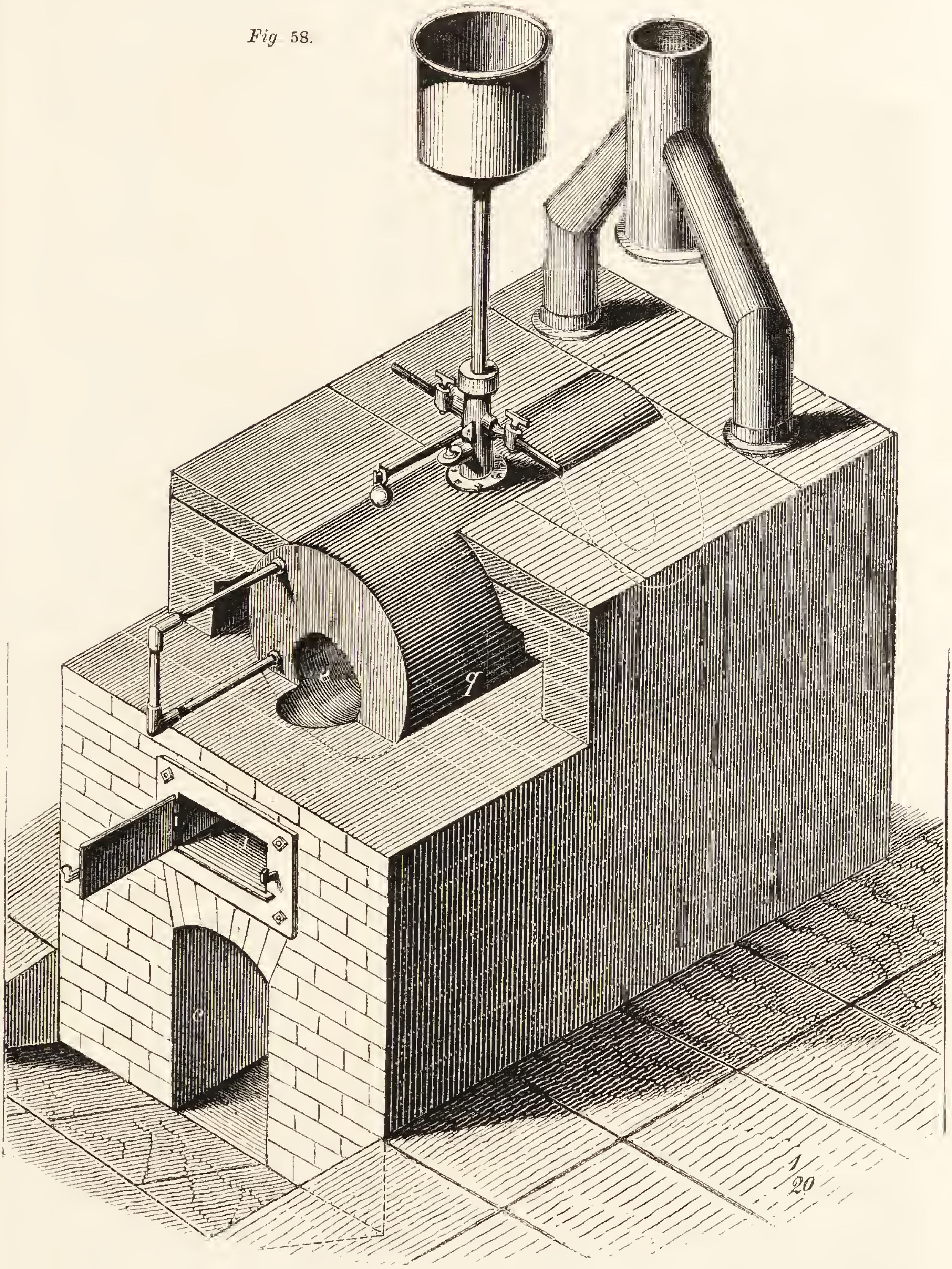

STEAM BOILER.

*a*. The fire-place, with the door removed.
*b*. The grate.
*c*. The ash-pit.
*d*. The fire-flue passing under the boiler.
*e*. The fire-flue returning through the boiler.
*m, m*. The water in the boiler.
*n*. The space for the steam, above the water.
*o*. A cast-iron plate covering an empty space, left for the purpose of saving bricks.
*p*. A moveable brick, to be taken out for the purpose of cleaning out the flue.

The flue which returns through the boiler, divides into two in front, and then passes backward on each side of the boiler.

Fig. 58, gives another representation of the boiler, with part of the brick-work removed from the front.

*Fig* 58.




STEAM BOILER.

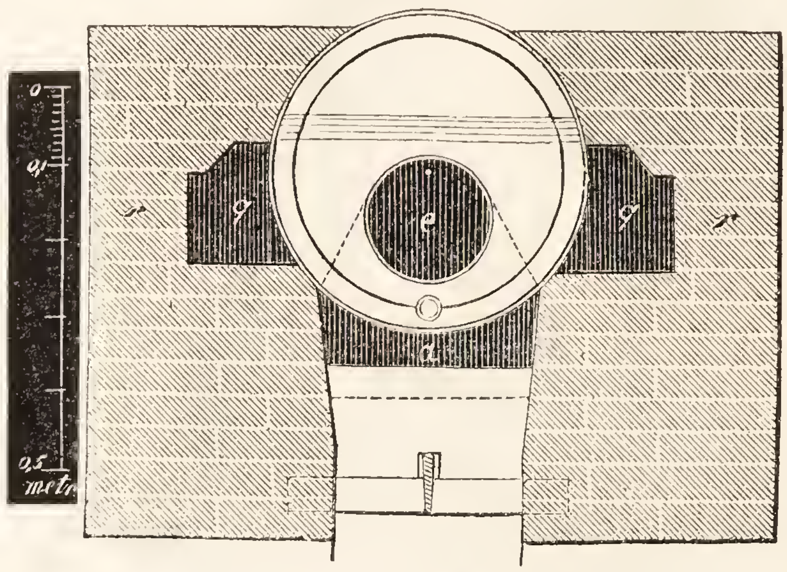
*q, q.* The two lateral flues. *e.* The interior flue.

This figure shews the way in which the glass tube for indicating the height of the water, is connected with the boiler by means of two copper tubes which pass through the brick work.

This and the preceding figure also shew the large funnel-pipe for supplying water to the boiler, the pipes for conveying away the steam, and the safety valve, which are all inserted in one place.

Fig. 59 represents a vertical section of the boiler and brick-work. This figure is drawn to a smaller scale than the two preceding figures, in the proportion of nine to eleven.

*Fig.* 59.



SECTION OF STEAM BOILER.

*a.* The flue running under the boiler. *e.* The internal flue. *g, g.* The lateral flues.

[It is questionable whether this would be the best form of boiler to adopt in a pharmaceutical laboratory; but undoubtedly, whether this or a different form be selected, it ought to have such fittings as would admit of the steam being used under some degree of pressure, without which it would not be susceptible of application to the full extent required. The cylindrical boiler with the fire-flue passing through it, is certainly the most economical with regard to heat, but it presents much more difficulty than the plain cylindrical or wagon-shaped boiler does, to the removal of the incrustations of carbonate of lime which are deposited on the inner surface. For this reason I prefer one of the two last-named forms. The boiler may be made entirely of wrought iron, if economy in price be a consideration; for although it is sometimes stated that the steam acquires a disagreeable smell when generated in an iron boiler, and that this is communicated to the condensed water, I have never experienced this evil, after using one of these boilers for chemical and pharmaceutical purposes during many years. It should be provided with a man-hole, to admit of its being from time to time properly cleaned out; and, above all, it ought to have a self-acting feed-pipe, by which a uniform supply of water may be always maintained in it. Of course it is necessary that the cistern from which the water is supplied to the boiler should be elevated to such a height that the column of water in the feed-pipe shall exercise a pressure greater than that to which the steam is intended to be submitted. These arrangements, however, are well understood by those who supply and fit up steam boilers.

In adopting a steam boiler for laboratory use, it is an important question to determine what ought to be its size. The economy and satisfaction in the use of it will mainly depend on the adaptation of the size of the boiler to the work required to be done by it. The calculation generally acted upon is, that a boiler having a bottom surface of four or five square feet, if well set, will vaporise a cubic foot, or about six gallons, of water per hour. If, however, the steam be required under pressure, the quantity generated will be proportionably less.

There are few cases where it is intended to be practically applied in a pharmaceutical laboratory, in which it would be wise to have a boiler of less capacity than thirty or forty gallons; and from this up to a hundred gallons may be considered to comprise the sizes best adapted for the purpose contemplated.

The steam boiler is intended to supersede, almost entirely, the necessity for other means of heating, by the use of furnaces; but, to accomplish this to the fullest extent practicable, the boiler and apparatus must admit of the steam being used under a pressure varying from five to ten pounds on the square inch.

The boiler will be in daily, or almost daily use, this being one of the conditions contemplated, and it will generally be the only source of heat in the laboratory. It is very desirable and important, therefore, so to arrange the apparatus, that the heat generated here may be economised as much as possible, by applying it in the most efficient manner to the most useful purposes.

In setting the boiler, it will be found advantageous, instead of enclosing it almost entirely in brick-work, as shewn in fig. 58, to have the upper part, to the depth of a few inches, covered with sand, so as to form a sand-bath. This, from the equable temperature at which it will be maintained, will be very useful in a variety of processes.

The chimney of the furnace should be made, if possible, to abut upon a drying closet, which would thus derive some of the unexpended heat of the fire. The closet may be further heated by means of a steam-box, of similar form to the box represented in fig. 30. This box may either be fixed as shewn in fig. 31, or it may form the bottom of the closet. It should be made of copper, well tinned on the inside, and should be connected with the boiler by a steam pipe of rather large diameter, the termination of which in the box should be near the top, so that the condensed water which collects there may not run into the boiler, but be conveyed by a *tin pipe* into a vessel suitable for its reception. A *tin pipe* may also be carried from the top of the steam-box, and made to traverse the back of the closet in a serpentine direction, being finally terminated at the upper end by a valve. In this way the closet would be efficiently heated, while pure distilled water would at the same time be collected; and by fixing a cock near the bottom of the steam-box, distilled water at a boiling temperature may at any time be obtained from this source.

The other purposes to which the steam may be applied are those of boiling, evaporating, distilling, and melting or otherwise heating the several substances operated upon in the laboratory. In performing these operations through the medium of steam, as the means of communicating heat, it is necessary to employ apparatus expressly adapted for its application. The kind of apparatus suitable for this purpose is represented in the drawing fig. 60.

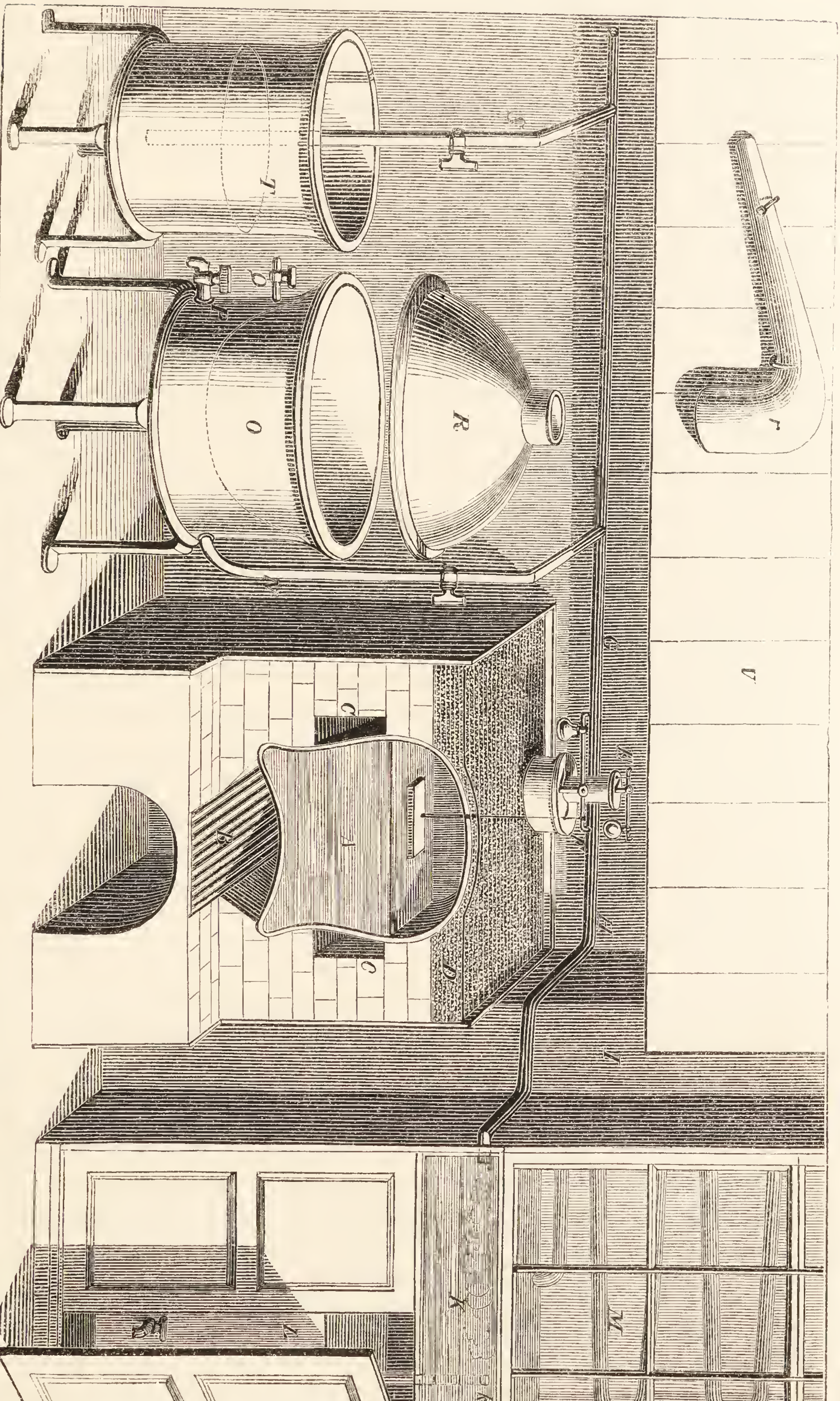
The process of *boiling* is conducted either in the jacketed pan O, or in the vessel T.

In the former case the ingredients are put into the pan and heated by the application of steam, which is conveyed by the pipe N to the chamber beneath. On first turning the steam on, by means of the stop-cock, it is necessary to allow the air previously occupying the steam chamber to escape through the valve Q, which is subsequently closed. The water which will condense in the steam chamber must, from time to time, be allowed to run off at the tap P. In boiling in this way, it is necessary to have the steam under a pressure of five or six pounds to the inch, otherwise the required heat will not be communicated to the contents of the pan; and much heat is lost during the process by radiation from the outer case, or jacket, of the pan.

A more economical, and often very convenient method of boiling, is that which is conducted in the vessel T. In this case the substance to be operated upon is put into the vessel, to the bottom of which a steam pipe (S) passes, and steam is allowed to escape from the end of this pipe. In some instances it is found advantageous, on commencing the process, to let the steam pass through the dry ingredients for a few minutes before adding any water, the effect of this being to cause the substance to swell out, and better admit of the subsequent penetration of the water. When the water is added, allowance must be made for the increase which will take place from the condensation of steam in the vessel, for in this case the effect of continuing the process is the reverse of that which occurs in boiling in the pan O. The operator, instead of commencing with more liquid than the decoction is intended to measure when finished, and boiling down to that measure, commences with a quantity less than is required, and boils up to the proper measure.

The pharmaceutical stove (fig. 4) might be applied for the pre-

*Fig.* 60.



A. The boiler.
B. The fire-place.
C. The lateral flues.
D. The sand-bath.

E. The safety-valve.
F. The lever attached to the stone float.
G, H, M, N, S. Steam pipes.

I. The chimney.
K. The steam-box of the drying-closet.
L. The cistern for distilled water.

O. The evaporating pan, made of block-tin, the outer case, or jacket, being of cast-iron.

R. The cover of the pan, converting it into a still.
*r*. The still-head.
V. Boards enclosing the space

paration of decoctions in this way, a suitable vessel being so placed that the pipe K shall reach to near the bottom of it.

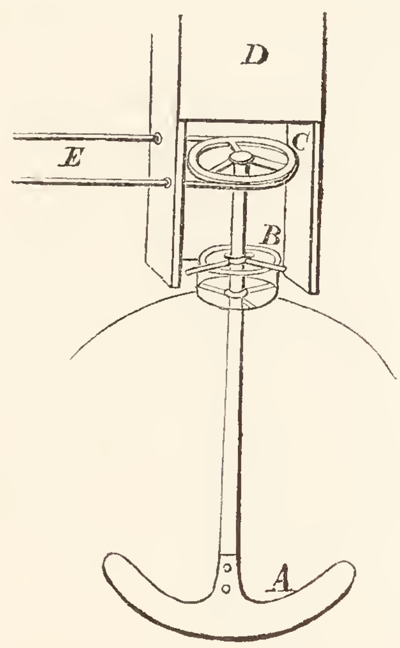
The process of *evaporation* is conducted in the pan O. A mechanical stirrer may be used for expediting the process; but there are certain precautions which it will be necessary to observe in the use of this instrument in the evaporation of extracts, which will be further alluded to hereafter.

There is perhaps no process in the pharmaceutical laboratory that occasions so much annoyance, in the way in which it is usually conducted, as that of evaporation, and this arises from the large quantity of steam generated, which fills the apartment and often interferes injuriously with other operations. It is very important, if possible, to get rid of this steam and prevent its diffusion into the room. This might be done by putting the cover R on the pan, and fixing a pipe to the opening in the top, so as to convey the vapour into the open air. The pan would be thus converted into a still, and the evil alluded to entirely prevented; moreover, there would be a manifest advantage in conducting the process in this way, in as much as the substance under operation would be less exposed to the action of atmospheric air than it would in the open pan. There are, however, some difficulties in the adoption of this arrangement, which require to be met by special provisions. If the steam has to be conveyed to a height of many feet above the pan, much condensation will take place in the pipe, and the process of evaporation will thus be considerably retarded. This evil may be obviated in the following manner:—Instead of fixing the cover R on the top of the pan, as would be done in distilling, three or four blocks of wood, about four inches deep, are placed on the rim of the pan, and the cover is made to rest on these, so that there shall be an open space to this extent all around between the pan and the cover. The air enters freely through this opening, and mixing with the steam at an elevated temperature, they pass off together through the pipe above. The pipe ought to be at least six or eight inches in diameter, so as to admit of a large volume of air passing off with the steam, in which case little or no condensation will take place. The space between the pan and the cover admits also of the introduction of a stirrer to be worked with the hand. This plan answers very well for getting rid of the steam, but while the difficulty arising from the condensation of vapour in the steam pipe is thus obviated, the evil of admitting atmospheric air into the pan is at the same time effected. Another, and probably a preferable arrangement, might therefore be adopted, which consists in fitting the cover to the pan without the blocks, and placing over the opening at the top a large pipe, with a space left open as in the other case, for the admission of air, into which the vapour may diffuse itself. A square wooden shaft, about eight or ten inches in diameter, may be used for this purpose.

If the cover of the pan be thus fitted on, it would be necessary to provide means by which the progress of the inspissation might be observed. The best method of effecting this is to have two circular pieces of strong plate glass fixed in two opposite sides of the cover R, as shewn in the vacuum pan, fig. 71, at O. The light entering at one of these windows, is reflected from the surface of the liquid in the pan, and passes out through the other window, thus enabling the operator to see the contents of the pan.

With the arrangements now under consideration, it would also be necessary to have a mechanical stirrer for agitating the liquid during evaporation. Fig. 61 represents the kind of stirrer that would be most conveniently applied. The agitator (A) may be made either of block-tin or of wood. It is suspended by a frame placed on the opening in the cover of the pan at B, so that the arms of the agitator shall not come in contact with the sides of the pan; and a rotatory motion is given to it by means of a cord (E) passing round the wheel C. The manner of fixing the wooden shaft (D) is also shewn in the drawing.

*Fig.* 61.




MECHANICAL STIRRER.

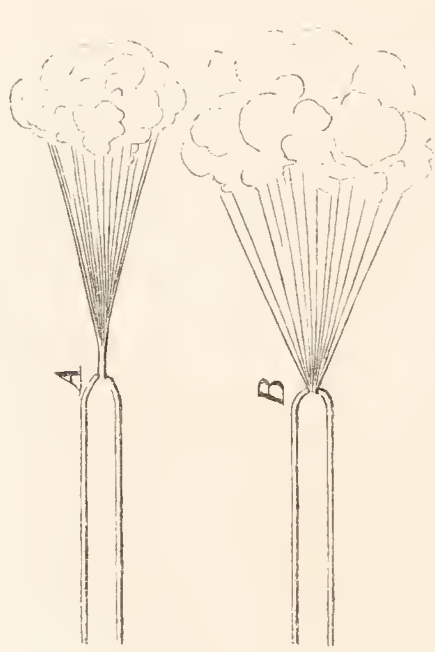
The process of *distillation* is conducted in the pan O, which is converted into a still, by fitting on the cover R, and the still-head *r*. The refrigerator is not shewn in the drawing; it might conveniently stand beyond the vessel T. The kind of refrigerator that I have been accustomed to use is constructed on the same principle as that represented in fig. 71. A common block-tin worm is fixed in a wooden or metallic case, of little more than the dimensions requisite for holding it. The case is covered at the top, so as to be perfectly water-tight; and a pipe communicating with a cistern supplies cold water to the bottom of this vessel, while another pipe conveys away the heated water from the top. This latter pipe may convey the hot water to a second cistern underneath the floor, or it may deliver it for use at the sink. While the process of distillation is proceeding, the water must be constantly running through the refrigerator. By this arrangement two of the greatest inconveniences attending the use of the common worm-tub are obviated.

In most pharmaceutical laboratories, fitted up on the old-fashioned principles, the most striking object on entering the apartment is the worm-tub, which, being designed to hold the supply of water required for all the processes of distillation, is necessarily of very large dimensions, and often occupies space that cannot be conveniently spared. This worm-tub is open at the top, and, as the water heated during the process of condensation rises to the surface, the upper strata of water are often at a temperature near the boiling point, and consequently a large quantity of steam is given off from the worm-tub when in use. The size of the worm-tub, and the disengagement of steam from the surface of the water when it is in use, are, therefore, the two evils alluded to which are obviated in the arrangement I have recommended.

The pan O may be further used for any operations involving the application of a temperature not much exceeding that of boiling water, such as the preparation of plasters, ointments, &c.; but it would generally be found more convenient to have a separate pan of similar construction for these purposes.

In addition to the means already pointed out for getting rid of the steam generated during the processes of evaporation, there is another method which may be conveniently and successfully applied in some cases, and which will also at the same time promote the general ventilation of the apartment. This means is dependent upon the use of a jet of high-pressure steam, and therefore can only be applied where there is a steam boiler with a constant supply of steam under a pressure of eight or ten pounds to the inch.

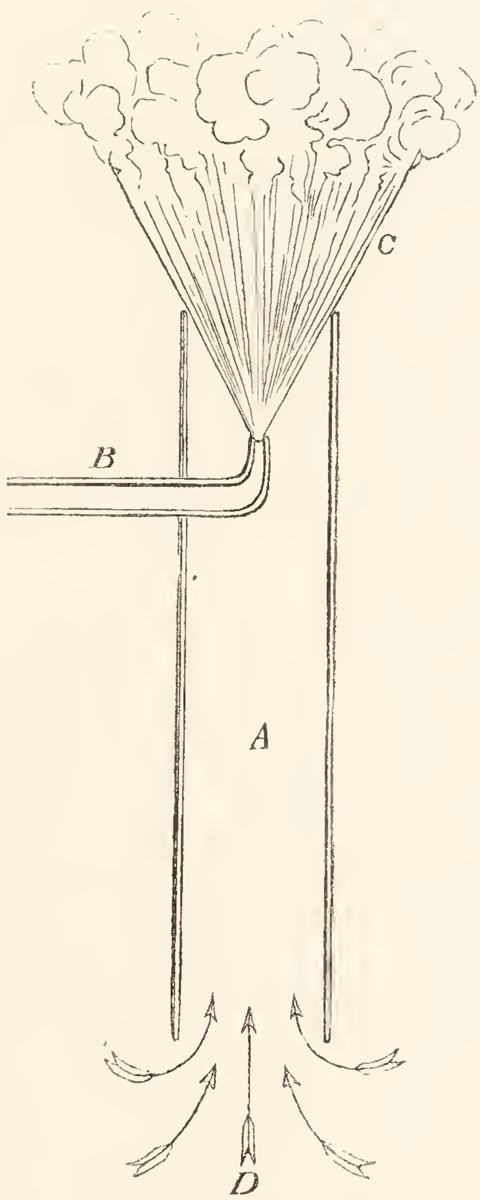
*Fig.* 62.




STEAM JETS.

It has long been known, that, if any gas or vapour be forced with much pressure through a tube, having a small aperture at the end, immediately on issuing into the air it will expand into a cone, as shewn at B, fig. 62; whereas, if propelled with a very slight pressure, it will maintain a cylindrical form for some distance after issuing from the tube, but will still ultimately expand into a cone, as shewn at A, fig. 62. The conical expansion in both cases has been found to arise from the admixture of the surrounding air, which is mechanically drawn into the propelled jet, the amount of air thus drawn in, and the consequent expansion of the cone, being greater in proportion as the force with which the jet is propelled is increased. The knowledge of these facts has been applied in effecting the ventilation of apartments, a strong current of air being determined through a tube or shaft, by discharging a jet of high-pressure steam at one end of it, as shewn in fig. 63. A, is a cylinder nine or ten inches in diameter; B, a steam-pipe, the orifice of which is one-sixteenth of an inch in diameter, fixed at such a point that a jet of steam issuing from it shall expand to the full circumference of the cylinder on reaching its mouth. Under these circumstances air is drawn with great force into the cylinder from below, as indicated by the arrows, and passes off in admixture with the steam. The size of the apparatus may, of course, be varied to suit the different circumstances under which it may be applied.

*Fig.* 63.




STEAM JET VENTILATOR.

PREPARATION OF EXTRACTS.

The preparation of extracts has occupied much of the attention of practical pharmaceutists, and many propositions have, from time to time, been made, with the view of improving the process.

Extracts are frequently distinguished as *aqueous*, *alcoholic*, or *ethereal*, according as one or other of the liquids indicated by these names has been used in their preparation; for not only the character of the extract, but the process also, depends upon the nature of the liquid used for extraction.

Improvements in the preparation of extracts must have reference either to the quality of the products, or to the economy of the process; and a correct knowledge of all that relates to these points is essential in determining which is the best of the many methods of proceeding which have been suggested.

*Aqueous Extracts.*—Berzelius, in his work on chemistry, has entered very fully into the theoretical questions relating to the nature and preparation of extracts. He has shewn that they undergo important changes, and ultimately are completely spoiled, if long exposed to the action of heat, and especially a high temperature. Great care, therefore, ought to be taken, to avoid this source of deterioration.

There are three ways of preparing aqueous extracts, or rather of making the solutions from which they are prepared:—1st, By boiling the solid ingredients with water; 2ndly, By digesting them in boiling water; and, 3rdly, By macerating them in cold water.

Extraction by boiling, can only be applied with advantage to hard woods, roots, and barks, such as guaiacum wood, quassia, Peruvian bark, cascarilla bark, &c., which are with difficulty exhausted of their soluble parts. The substance to be operated upon is first to be cut or sliced, and then boiled with just enough water to cover it, and admit of its being well stirred with a spatula. It is better to avoid active ebullition, and induce only a gentle simmering, [which should be continued for a quarter of an hour or twenty minutes.] The decoction is then poured into a strainer and allowed to drain; and the solid ingredients are twice more treated in the same way with fresh portions of water. These several decoctions are mixed together, allowed to settle, and then the clear liquor evaporated over the water-bath.

It should be observed, however, that, in making extract of Peruvian bark, the sediment which forms in the decoction as it cools is not to be separated and rejected.

In evaporating the liquor, a small quantity only should be introduced into the pan at a time; and when this has been evaporated, with the constant use of the stirrer, to the consistence of syrup, it should be taken out and the process repeated on another portion, until the whole has been thus reduced. Finally, these syrupy liquors, being united, are to be carefully evaporated to the consistence of an extract.

Formerly all aqueous extracts were directed to be made from decoctions of the solid ingredients. In process of time, however, it was ascertained, by experiment, that in most cases it was more advantageous to effect the extraction by means of infusion than by decoction. Thus, for instance, well authenticated experiments have shewn that

| | | | | |
|---|---|---|---|---|
| 16 oz. Rad. Patientiæ | gave, | by decoction | ℥ij ʒvj | Extract. |
| „ „ | „ | by infusion | ℥iij | „ |
| „ Rad. Gentianæ | „ | by 12 hours' cold maceration | ℥v ʒij ℈ij | „ |
| „ „ | „ | by 12 hours' hot infusion | ℥v ʒj | „ |
| „ „ | „ | by 15 minutes' decoction | ℥iv ʒvj ℈ij | „ |

The extract obtained by infusion, and especially that by cold maceration, was more bright, clear, smooth, bitter, and odorous than that obtained by decoction.

| | | | | |
|---|---|---|---|---|
| 16 oz. Rad. Consolidæ, gathered in March, | gave, | by infusion | ℥ij ʒvij gr. l. | Extract. |
| „ „ | „ | by cold maceration | ℥iij ʒiij gr. xxxviij | „ |
| „ Rad. Rhei | „ | by infusion | ℥v ʒvj | Clear extract, soluble in water. |
| „ „ | „ | by decoction | ℥v | Turbid, slimy, extract, partly insoluble. |

On the other hand,

| | | | | |
|---|---|---|---|---|
| 16. oz. Cort. Cinchonæ | gave, | by decoction | ℥iv gr. lxxxvij | Extract. |
| „ „ | „ | by infusion | ℥iij gr. lxviij | „ |

Besides, the extract of bark obtained by decoction is much richer in alkaloids, and is of a different character from that obtained by maceration or infusion. Guaiacum wood also yields more extract by boiling than by infusing, and the extract so obtained has a more balsamic odour.

16 oz. Rad. Rhataniæ gave, by decoction, ℥iij ʒvij gr. xxij extract, which consisted of—

| | | |
|---|---|---|
| ʒxiij | gr. viij | soluble matter. |
| ʒxviij | gr. xiv | insoluble matter. |

16 oz. Rad. Rhataniæ gave, by infusion, ℥iij ʒiv. gr. iij extract, which consisted of—

| | | |
|---|---|---|
| ʒxviij | gr. viij | soluble matter. |
| ʒix | gr. l | insoluble matter. |

Thus, in case of rhatany, although more extract was obtained by decoction than by infusion, yet that obtained by the latter process contained the largest quantity of soluble matter.

The French Codex of 1839 contains a formula for extract of rhatany made with alcohol; but the extract thus made contains a very large quantity of insoluble matter. A quantity of the root that yielded 70 parts of aqueous extract, gave 120 parts of extract when treated with alcohol; but of this latter only 51 parts were soluble in water.

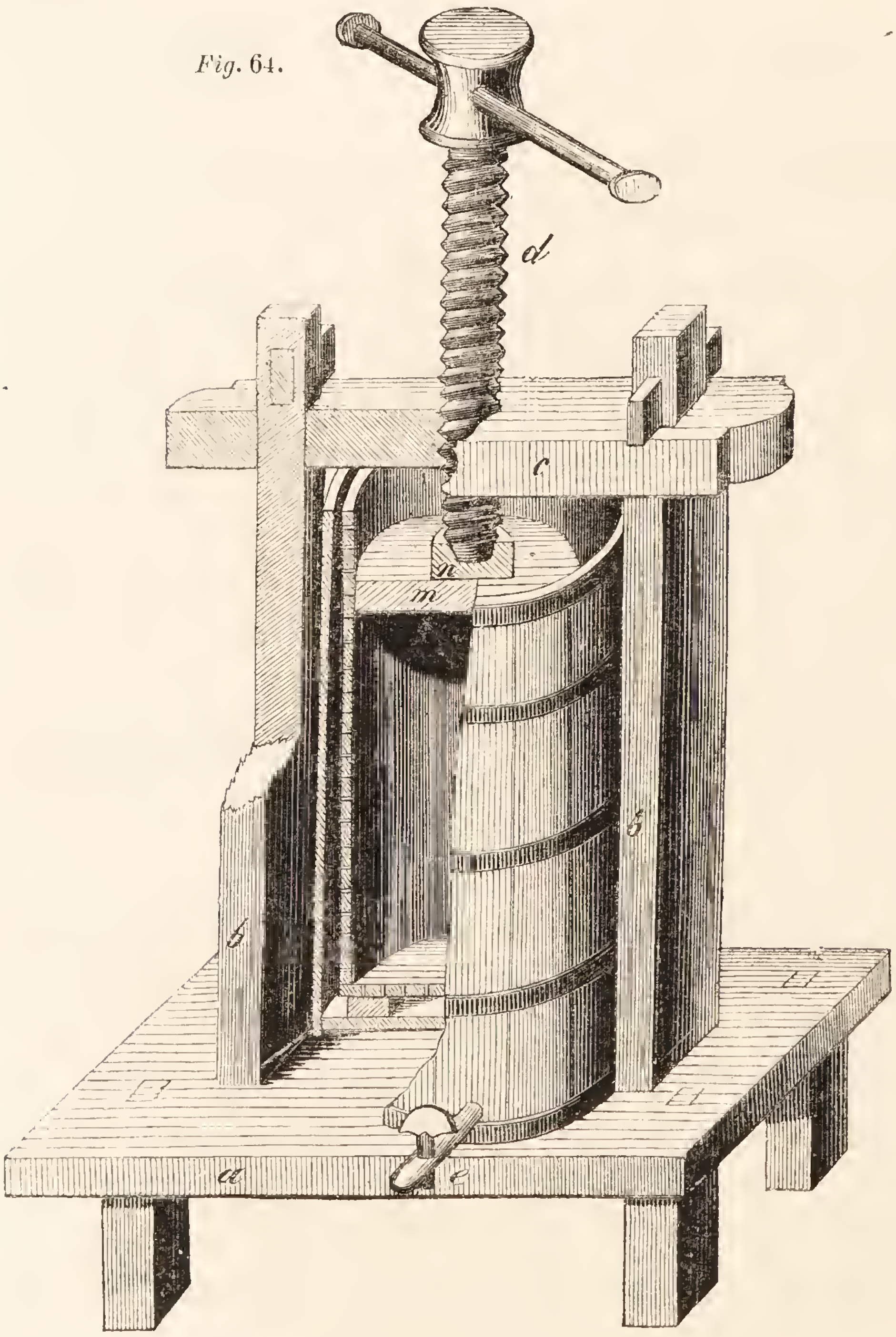
It appears, then, from these experiments, that in most cases the process by infusion yields extracts better in quality, and greater in quantity, than those obtained by decoction.

It remains to be considered what is the best method of proceeding in the preparation of extracts by infusion.

In order to use the smallest possible quantity of the extracting medium, it is desirable to effect a rapid removal of the liquid as it becomes charged with the soluble matter of the substances operated upon; and there are three ways in which this is effected:—1st, By the press; 2ndly, By displacement with high pressure; and, 3rdly, By displacement with low pressure.

First, with regard to *the press.* The substances after having been infused are usually put into bags or wrapped in cloth, and put into one of the laboratory presses. This operation is very troublesome where there are large quantities of materials to be operated upon; and, as repeated additions of boiling water are required, this makes the substance to be pressed so hot, that much inconvenience is experienced in handling it. On this account, a particular press for extracts has been introduced, and I have already described and sketched one of these in the "Annals of Pharmacy," vol. xxxi. page 303. Fig. 64 gives a correct representation of it.

*Fig.* 64.




Mohr's Press for Extractions.

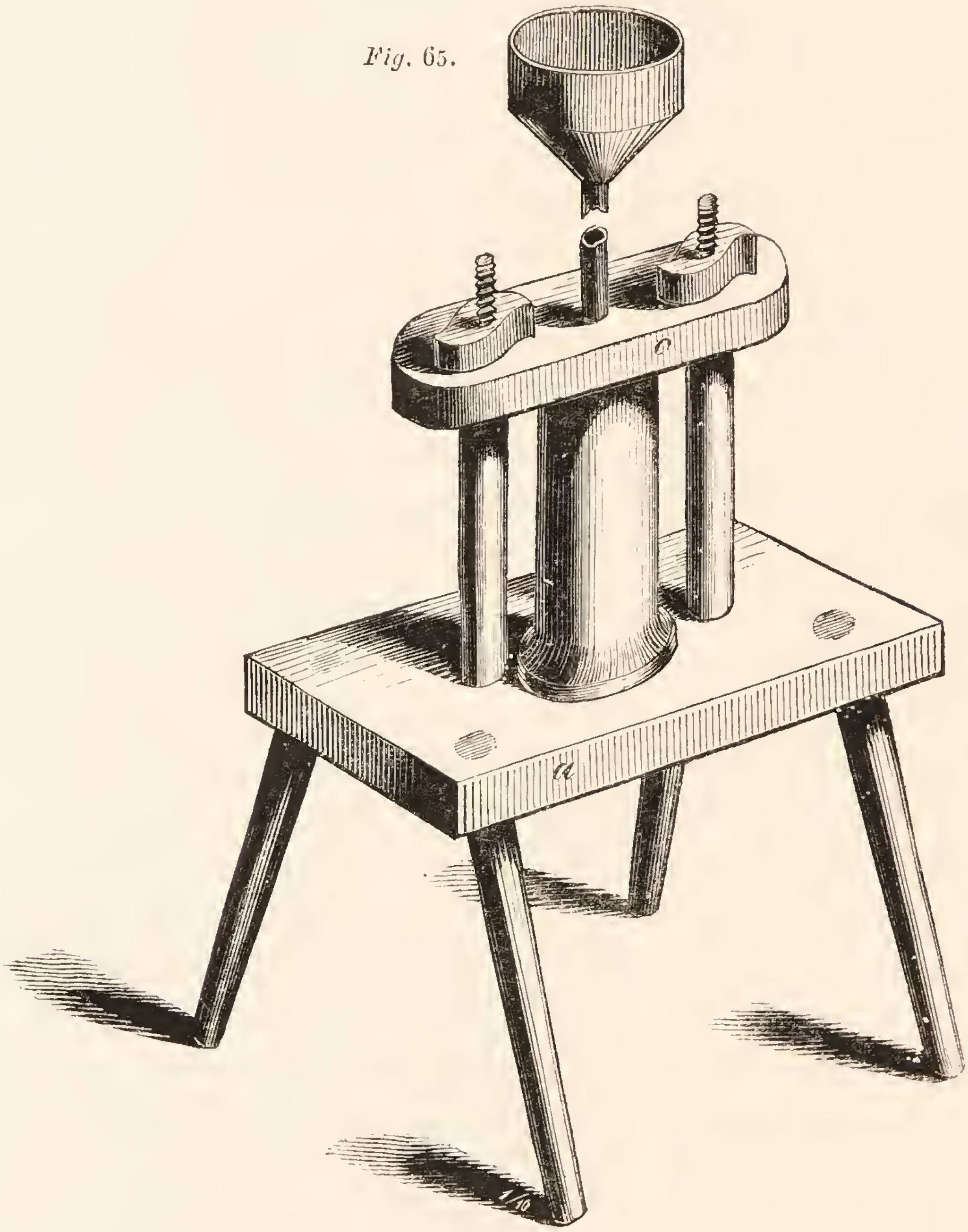
In the stout oaken top (*a*) of a low table or stool two square holes are cut, to receive the ends of the upright pieces of wood *b*, *b*, which pass through to be fastened below by wedges. A cross-beam (*c*) is fixed at the top, as shewn in the drawing, and in this a female screw is cut, beneath which the press-tub stands. This press-tub is double, the inner one being perforated with holes. It is also furnished with a stop-cock (*e*). The substance to be operated upon being put into this tub, the water, either hot or cold, is poured over it; the press-block (*n*) is then placed on the top, and the ingredients are thus allowed to stand during the specified time, at the expiration of which the liquor is allowed to run off through the stop-cock, and pressure applied by means of the screw. This method of proceeding has been found to answer well. The liquor thus obtained is to be evaporated as already described.

*The Displacement Process.*— The removal of a saturated solution from the solid ingredients which have been acted upon, by means of a superincumbent column of the uncharged solvent, was a fruitful idea, which caused much stir among pharmaceutists, and has been productive of benefit to the pharmaceutic art.

When Count Real invented the press which has been named after him, the idea of effecting a more complete penetration of the vegetable fibres, and extraction of the soluble parts, than had previously been attained, appears to have prevailed in his mind, over that of merely displacing the solution when formed. This he proposed effecting by the pressure exercised by a column of water, increased by elongation to the extent required. In practice, however, it has been found that but little advantage was gained by the accumulated pressure acquired in Real's press; and successive attempts at simplification have resulted in the reduction of the gigantic forms and expensive construction of the original apparatus, with all its philosophic glory, to the dimensions of a sugar-loaf mould, or small tin cylinder.

*The Press of Count Real.*—Real's press consists of a metallic cylinder, in which the substance to be acted on is placed on a perforated disc. It has a cover which may be fixed on with a water-tight joint, and to the cover is attached a perpendicular tube, usually eight or ten feet high. In connecting these parts together, it has been found difficult to prevent leakage at the joints, especially when the tube is carried, as it sometimes has been, to the height of two or three stories of the building; and this has constituted one of the practical objections to the use of the apparatus. In addition to this, the method generally adopted, of fastening the cover to the cylinder by means of screws, was found to be troublesome, as much time was occupied in fixing and unfixing it, and some of the screws were frequently lost. To obviate these objections, I have proposed a modification in the construction of the press, which is represented in fig. 65. Upon a stout table (*a*) two upright bars are fixed, the upper ends terminating in screws. These are connected by a cross-bar, *c*, which is fixed on by two nuts, such as the bookbinders have to their presses. In the centre of the

*Fig.* 65.



Count Real's Press, modified by Mohr.

cross-bar a female screw is cut, through which the vertical pipe is to pass. There is also a hole in the centre of the table, through which the lower end of the cylinder, which has a stop-cock attached to it, passes, as shewn in fig. 66. The top of the cylinder fits on with a collar, and a leather or pasteboard washer, and these are closely compressed by the cross-bar, which is screwed tightly down by the nuts. The whole apparatus is thus rendered water-tight, and at the same time firmly fixed to its stand by means of the two nuts at the top.

The perpendicular tube is screwed into the top through the hole in the cross-bar. The tube should not be less than seven lines in diameter.

The substances to be acted upon are placed in the cylinder, over the perforated strainer, in a dry or moist state, with certain precautions which will be subsequently stated; and the cover being fitted on, and the pressure-pipe fixed in its place, water is poured in through the funnel at the top, so that the ingredients in the cylinder shall be exposed to the pressure of a column of water. After standing for some hours, the liquor is slowly drawn off through the stop-cock at the bottom, while fresh water is added from above.

*Fig. 66.*

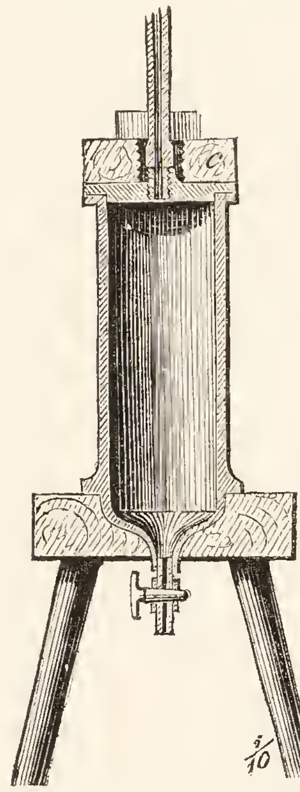


*Fig. 67.*

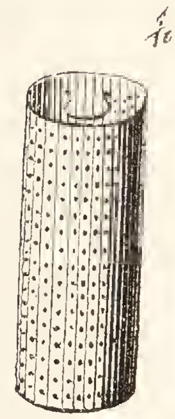
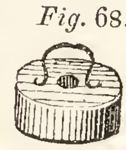


*Fig. 68.*



Real's Press, modified by Mohr.

The principal objection to this apparatus is that the liquid passes too rapidly through the solid ingredients, in consequence of the pressure exercised by the column of liquid in the tube.

With a few additions, the apparatus above described may be rendered applicable for use as a mechanical press. For this purpose, a cylindrical strainer (fig. 67) must be made to fit into the cylinder of the press and to stand on the perforated disc at the bottom. The materials are placed inside this, and a small press-block (fig. 68) put over them. The cover of the press and the vertical pipe are dispensed with, and, in place of the latter, a screw with a lever-handle at the upper end is passed through the hole in the cross-bar, which, as already stated, has a female screw cut in it, and this screw, acting on the press-block, effects the required pressure.

This application of the apparatus is very convenient in operating with spirit, as it admits of the extraction and the expression being effected in the same vessel, and thus the loss from evaporation and otherwise, that would occur in transferring the materials to another vessel, is avoided.

The objections which attach to the use of Real's press, have led to the adoption of a more simple method of effecting displacement, in which high pressure is avoided. Indeed, the process of displacement by low pressure may be said to have entirely superseded the other. The Real's press may be reduced to a low pressure displacement apparatus, as a slipper would be made out of an old boot, by removing all the upper portions.

The outer cylinder of the Real's press, placed on a suitable stand, is all that is required for a displacement apparatus.

The method of manipulating with this apparatus, so as to obtain satisfactory results, is not, however so simple and easy as might be imagined; and the French pharmaceutists have accordingly been occupied for years in classifying the different vegetable substances according to the treatment they severally require in submitting them to this process.

The process of displacement consists in pouring the liquid to be used over the solid ingredients, previously reduced to a state of division, and confined in a cylinder of greater length than diameter, and thus causing the liquid to pass through many layers of the solid body, until it becomes charged with the soluble matter, which it extracts and carries away with it.

The advantage of this process is said to consist in its effecting the exhaustion of the solid substances acted upon, of their soluble matter, with a smaller quantity of liquid than would be required under other circumstances. This is said to be accomplished in consequence of each particle of liquid coming successively in contact with a great number of particles of solid matter, while at the same time the latter particles are also successively acted upon by a great number of particles of the liquid.

If, as is assumed in the above theory, there were no obstacle to the equal penetration, in all parts, of the mass of solid matter, and of the separate particles of which it is composed, by the liquid, and, further, if there were no disposition in the different parts of the liquid to intermingle with each other, the process would, indeed, accomplish all that could be desired. In practice, however, such satisfactory results are but rarely obtained. It is found that the fluid does not pass with the same facility through the pieces of solid matter as it does through the interstices between these pieces; that it frequently flows more freely through one part of the mass than another, in consequence of unequal packing of the materials, or from some other cause; and, further, that, however well the materials may have been packed in the first instance, as the solvent extracts the soluble parts, the remaining solid matter occupies less space; and the mass, shrinking from this cause, forms a number of channels through which the fluid flows without further effect. Yet, notwithstanding these disadvantages, there are some cases in which the process of displacement is found to be available with much advantage.

In the application of this process, an essential condition of success is the reduction of the solid substances to the proper state of division. The opinion which has been formed by many persons, that certain substances of a mucilaginous nature are impenetrable, and cannot be exhausted by displacement, has probably been formed in consequence of a want of proper attention to the above condition. There are, I believe, few substances that do not admit of being treated by this process, if all the necessary conditions be observed.

Leaves, herbs, or the tops of plants, when properly dried and made friable, may be rubbed through a sieve of about 10 meshes to the square inch, or they may be cut up and then passed through the sieve. Barks, roots, and all kinds of wood, are properly cut up, or bruised in a mortar or mill, and finally sifted, the coarse powder only being used, while the fine is set aside for some other purpose.

Mucilaginous substances should be less finely comminuted than those of a more woody nature.

It would be difficult to describe the degree of division necessary for each separate substance; this must be left to the judgment and experience of the operator. It would be equally difficult to decide how much of the solid substance ought to be put into the cylinder at once, as this depends on the nature of the substance.

There are two methods of proceeding in the treatment of vegetable powders by displacement: one consists in packing the dry substance in the apparatus, and pouring the liquid over it until it begins to run out at the bottom, when the moistened mass is allowed to stand for some time with the stop-cock shut off before the displacement is commenced; the other consists in moistening the powder in a separate vessel, allowing it to stand for some time, and then packing it in the cylinder of the apparatus.

The former of these methods offers no advantage over the other, while it is frequently found that the powder does not become completely moistened when thus treated, and hence that one of the principal objects of maceration is frustrated. [It also occurs, frequently, that, when the powder is moistened in the cylinder of the apparatus, it swells on the addition of the liquid, and thus becomes so tightly packed as to resist the further passage of the liquid. This inconvenience is principally experienced when water is used as the extracting agent.]

A dry sponge imbibes water but sluggishly; while, on the other hand, a moistened and expressed one absorbs it greedily: so, in like manner, a dry powder offers some resistance to the entrance of water; while in a moistened powder the absorption is promoted, through the influence of capillary attraction. The resistance offered by the dry powder arises partly from the formation of an impenetrable coating on the surface, by the swelling of the first particles that are wetted, and partly by the pressure of air between the particles of the powder, which has not sufficient means of escape.

The best method of effecting the moistening of the dry substances is that which was originally suggested by Count Real, and which consists in adding to the powder half its volume of water, allowing the mixture to stand for some hours, then packing it more or less closely in the cylinder of the apparatus, covering it with a piece of linen or with paper pierced with holes, and finally pouring water over it. Should the liquor run off too rapidly, the powder should be pressed a little closer in the cylinder, or the escape of the liquid be regulated by means of the stop-cock.

Soubeiran has made a classification of substances, according to the pressure they require to be submitted to when treated with water by displacement, which is as follows:—

To be strongly pressed:—

| | |
|---|---|
| Chamomile flowers, | Hops, |
| Arnica flowers, | Quassia wood. |

To be pretty strongly pressed:—

| | |
|---|---|
| Bistort root, | Liquorice, |
| Cahinca root, | Peruvian bark, |
| China root, | Pomegranate bark, |
| Colchicum cormus, | Rhatany root, |
| Calumba root, | Sarsaparilla, |
| Dulcamara, | Willow bark, |
| Ipecacuanha, | Valerian root. |

To be moderately pressed:—

| | |
|---|---|
| Aconite plant, | Rue, |
| Anemone, | Savine, |
| Belladonna, | Stramonium, |
| Buckbean, | Soapwort, |
| Hemlock, | Veronica. |

To be slightly pressed:—

| | |
|---|---|
| Borage, | Nut-galls, |
| Great burdock, | Parsley root, |
| Gentian root, | Senega root. |
| Heartsease flowers, | |

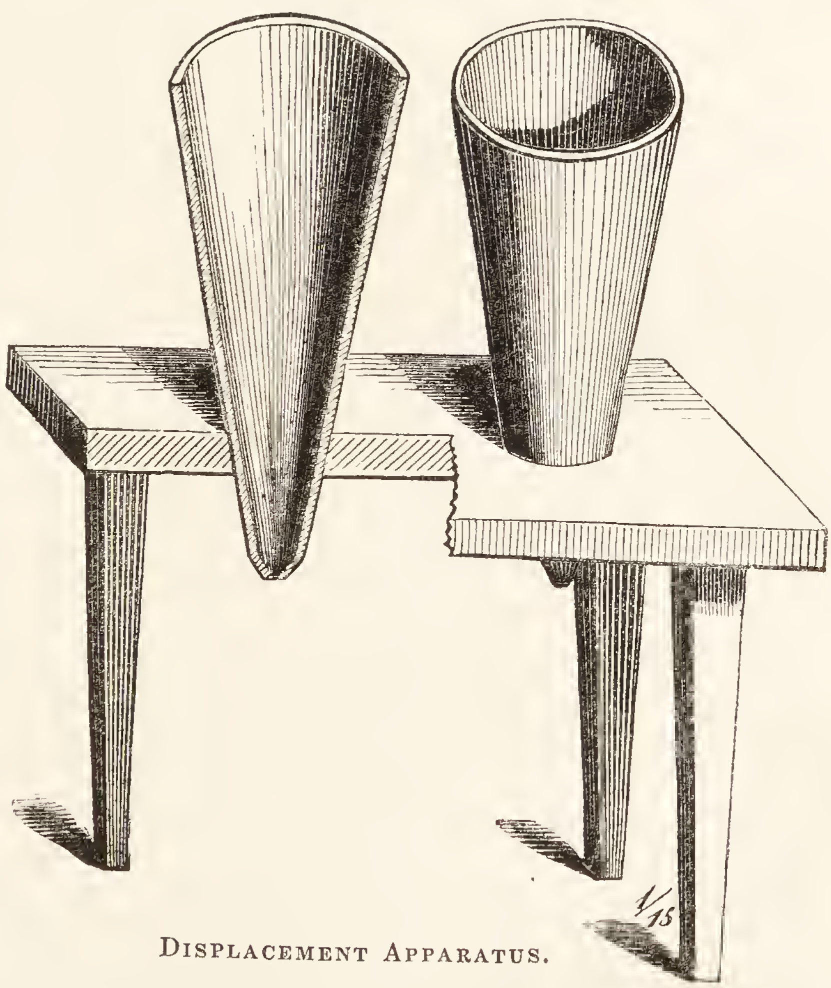
Not to be pressed at all:—

| | |
|---|---|
| Red roses, | Saffron, |
| Rhubarb, | Squill. |

The displacement process cannot be advantageously applied to poppy capsules, and there are difficulties in the way of applying it to gentian and rhubarb. The last-named, if treated at all by this process, should be reduced to very coarse powder and moistened with an equal weight of water, before commencing the displacement. The best method of treating senna is, to bruise it slightly, then pack it in the apparatus and add four times its weight of water, and after allowing it to macerate for twelve hours, to proceed with the displacement.

Complicated or expensive forms of apparatus are not required for conducting this process, and this certainly constitutes a recommendation to it. In the absence of a metallic cylinder, a sugar-loaf-mould, such as is represented in fig. 69, may be conveniently used. These moulds are conical earthenware vessels, with a small opening at the apex. They are used for crystallizing the loaves of sugar, and may be obtained from the sugar-refiners where they are constantly in use, from the stone-ware manufacturers who make them, or from any common potter who would make them to order. As obtained from the last-named source, however, they would not be so strong as those made for the sugar-refiners. Two or more of these vessels are fixed in a table, as shewn in fig. 69. In using them, the liquor obtained by treating the solid ingredients in one mould is added to a fresh portion of the same ingredients in the next mould, and so on until the liquor becomes highly impregnated. In this way, when there are large quantities of materials to be operated upon, very strong solutions are obtained, which, in proportion to their concentration, require less evaporation in reducing them to the condition of extracts, and thus one of the most fruitful sources of deterioration in these preparations is avoided.

*Fig* 69.




Displacement Apparatus.

Let us now consider the question, which of the two processes described, that of expression, or that of displacement, affords the most satisfactory results?

According to my view and experience, the advantage is on the side of the process of expression.

The process of displacement offers advantages only when continued uninterruptedly with large quantities of the same materials, so that solutions which are comparatively weak may be rendered stronger by using them to act on fresh portions of unexhausted materials. In pharmaceutical operations this is rarely possible, as the quantities operated upon are generally small. The influence produced by the extent of the operations will afford an explanation of the difference in the results which have been obtained in the application of this process in large and in small laboratories. The process of expression is not subject to this defect, the results being alike with small as with large quantities.

In the displacement process the solutions first obtained are the most concentrated, but they soon decrease in strength, and continue for some time to get weaker, although still sufficiently strong to prevent their being rejected; and if there be no more substance to be acted upon by these weak solutions, there is no alternative but to concentrate them by evaporation. In the process of expression, the liquor obtained is of the same degree of concentration throughout the operation. It is true that the marc still retains a small quantity of liquor similar to that which has been expressed, but this may in great measure be removed by the addition of a little more water, and a second expression. Substances which are with much difficulty treated by displacement, such as rhubarb, gentian, nutgalls, &c., present no difficulties in the process of expression; indeed, this is frequently resorted to as the readiest means of finishing the operation after beginning it by the other. Expression is advantageous, in many cases, from its tending to burst the fibres, which in their unbroken state retain portions of soluble matter, or of solution, which is not otherwise easily removed.

Moreover, with regard to the time required for conducting either process, the press again has the advantage. By the application of heat the extraction may be accelerated, and the expression then effected as soon as deemed expedient. In the case of ordinary displacement, no further heat can be applied; and with substances of a mucilaginous nature the percolation is so slow, that the ingredients frequently become mouldy and spoil before the process is finished. Sometimes the percolation stops altogether, and in these cases there is no other remedy than resorting to the press.

Finally, I conclude, from these several views of the question, that the process of expression, with properly constructed apparatus, is preferable to that of displacement.

[In the preparation of extracts the quality of the product will depend less upon the means adopted for extracting the soluble matter from the vegetable substances operated upon, than upon those by which the inspissation of the solutions is effected.

An *extract*, for medicinal use, ought to contain the active constituents of the substance from which it is made, if possible, in an unaltered condition. It should represent the infusion, decoction, tincture, or juice, by the evaporation of which it is obtained, in every respect, excepting the state of concentration of the active ingredients, and the permanency of their condition.

*Extracts* are, or ought to be, composed of a number of chemical constituents, or proximate vegetable principles, *educed* and not *produced*, during the process of preparation. Among these constituents are, starch, gum, sugar, pectin, albumen, gluten, vegetable acids, alkaloids and allied bodies, oils, resins, and colouring matters. These substances are very liable to undergo decomposition or changes of constitution, especially when exposed to the action of heat and atmospheric air; and it is with the view of preventing these changes that different modifications of the process of evaporation in making extracts have been proposed.

Evaporation may be effected :—

1. By the direct radiation of heat from a fire upon the bottom of an uncovered evaporating-pan or dish. This is called *evaporation over the naked fire.*

2. By the conduction or convection of heat to the pan, through the medium of water or steam. This is called *evaporation by the water-bath or steam-bath.*

3. By the application of heat by either of the foregoing methods, together with the removal of atmospheric contact and pressure from the surface of the evaporating liquid. This is called *evaporation in vacuo.*

4. By the spontaneous diffusion of the vapour of the liquid into the atmosphere, assisted by a current of air passing over the surface of the liquid. This is called *spontaneous evaporation.*

*Evaporation over the naked fire*, is sometimes resorted to where rapid concentration is required. Where a large quantity of decoction or infusion has to be inspissated to the consistence of an extract, it is not unusual to adopt this method of concentrating the liquor in the first instance, before resorting to the use of the water-bath. This indeed is the mode of proceeding which is prescribed by the London College, in the preparation of many of the extracts ordered in the Pharmacopœia. Thus, the extracts of gentian, liquorice, hop, poppy, sarsaparilla, dandelion, &c., are directed to be made by macerating the vegetable ingredients in boiling water for twenty-four hours, then boiling down to one-half, straining the liquor while hot, and finally evaporating to a proper consistence in the water-bath. In these cases it must have been intended that the boiling down to one-half should be performed over the naked fire; for the liquors could not be boiled in the water-bath, which is the only other process alluded to in the Pharmacopœia for the preparation of extracts.

This method of evaporation, however, is subject to great objections, although, certainly, these do not apply so strongly in reference to the first concentration of the liquors, as to the subsequent inspissation of the extract. Yet, in every stage of the process, evaporation over the naked fire, with an uncased open pan, is liable, in unskilful hands, to result in the injury, if not destruction, of the properties of the product. It cannot be denied, indeed, that a skilful and experienced operator will often effect all that can be desired with these means of evaporation, but with deficiency of judgment, or want of attention and care, an opposite result would inevitably be attained.

In evaporating a liquid over the naked fire, especial attention should be paid to the condition of the fire, and the position of the pan in reference to it. The pan ought in no case to be in contact with the ignited fuel: the heat received by the pan should be that of radiation, not of conduction. There should even be a considerable distance between the bottom of the pan and the surface of the fire, especially when the extract begins to thicken; the fire should now, also, be clear and low, so that an equable and not too intense heat may radiate upwards. Moreover, in operating in this way, it is not desirable to have a very small quantity of extract in the pan at a time, as in this case it would be more difficult to avoid the application of undue heat.

*Evaporation by the water-bath*, or *steam-bath*, has almost wholly superseded the process last described, and is the method now generally adopted in the preparation of extracts. The water-bath and the steam-bath are here classed together, because they have some characters in common; but in the practical application of these two means for effecting evaporation, it will be found that they differ from each other in some important particulars.

*The water-bath* is an arrangement by which the heat of boiling water is applied to the outer surface of the vessel containing the evaporating liquid. Thus, a double or jacketed pan, with the intermediate space between the pan and its outer case partly filled with water, constitutes a water-bath. If this be placed over a fire, the temperature of the water in the jacket rises to the boiling-point, and all excess of heat beyond this passes off in the steam, which has free means of escape. The greatest amount of heat, therefore, applied to the *outer surface* of the pan containing the evaporating liquid is 212°; and as the metal of which the pan is composed offers some obstruction to the passage of the heat through it, the liquid within will only attain to a temperature a few degrees *below* the boiling-point. Hence water cannot be boiled in a water-bath, and the evaporation which takes place under these circumstances is confined to the surface of the liquid.

In *the steam-bath* the steam is employed under pressure, and consequently at a temperature above 212°. Thus, the temperature will be 226° Fahr., if the pressure be five pounds to the square inch; and, rising with increase of pressure, it will be at about 233° when the pressure is seven pounds and a half, and 240° when the pressure is ten pounds to the inch. Now, steam at a pressure of five pounds to the inch, when applied to the outer surface of the pan, will heat the liquor contained in the pan to the boiling-point, and therefore a steam-bath with steam at the lowest of the above temperatures, by maintaining the evaporating liquor in a state of ebullition, will effect much more rapid evaporation than the water-bath will.

In the inspissation of extracts, when the process is conducted in vessels open to the access of atmospheric air, it is important to effect the required evaporation rapidly, and without the application of a high temperature. In the water-bath the temperature is lower, but the rate of evaporation is very much less rapid than it is in the steam-bath. When evaporation takes place at a temperature below the boiling-point of the evaporating liquid, as is the case with the water-bath, the rate of evaporation depends on the extent of surface of the liquid exposed to the air, on the temperature of the liquid, and on the temperature and state of dryness of the air which is in contact with it. The reduction of a few degrees in the temperature of the evaporating liquid below the boiling-point occasions a great diminution in the rate of evaporation, as will be seen in the following table:—

WATER.

| Temperature. | Rate of Evaporation. |
|---|---|
| 212° | 512 |
| 180° | 256 |
| 150° | 128 |
| 125° | 64 |
| 100° | 32 |
| 79° | 16 |
| 58° | 8 |
| 38° | 4 |

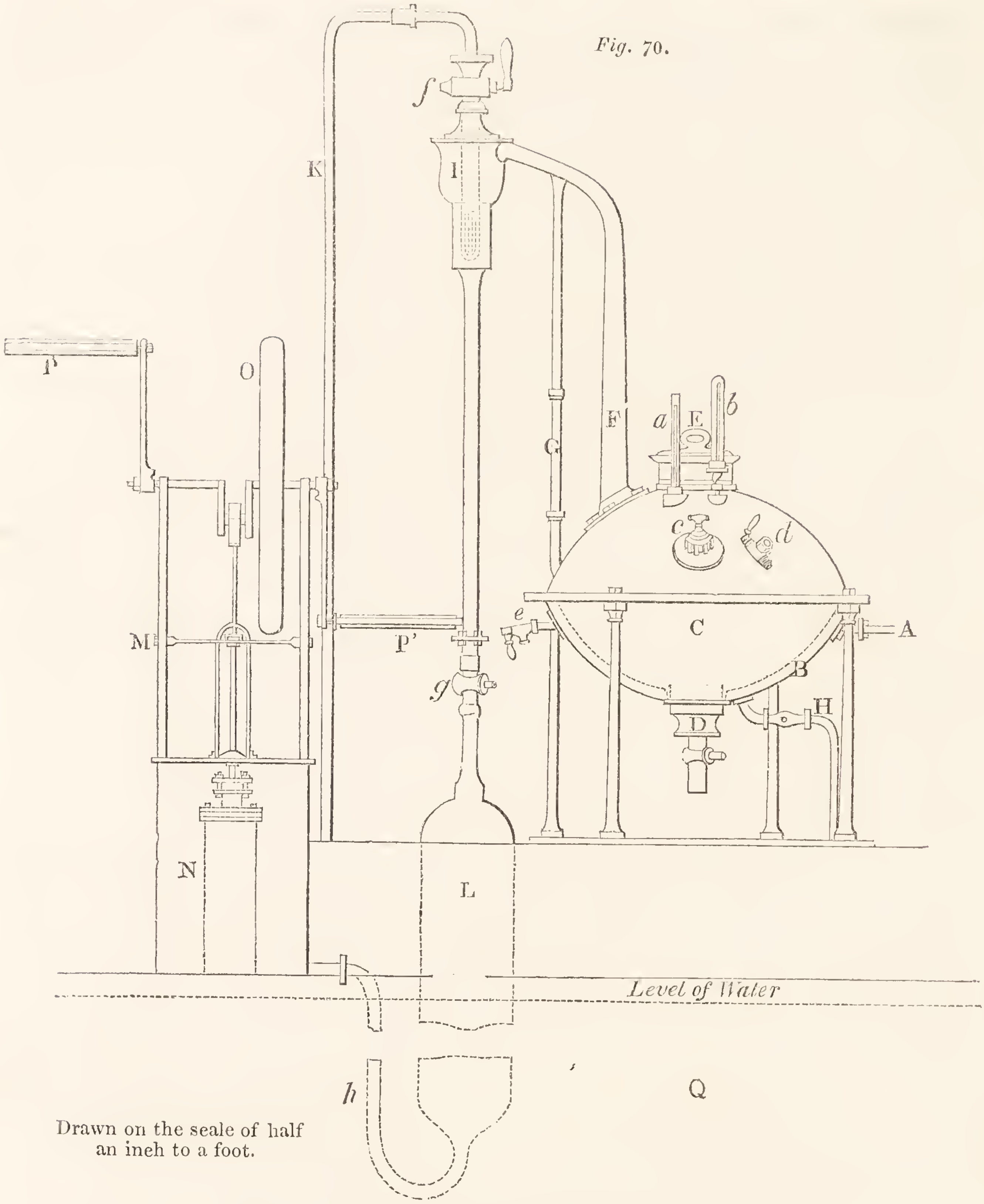
When evaporation takes place at the boiling-point, and therefore accompanied with ebullition, as is the case with the steam-bath, the rate of evaporation depends, principally, upon the extent of surface to which the heat is applied.

The more rapid evaporation obtained by the steam-bath, gives to this method of operating a great advantage over the water-bath; the ill effects of the slight increase of temperature being more than compensated for, by the diminution of time during which the extract is exposed to the combined influences of heat and atmospheric air. It must be observed, however, that the steam-bath cannot be safely and advantageously used in the preparation of extracts, if the steam be under a pressure much above five pounds to the inch, and in some cases it is desirable to have it even less compressed than this. The temperature of steam under a pressure of ten or twelve pounds to the inch would materially injure the product, especially in the latter stage of the process.

The steam-bath offers great facilities for regulating the temperature, by the admission of more or less steam into the jacket, or, if necessary, by its total exclusion, which may be effected instantly. In this way the heat is completely under the control of the operator, and a little skill in the management of the valves, and in manipulation, will enable him to guard against the injuries resulting from its injudicious application. When steam under pressure is used, it is not desirable to operate upon a very small quantity of extract at a time, for the reason that has already been assigned in treating of *evaporation over the naked fire.* It will also be found that a pan that is rather deep will be preferable to one that is very shallow. It is even necessary to observe some caution in the use of the rotating stirrer, or agitator, (fig. 61,) for if there be not much extract in the pan, this, by the rapid rotation of the agitator, would be spread in a thin stratum over the surface of the sides of the pan, where the metal is at a higher temperature, and the heat thus applied, together with the extended contact with atmospheric air, would cause speedy decomposition of the vegetable principles present. In preparing the extracts, or inspissated juices, which have a green colour, from the presence of chlorophyle, if they be treated in this way, the colour will be almost instantly destroyed.

In making the extracts of henbane, hyoscyamus, aconite, and others of this description, the practice is frequently adopted, of collecting the chlorophyle, or green colouring matter, which separates together with the albumen on first heating the expressed juice, by passing the liquor through a sieve or other strainer. This is kept, excluded as much as possible from the air and light, until the remaining part of the juice has been inspissated, and it is then mixed with the extract to give it the green colour, which is, by many, considered a test of its good quality. This practice may serve for the deception of those to whom the extract is sold, but it can answer no good purpose. The chlorophyle itself possesses no medicinal activity, and its rejection altogether has been proposed by some pharmaceutists, with a view to the improvement of the extracts. If, however, it be retained, as is directed in our pharmacopœias, it should be subjected to all the influences to which the other parts of the extract are exposed, so that it may serve as an indicator of the care and judgment which have been exercised during the process of evaporation; for as this substance is very easily decomposed, and its green colour destroyed, by those agencies which cause the decomposition of other more active constituents of the extract, its unaltered condition, if it have remained present during the whole process, will afford good grounds for assuming that the extract in other respects is uninjured.

*Evaporation in vacuo*, affords the most perfect means for the preparation of extracts. The sources of deterioration to the product, which the other methods present, are not found here, if the proper arrangements be adopted. By enclosing the liquor to be inspissated in an air-tight still, and removing the air from the interior of the vessel, evaporation is rapidly effected at a much lower temperature than that employed in either of the processes hitherto noticed, and without the possibility of injury from the contact of the atmosphere. The only obstacle to the general adoption of this method arises from the great expense of the requisite apparatus. Mr. Barry first introduced the use of the *vacuum-pan* in the inspissation of extracts; but the apparatus and mode of operating which he recommended, and for which a patent was taken out, has not been found, practically, to be the best. My attention was directed to this subject some years ago, and the result of experiments then made has convinced me that the form of apparatus now so extensively employed by the sugar-refiners for the concentration of their syrups might be advantageously applied to the preparation of medicinal extracts. This apparatus consists essentially of an air-tight still, to the receiver or condenser of which a pump is attached, which is kept in constant action. By this means the apparatus is first exhausted of the air, and the condensed water and steam are subsequently pumped out as fast as they collect in the receiver. The apparatus which I principally employed in my experiments is represented in fig. 70. It was




Apparatus for preparing Extracts in Vacuo.

A. Pipe for conveying steam to the steam-chamber.
B. Steam-chamber for heating the pan.
C. Body of the pan.
D. Aperture for the discharge of the contents of the pan. This aperture is fitted with a plug, which is removed on taking out extracts, and has a stop-cock for the discharge of liquids.
E "Man-hole" for charging the pan, having a cap which fits on air-tight.
F. Neck for conveying the steam from the body of the pan.
G. Glass tube for indicating the boiling up of the contents of the pan.
H. Pipe for conveying the waste steam from the steam-chamber.
I. Perforated copper funnel for supplying a shower of cold water to the descending steam-pipe and condensing cylinder.
K. Pipe for conveying water from the cistern underneath the apparatus, to supply the perforated funnel.
L. Condensing cylinder, partly immersed in cold water, for receiving the steam from the pan, and the condensing water from I.
M. The frame of the air-pump.
N. The barrel of the pump, connected by the pipe *h* with the cylinder L, and standing in a cistern of water.
O. The fly-wheel of the pump.
P, P. Handles of ditto.
Q Cistern of cold water underneath the floor.
*a*. Thermometer inserted in the pan.
*b*. Barometer, for indicating the exhaustion of the interior of the pan.
*c*. "Proof-stick," for taking out small quantities of the contents of the pan, to observe the state of inspissation, without destroying the vacuum.
*d*. Stop-cock for admitting air into the pan.
*e*. Valve for letting out the air on the admission of steam into the steam-chamber.
*f*. Stop-cock for regulating the supply of condensing water to the perforated funnel.
*g*. Stop-cock for shutting off the communication between the pump and the pan.

originally made as a model of a sugar-pan, and is adapted for working about fifteen gallons of liquor at a time. The drawing, however, differs in some respects from the arrangements now generally adopted by the sugar-refiners. The neck (F) is now usually made much shorter and thicker than the drawing represents, and the perforated funnel (I) is dispensed with, the steam itself being pumped into a cistern of water, where it is condensed. It would also be desirable to have the steam-chamber (B) much more capacious than it is here represented.

The liquid to be inspissated is put into the pan at E, and the cap fitted on. The steam is now admitted into the steam-chamber, and the air exhausted from the interior of the apparatus by means of the pump. A vacuum being produced, active ebullition will take place when the temperature rises to about 120° Fahr. The vapour passes up the neck (F) and through the descending pipe into the cylinder L. A jet of cold water is now allowed to run at *f*, and is dispersed in a shower by means of the perforated funnel (I), assisting to condense the steam in its passage into L, from whence it is removed, together with the condensed steam and any air remaining in the apparatus, by means of the pump. The pumping is continued until the completion of the process, and thus a pretty complete vacuum is maintained, and a rapid evaporation ensured.

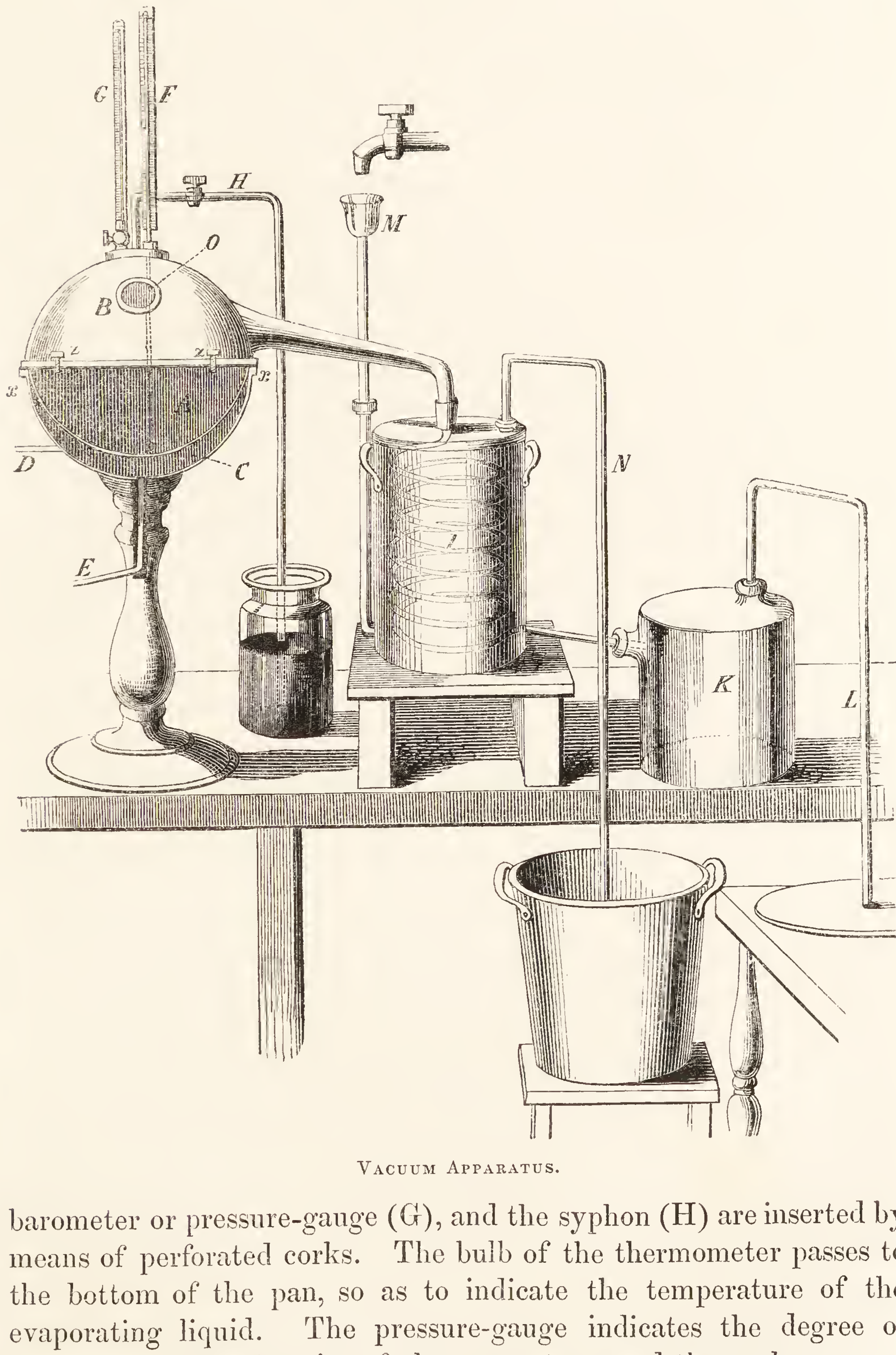
As the loss of some of the contents of the pan may arise from their boiling up through the neck (F), and being carried off by the pump, a glass tube (G) is made to communicate between the pan and the upper part of the neck, so that when the liquid is seen to rise in this tube, the pumping is immediately stopped, and, if necessary, air is admitted into the pan by the stop-cock *d*, which effectually suppresses the ebullition. No more water should be admitted through the perforated funnel (I) than is sufficient, with the external application of cold water to the cylinder, for the condensation of the steam. This is ascertained from the temperature of the descending steam-pipe and the upper part of the cylinder. The admission of too much water would tend to destroy the vacuum, by supplying air to the interior of the apparatus.

The steam used for heating the pan ought not to be under a pressure of more than one or two pounds to the inch, and there should be a plentiful supply of it. The amount of heat carried off during evaporation is precisely the same in this process as it would be if conducted under the pressure of the atmosphere at a much higher temperature, for at whatever temperature the vapour of water rises, the sum of its sensible and latent heat is always the same. Thus,

| | | | | | | |
|---|---|---|---|---|---|---|
| Water evaporating at | 32° | has | 1180° | of latent heat | = | 1212° |
| „ „ | 100° | „ | 1112° | „ | = | 1212° |
| „ „ | 212° | „ | 1000° | „ | = | 1212° |
| „ „ | 300° | „ | 912° | „ | = | 1212° |

It will therefore be evident, that, in evaporating a liquid, exactly the same amount of heat is always required, whatever process may be adopted; whether it be by boiling under the pressure of the atmosphere, by spontaneous evaporation, or evaporation *in vacuo*, in each case the heat required for the vaporization of a given quantity of liquid will be the same, and this quantity for water will be equal to 1212°, as the amount of sensible and latent heat. Fig. 71 represents a smaller apparatus, which I have been accustomed to use for experimental purposes: it will serve to illustrate the essential parts of a vacuum-pan, in its most simple form. A, is a jacketed-pan supported on a cast-iron stand. There is a thick brass flange to the top of this pan at *x x*, which is ground to a smooth surface in the same way as the plate of an air-pump is. The top or head (B) also has a similar flange, which is ground so as to fit closely on to that of the pan. Between these two flanges is placed a washer of *vulcanized India-rubber*, which is compressed by four screws, two of which are seen at *z z*, and a perfect air-tight union is thus made, which may be disconnected and re-formed with very little trouble. Before trying the *vulcanized India-rubber*, I found it very difficult to make a sound temporary joint between the pan and its cover, without using some substance the presence of which was objectionable. Common India-rubber cannot be used, on account of the action of the heat upon it, but when vulcanized, it is no longer affected by the heat to which it has to be subjected, and in every respect it fulfils all that is desired. The *vulcanized India-rubber* is sold in sheets about the sixteenth of an inch in thickness, out of which the washer must be cut in one piece, allowing a little for its expansion when compressed. Two circular plates of thick glass are inserted on two opposite sides of the cover of the pan, as shewn at O, so as to enable the operator to observe the progress of the inspissation in the pan. The neck is fixed to the head of the pan in such a manner, that, by means of a groove inside the head, just above the flange, whatever vapour is condensed in the head is carried off by the neck instead of returning to the contents of the pan. The beak of the neck is attached by an air-tight joint to a condenser (I); and the lower end of the worm of this condenser is inserted into a two-necked bottle (K), from the other opening of which a tube (L) is carried, which is attached to a good air-pump. At the top of the head of the pan there is a brass plate with three openings, through which the thermometer (F), the

*Fig.* 71.




VACUUM APPARATUS.

barometer or pressure-gauge (G), and the syphon (H) are inserted by means of perforated corks. The bulb of the thermometer passes to the bottom of the pan, so as to indicate the temperature of the evaporating liquid. The pressure-gauge indicates the degree of exhaustion of the interior of the apparatus; and the syphon serves to supply fresh portions of liquid to the pan, from any vessel into which the lower end of it is immersed, by opening the stop-cock, during the progress of the evaporation, without affecting the vacuum.

The liquid to be evaporated being introduced into the pan, and the joints all made tight, exhaustion is effected by the pump, which communicates with the receiver (K), the worm of the condenser (I), and the interior of the pan (A). When the mercury in the pressure-gauge has been reduced to a column of four or five inches, steam is conveyed through the pipe D, to the steam-chamber (C), while the water which collects here from condensation is carried off by the pipe E. The action of the pump should now be resumed, and continued throughout the process. The liquid, if aqueous, will commence boiling when heated to about 120° Fahr., and the evaporation may be actively kept up at a temperature varying from this point to 140° Fahr., according to the degree of exhaustion maintained and the state of inspissation of the extract. The condenser must be continuously supplied with cold water, which enters through the tube M at the bottom, while the hot water passes off from the top through the tube N.

It may be well to observe, that the preparation of extract of sarsaparilla by this process is attended with considerable difficulty, in consequence of the tendency of the liquor to froth up, and thus pass over into the receiver.

*Spontaneous evaporation*, has within the last few years been very successfully applied in the preparation of extracts. This process consists in the means for effecting evaporation at the ordinary temperature of the atmosphere. Practically, however, artificial heat to a certain extent is generally employed, and the process is still called one of spontaneous evaporation, if conducted at the temperature of a drying-room. The first specimens of extract prepared by this process were made by exposing the liquid in shallow vessels to the direct rays of the sun. Extracts of very good quality have been thus made from the expressed juices of some of our indigenous plants, such as hemlock, henbane, belladonna, dandelion, &c., by merely exposing them, in large shallow pans, in the open air, during fine warm summer weather. But the climate of this country is too uncertain to admit of the general adoption of this means of inspissation, and numerous contrivances have therefore been resorted to for promoting evaporation at low temperatures by artificial means.

The evaporation of water and other liquids at temperatures below their boiling-points is due to the diffusion of their vapours into the superincumbent atmosphere. All gases and vapours have a tendency to diffuse themselves into—that is, to become intimately mixed with—other gases or vapours that they have access to. In the case of water, it is found that the extent to which the diffusion of its vapour will take place in air, is the same as would occur at a like temperature into a vacuum of the same area. The amount depends on the temperature of the air or vacuous space. Thus, the quantity of vapour of water that a given volume of air is capable of holding in diffusion at 60° Fahr. is double what it would be at 40°.

In effecting spontaneous evaporation, therefore, the rapidity with which the process is conducted will depend,—1. *On the previous state of dryness of the air;* for as air can only hold a certain limited quantity of vapour of water in suspension, whatever it may already contain will so far limit its power of inducing diffusion; and if it be already saturated, no further diffusion can take place into it: 2. *On the temperature of the air;* for the higher the temperature, other circumstances being equal, the greater the amount of vapour it is capable of taking up: 3. *On the removal of the superincumbent air as soon as diffusion has taken place into it;* for the speed with which the vapour rises is greatly retarded as the air becomes partly saturated.

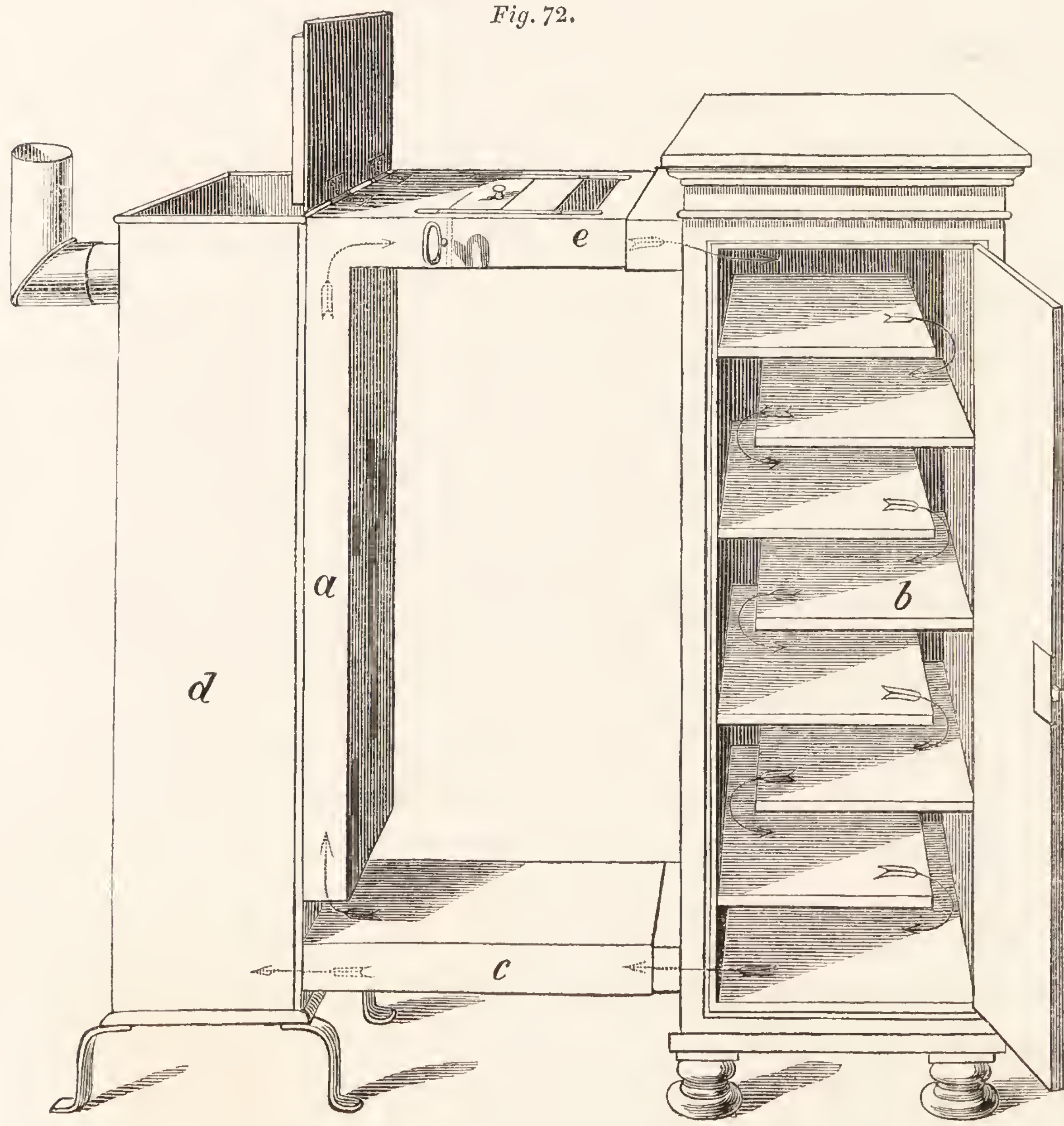
The most effectual means for promoting spontaneous evaporation consists in causing a current of warm dry air, to pass over the surface of the evaporating liquid. In fact, an efficient drying-closet, or drying-room, constitutes the essential part of the required arrangement; but in the preparation of extracts it is much more important to adopt *all* practicable means for expediting the process, than it would be in the ordinary use of a drying-closet for the desiccation of plants or drugs.

The principal obstacle to the application of spontaneous evaporation in the preparation of extracts arises from the difficulty there is in ensuring the speedy evaporation by this means of large quantities of liquid in all states of the weather. Most of the plans hitherto recommended have been applicable only to operations on the small scale; indeed, the process has hitherto been applied principally to the preparation of small quantities of some particular extracts, which are supposed to be much injured by the application of heat. Some of the specimens thus prepared, however, have been of very superior quality, possessing the peculiar flavour and aroma of the plant, I think, in a higher degree than is usually the case with those prepared by the vacuum process. It is a question, therefore, deserving careful investigation, whether it be not possible to construct such a drying-closet as shall ensure the uniform, speedy, and economical evaporation of large quantities of liquid at the temperature contemplated in this process.

I have found that a drying-loft at the top of the house, with louver boarding on two opposite sides of it, admitting a current of air to pass through, and one of Arnott's stoves fixed in the centre of the room, to maintain a constant temperature of about 80°, afforded means for evaporating many gallons of liquid in the course of a day in favourable weather, if the liquor be exposed in very shallow vessels. When the weather is unfavourable, however, this arrangement does not answer well.

The drying-closet attached to the *pharmaceutical stove*, described at page 5, is constructed on a principle which, I believe, would admit of successful application for the purpose here contemplated.

*Fig. 72.*



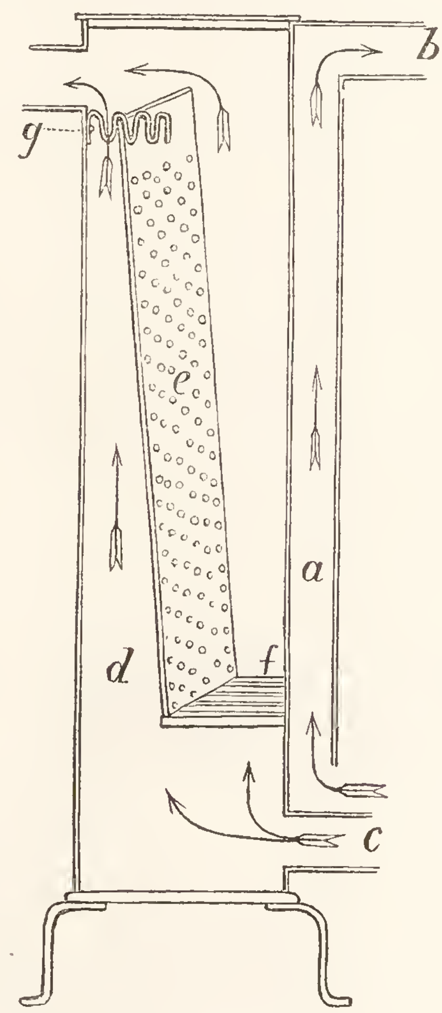

Apparatus for spontaneous Evaporation.

I have constructed a small closet on this principle expressly for the preparation of extracts, with the view of trying its efficacy, and can strongly recommend its adoption on the large scale. Figs. 72 and 73, which represent the apparatus as I have used it, will serve to explain all the essential features of the arrangement, but some modifications would perhaps be required in applying it on the large scale.

The closet (*b*, fig. 72) is furnished with shelves, fixed as shewn in the drawing, and a door which fits closely when shut. Air enters the closet through the tube *a e*, and passing down over the shelves in the manner indicated by the arrows, it escapes through the tube *c* into the bottom of the stove (*d*).

A section of the stove is shewn in fig. 73, from which its construction will be better understood. The grate (*f*) and the perforated iron plate (*e*) form the fire-place, which is supplied with gas-coke, or other suitable fuel, through the top, which opens as shewn in fig. 72; and the combustion is supported by the air which is drawn from the closet through the tube *c*. The size of the fire-place is regulated by inclining the perforated plate (*e*) more or less, by means of a support (*g*) at the top, and a space (*d*) is left for a current of air to pass into the chimney.

*Fig. 73.*

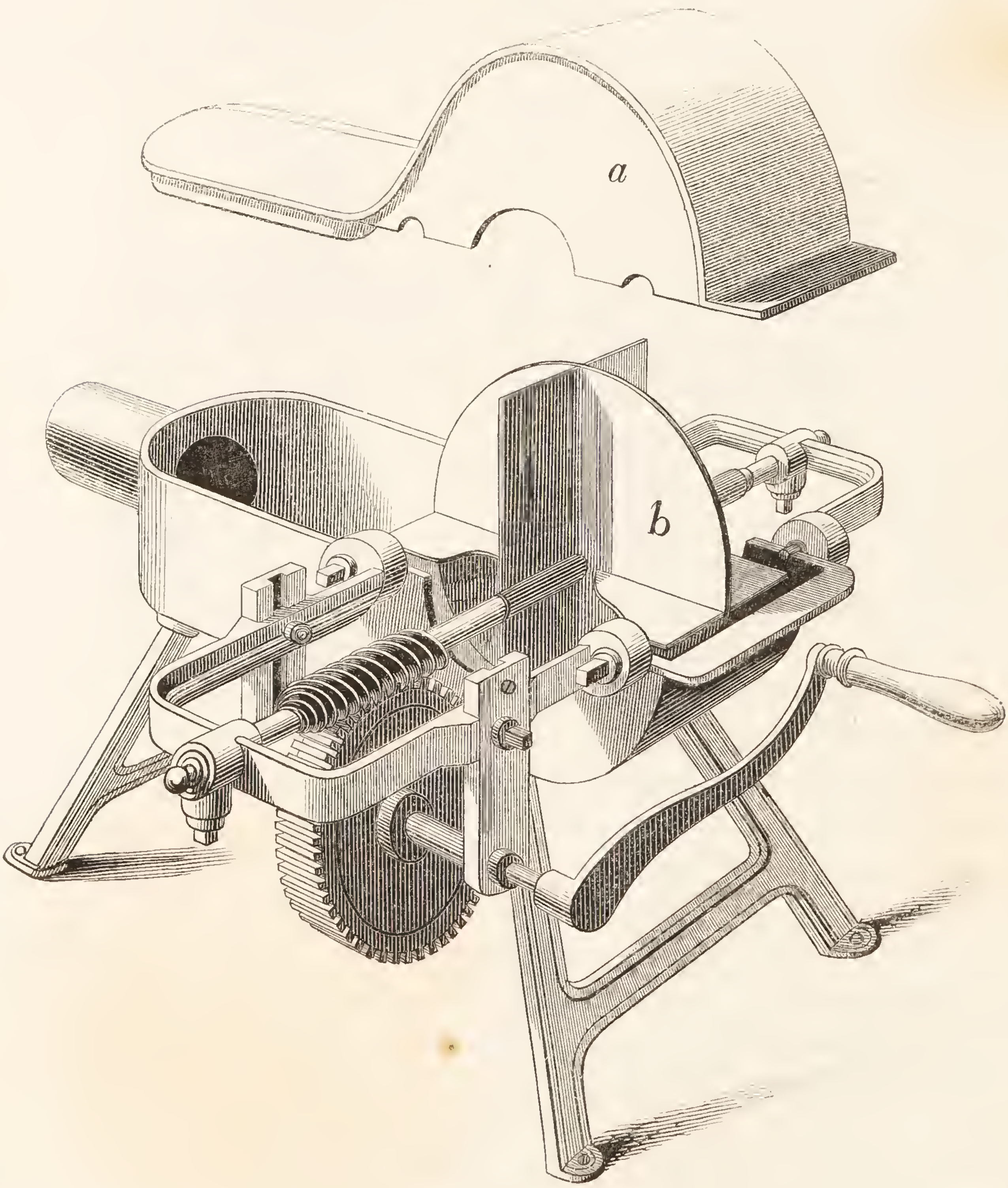



SECTION OF STOVE.

When the stove is in operation the air passes through *a*, in contact with the heated metal of the stove, and enters the top of the closet in a state best adapted for absorbing moisture. There is a sliding door in the tube *e*, (fig. 72,) by which air can be admitted there if required, and a valve for checking the current through *a*, by which means the temperature of the air as it enters the closet can be regulated. The higher the temperature of the air, of course the more rapid will the evaporation be; and a heat of 100° does not appear to be too high in reference to its influence on the extract under operation. The air entering the closet at this temperature comes in contact with the liquid to be evaporated, which is placed on the shelves in shallow vessels. Diffusion of the vapour of water takes place into the heated air, and this is necessarily accompanied by a reduction of temperature: the air, therefore, becomes specifically heavier, in consequence of the moisture it has absorbed and its reduced heat; hence it tends downwards, whilst its place is supplied by fresh particles of warm and less saturated air from above. Each particle of air thus traverses the surface of all the trays containing the evaporating liquid, commencing at the top in its most efficient state, and finally passing off at the bottom reduced in temperature and loaded with moisture. On entering the stove, part of the air contributes to the support of the combustion, and the remainder, now again heated by the fire, rapidly passes off through the chimney.

A blowing-machine has sometimes been employed for sending a current of air through a closet used for spontaneous evaporation;

*Fig. 74.*




Blowing Machine.

but I have not found this method to be efficient unless it be accompanied by means for supplying heat. Every ounce of water evaporated, whatever the process adopted may be, absorbs as much heat as would be sufficient to raise the temperature of that water to 212° Fahr. The reduction of temperature occasioned by spontaneous evaporation is, therefore, very great, and provision must be made to compensate for this reduction, if rapid evaporation be required. Accompanied with such provisions, however, a blowing-machine may be advantageously used. Fig. 74 represents a very efficient machine, by which a powerful blast of air is propelled. The cover (*a*) is removed, to shew the construction of the fanners (*b*), to which very rapid motion is given by the accelerating wheels.

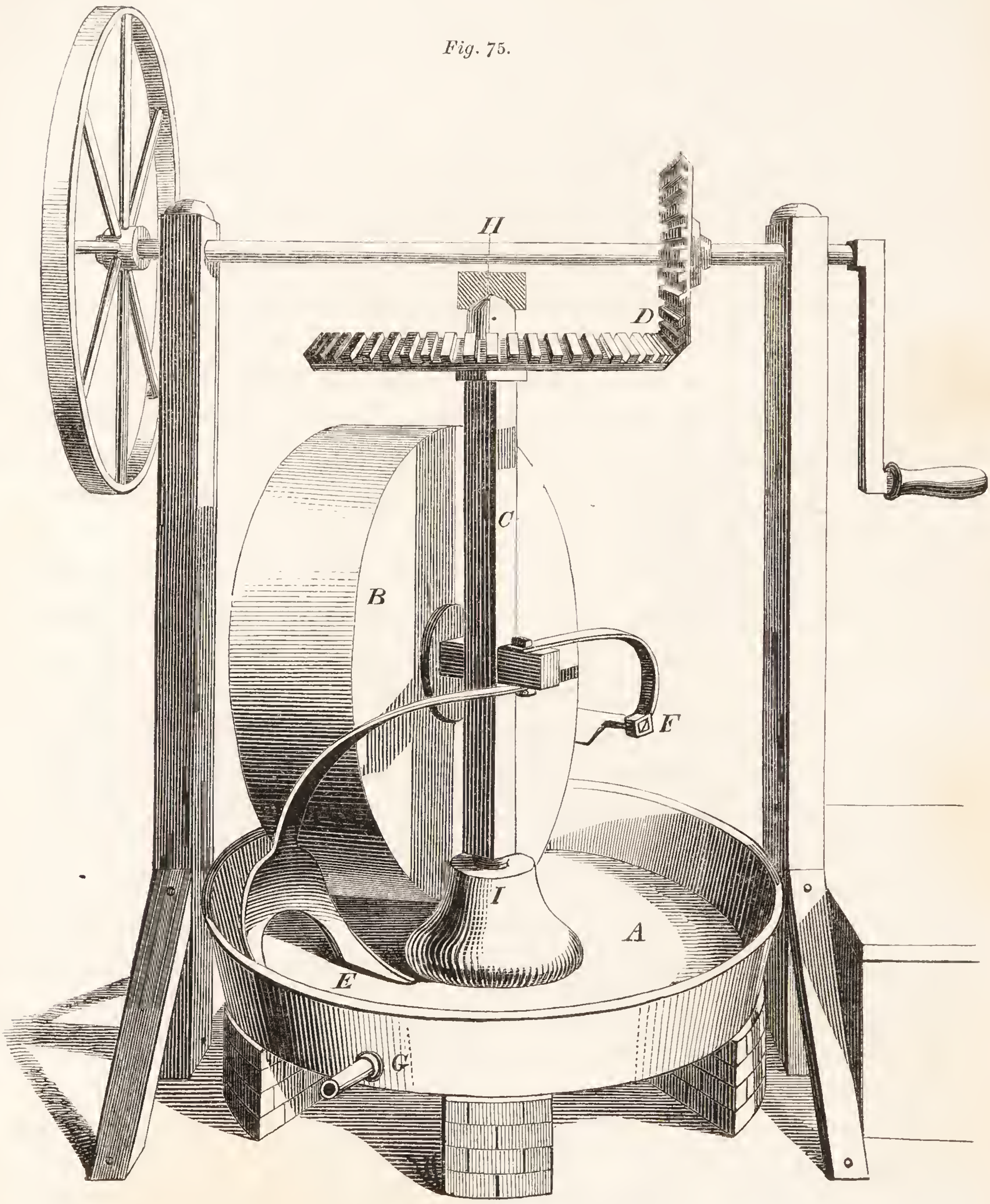
But, even under the most favourable circumstances, spontaneous evaporation will be a much slower process for the preparation of extracts, than any of those previously noticed, unless the extent of evaporating surface be greatly extended. The operator will, therefore, be inevitably disappointed in the result, if his provisions be not made on a very ample scale, a small room, rather than a closet, being required, where large quantities are operated upon.

There is yet another point deserving of notice in connexion with the preparation of extracts. Those who are much engaged in these manipulations frequently experience difficulty in providing efficient means for crushing the recent herbs, from the expressed juices of which some of the most active and valuable of the medicinal extracts are made. This operation is sometimes performed with the pestle and mortar; but the time and labour expended in crushing a large quantity of herb in this way occasions a considerable increase in the duration of the process and the cost of the product. In making the extracts now under consideration, the herb ought to be gathered, crushed, and pressed, and the liquor evaporated to the proper consistence, in one and the same day; and this can only be done where efficient means are provided for accelerating every step in the process.

The best apparatus for crushing herbs is that represented in fig. 75, which is commonly known as the *Pugging-mill*. It consists of the platform A, with raised sides, which may be made of thick cast-iron, and set on brick-work. On this a large stone runner (B), turning on an axle fixed to the beam C, is trundled round by the winch and bevelled wheel and pinion (D). The outer surface of the runner is not bevelled, but is at right angles with the lateral faces; therefore, if trundled without controul, it would move in a straight line, and, in being carried round the axis C, which works in two sockets at H and I, a peculiar grinding motion is maintained, which contributes greatly towards producing the effect required.

The substance to be crushed or ground is placed on the platform, in the path of the runner, which passing over it, the weight of the stone, together with the friction occasioned by the particular

*Fig. 75.*




DRUG-MILL, OR PUGGING-MILL.

motion alluded to, causes the required disintegration. In continuing this operation, the partly disintegrated substance will be dispersed on each side of the course of the stone, and this is again put into its proper position by the *plough* (E) which precedes the runner, while the *scraper* (F) is fixed behind to remove any portion of the substance that may adhere to the stone and obstruct its progress or action. Any juice that escapes during the process will run off through the pipe G.

This mill will be again alluded to in connexion with the subject of drug-grinding.]

Alcoholic and Ethereal Extracts and Tinctures.—Alcohol and ether swell out the fibres of plants to a much less degree than water does, and therefore the process of displacement may generally be conducted with these liquids without any difficulty. Indeed, it is more frequently found that the menstruum flows too rapidly, by the formation of channels. Vegetable powders should therefore be reduced to a finer state of division, and compressed more closely in the cylinder, when intended to be acted on by alcohol or ether, than would be the case when water is used.

In the preparation of aqueous extracts, it is an object of some importance, to effect the exhaustion with as small a quantity of liquid as possible, partly with the view of preventing decomposition resulting from a protracted evaporation, and partly from motives of economy in the use of fuel. But, when alcohol or ether is used, the only consideration will be the economy of the menstruum, on account of its expense.

If the relative merits of the two processes already adverted to, namely, those of expression and displacement, be compared, in reference to the preparation of alcoholic and ethereal solutions, the advantage in economy will be found to be on the side of expression.

The common mode of proceeding is, to digest the substance with spirit in a retort or alembic, and then to place the mixture, when completely cold, on a straining-cloth, and, after allowing as much of the liquor as will do so spontaneously to run through, to press the remainder strongly with the hands.

This very simple process has the disadvantage of involving a rather considerable loss of spirit, and a still greater loss if the menstruum be ether. In the latter case the loss may amount to nearly three-fourths the quantity used, if the process be on the small scale.

It is a great improvement, in conducting this process, to effect the extraction and expression in the same vessel, in the manner already described under the head of "Real's Press," and illustrated by figs. 65, 66, 67, and 68. The access of air, which occasions so serious a loss of spirit or ether, is thus avoided.

If the substance to be acted upon be in the form of powder, it should be placed in the cylinder of the press in a bag of loose texture. The fluid, as it runs through, should not be collected in an open vessel, such as a dish, but should flow at once into a bottle.

Notwithstanding these precautions, however, considerable loss is sustained in preparing ethereal extracts, in consequence of the great volatility of this liquid; and when only small quantities are operated upon, the loss from spontaneous evaporation and absorption by the bag is so great, as to render it scarcely worth the trouble to recover the remainder by distillation.

I have recently constructed an apparatus, consisting of a perfectly close vessel, for effecting extraction with small quantities of ether, and for recovering the ether by distillation.

Figs. 76, 77, and 78 represent this apparatus, which consists of a two-necked Woulf's bottle, (fig. 76, *p*,) into the central mouth of which the metallic vessel (R, fig. 77) is fitted by means of a cork.

The vessel R consists of a metallic cylinder (*a*, figs. 76 and 77), having a perforated strainer (*k*) near the bottom, and terminating with a funnel-neck, to admit of its being fitted into the Woulf's bottle. This cylinder is surrounded by a second cylinder (*b*), the space between them being intended to contain either hot or cold water.

*Fig. 76.*

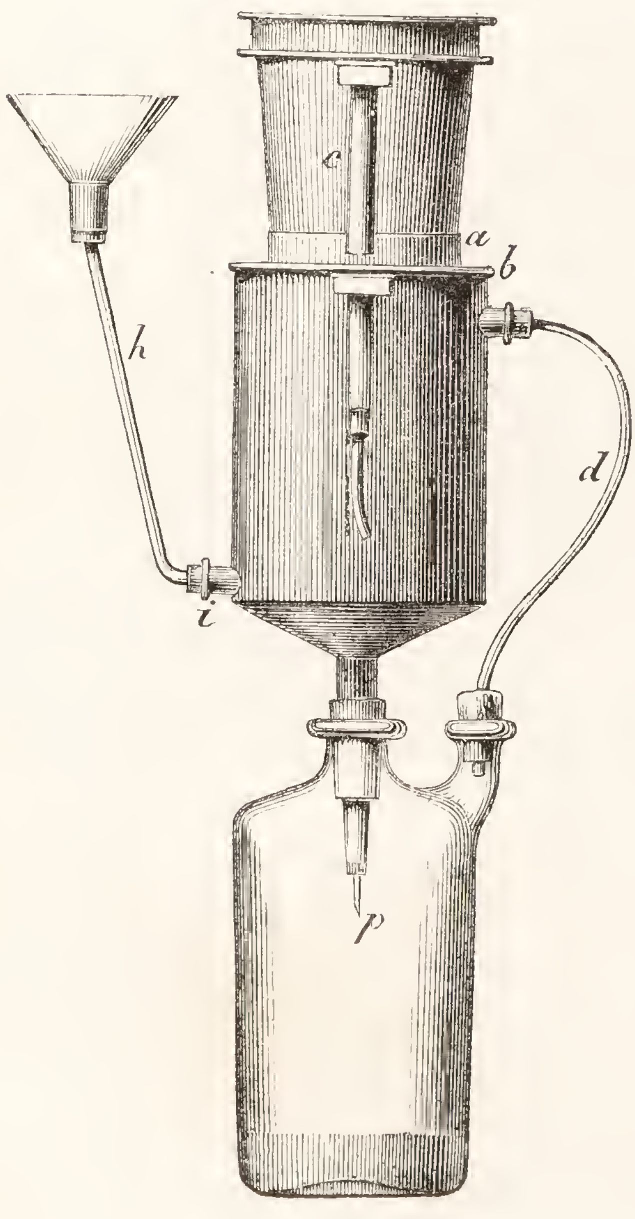
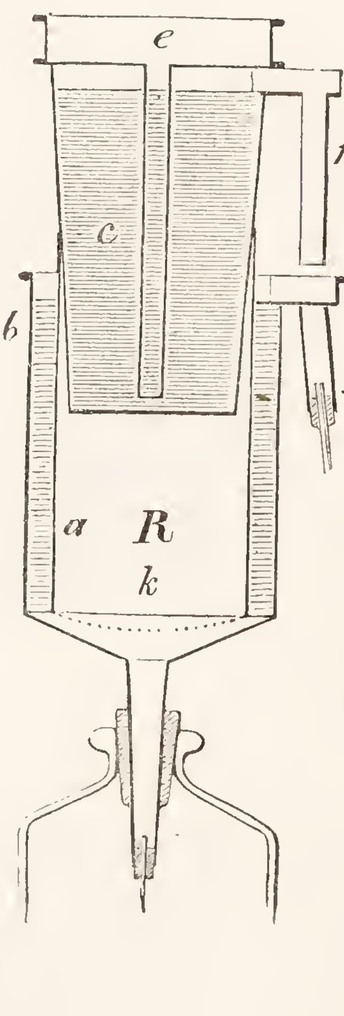


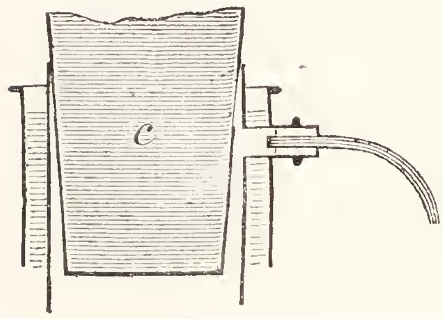

*Fig. 77.*




APPARATUS FOR MAKING ETHEREAL TINCTURES.

Into the top of the inner cylinder (*a*) a slightly conical vessel (*c*) is made to fit air-tight, as shewn in the drawing. This vessel (*c*) is intended to be used as a condensing apparatus, and for this purpose it is filled with cold water. From the second or lateral opening of the Woulf's bottle, a glass or tin tube (*d*) is carried to the upper part of the cylinder *a*, where it is inserted, as shewn in fig. 78. The cold water in the vessel *c* is renewed through the pipe *e*, which conducts it to the bottom, while the warm water runs off from the top through the pipe *f*. Hot or cold water is renewed to the space between the two cylinders (R), by the tube-funnel *h*, and the water from this space overflows into *g*, and is carried off together with that from *f*. The tube *h* is inserted through a perforated cork at *i*, so that, by turning the tube downwards, the water from the space between the cylinders can be thus allowed to run off.

*Fig.* 78.




The method of operating with this apparatus will now be easily understood. The substance, in coarse powder, is placed upon the preforated strainer in the space marked R, (fig. 77,) over a piece of flannel, cut to the size of the strainer. Ether is now poured over the substance to be operated upon, and allowed to percolate through it and run into the Woulf's bottle. The tube *d* is fixed in its place, and cold water is introduced into the space between the cylinders *a* and *b*, and into the vessel *c*. The bottle is now immersed in hot water, so as to cause the ether which has run into it to boil; and the vapour passing through the tube *d* into the upper part of the vessel R, is condensed there by the action of the surrounding cold water, and again passes in the liquid state through the substance to be exhausted. This circulation of the ether may be continued, without loss, until the solid substance is completely exhausted, which will be indicated by the ether dropping into the bottle colourless.

The extraction is in this way effected very rapidly. The following results were obtained from the treatment of eight ounces of worm-seed with ether. The worm-seed, in coarse powder, was put into the cylinder at R, and eight ounces of ether poured over it. The ether was nearly all absorbed by the powder, and scarcely anything passed into the bottle below: four ounces more of ether was therefore added, when a strongly-coloured solution passed. Heat was now applied, so as to boil and evaporate the ether, and in a few minutes afterwards a deep green liquor began to drop from the cylinder.

As the heat was continued and increased, the returning liquor increased in quantity, so as to run in a stream, until the perfect exhaustion of the worm-seed was indicated by the return of colourless ether. The apparatus was now taken out of the warm water, and allowed to cool. The cold water was in the next place removed from the space between the cylinders *a* and *b*, by turning down the tube *h*, and the water was also emptied out of the condenser (*c*). The tube *d* was removed, the neck of the bottle into which this had been inserted being at the same time closed with a cork; while from the opening into the cylinder, where the other end of the tube *d* had been inserted, a tube was fixed connecting it with a Liebig's condenser. Hot water was now poured through the funnel and tube *h* into the space between the cylinders, which, heating and vaporising the ether with which the powder was saturated, caused it to distil over through the condenser. This being completed, the vessel R and its appendages was removed from the Woulf's bottle, and a tube made to connect the mouth of the bottle with the Liebig's condenser; when hot water being again applied to the bottle, the ether distilled off, until a syrupy liquor was left, which was finally evaporated to the consistence of butter in a porcelain dish.

The eight ounces of worm-seed was thus completely exhausted in an hour and a half, with twelve ounces of ether, of which nine ounces was again recovered by distillation, and the resulting extract weighed ten drachms. With greater care in the condensation of the ether, I think another ounce might have been recovered.

This apparatus may also be applied in the process of extraction with spirit; but in this case it is necessary to apply more heat, by using a solution of chloride of calcium or a sand-bath.

If the principle of this apparatus were carried out on the large scale, and a metallic vessel employed instead of the glass bottle, the exhaustion of sabadilla-seeds, and even of bark, for the preparation of the alkaloids, might, no doubt, be accomplished with the smallest possible loss of alcohol.

[In making *Tinctures* the principal objects to be aimed at are—

1. To effect the solution of those parts of the solid ingredients used which are intended to be administered.

2. To obtain transparent solutions, which, when made at different periods, shall not vary in strength or composition.

3. To effect the above objects with the smallest possible loss of ingredients, or expenditure of time.

Three different processes have been adopted for the preparation of tinctures:—

1. The process by maceration as directed in the London Pharmacopœia.

2. The process by maceration as modified by Dr. Burton.

3. The process by percolation or displacement.

*Preparation of Tinctures by Maceration as directed in the London Pharmacopœia.*—This is a very simple process: it consists in putting the solid and liquid ingredients, together, into a stoppered glass vessel; allowing them to stand, generally for fourteen days, frequently shaking them during this time; and, lastly, straining off the solution. This is the method which, formerly, was always adopted for the preparation of tinctures. It has been thought, however, to be subject to some objections, and hence the introduction of other processes. When dry solid ingredients, either animal or vegetable, are macerated in spirit or other similar menstrua, as is the case in this process, the liquid immediately in contact with the solid matter at the bottom of the macerating vessel forms a saturated solution, which, being more dense than the liquid above it, prevents the contact and solvent action of the latter. It is on this account that the vessel is directed to be frequently shaken during the maceration; but when large vessels are employed, agitation is not easily effected, and, under any circumstances, the repetition of this very necessary part of the process is liable to be neglected.

*Preparation of Tinctures by Maceration as modified by Dr. Burton.*—This process has been proposed with the view of obviating the objections which apply to the process of maceration as usually conducted. It differs from the preceding in the adoption of an arrangement for suspending the solid ingredients near the top of the liquid, instead of allowing them to subside to the bottom. This is effected, either by having a perforated diaphragm midway between the top and bottom of the macerating vessel, on which the ingredients are put, or by enclosing the ingredients in a bag and suspending this bag by a string.

The advantages of this method of conducting the process as compared with the other are, that there is no necessity for shaking the vessel, and that the exhaustion of the ingredients is effected in a shorter time. The process is automatic: when the spirit begins to act on the solid, a coloured tincture will be seen to gravitate through the colourless and lighter spirit by which it is surrounded, the latter, at the same time, ascending and coming into contact with the solid matter. A descending and ascending current is thus established throughout the fluid, and continues until no more soluble matter is extracted.

This process is founded on the same principle as Mr. Alsop's method of making infusions, and a vessel, somewhat similar in construction to the infusion-pot described at page 39, might be used for effecting the maceration in the way proposed. It would be necessary, however, to have means for preventing evaporation of the spirit during the process, and this with a cylindrical vessel the mouth of which is not contracted involves some difficulty, and constitutes probably the greatest impediment to the general adoption of the process.

In making tinctures by maceration, according to either of the foregoing processes, it is important to attend uniformly to the instructions given, with regard to the time during which the ingredients are allowed to macerate. It is, however, sometimes difficult strictly to observe these instructions, especially where small quantities only are made at a time.

The number of tinctures employed in medicine is so great, and their consumption necessarily so unequal, that scarcely a week will elapse without its being found necessary to commence the preparation of some of them. There will, generally, therefore, be several tinctures macerating at the same time, which have been commenced at different periods, and it is difficult to recollect or attend to the precise time when the maceration in each case ought to terminate. The consequence of this is, that tinctures are often macerated for a much longer time than the Pharmacopœia directs. This is a common source of error in operating by this process, for the characters and properties of a tincture which has been allowed to remain for a long time in contact with the solid ingredients will often be found to differ considerably from what they would have been if the process had been terminated earlier.

Again: it often happens that the necessity for commencing the preparation of a tincture is only discovered when the stock on hand is nearly or entirely exhausted, and the tincture may perhaps be wanted for use before the maceration has continued for the proper length of time, so that there is a strong temptation to use it in its unfinished state. This is another evil resulting from the length of time occupied in the process of maceration. Moreover, when small quantities of tincture are made at a time, it is difficult to press the dregs completely, so as to avoid considerable loss of the product from this cause. Hence, many persons allow the dregs to accumulate in the macerating-vessel, making several fresh portions of tincture in contact with the dregs of previous preparations, until enough has accumulated to admit of their being efficiently pressed. This method of operating is subject, in an increased degree, to the objection which has already been urged against the prolongation of the process of maceration beyond the specified time. Thus the process for the preparation of tinctures by maceration is subject to some practical objections or difficulties. These are frequently experienced, and it was at one time thought that an easy means of obviating them had been discovered in the adoption of the process next to be described.

*Preparation of Tinctures by the process of Percolation or Displacement.*—This process is of comparatively recent introduction as a means of preparing medicines, although it has long been employed in the arts. It is sometimes called *lixiviation*, and under this designation it is especially applied to the solution of certain salts, as, for instance, in the preparation of soap-makers' ley. It is, of course, merely employed in those cases where only a part of the solid ingredients to which a liquid is added are soluble.

In making caustic leys for the soap-maker, it is important to recover all the alkali in solution from the mixture of lime and potash or soda, without using an undue quantity of water. This is done by allowing the solution first formed to run off from the solid residue, so much only remaining as is absorbed by the mass of moist carbonate of lime. This latter portion of solution is next removed by pouring some water over the surface of the wet mass, and allowing the liquid to run off through an opening at the bottom of the vessel in which the process is conducted. Under these circumstances the alkaline solution is displaced by the pressure of the column of water above it, and this displacement may be effected without any appreciable admixture of the two liquids, so that the whole of the alkaline solution is obtained without its being diluted to any sensible extent.

The same process is applied in a somewhat similar manner in brewing, with the view of obtaining as large a proportion as possible of saccharine matter from the grain in a concentrated state; and in this case the process is sometimes called *sparging*. In both the above instances water is used as the menstruum, and the process is usually conducted continuously with repeated quantities of fresh ingredients under circumstances which greatly favour its successful application. The results have proved satisfactory.

In making tinctures by this process spirit is used as the menstruum, and the circumstances under which the process is conducted are less favourable, than in the other cases mentioned, to its complete success. The results, therefore, have proved but partially satisfactory. There are some cases, however, in which displacement may be advantageously applied in the preparation of tinctures; it is mentioned in the Edinburgh Pharmacopœia as one of the means which the pharmaceutist is allowed to adopt in making most of the tinctures for which formulæ are given in that work, and for some of them it is recommended as the best process.

Several forms of apparatus have been adopted by different operators for performing this process. Some of these have been already noticed at pages 60, 61, and 65. In its essential parts the apparatus always consists of a cylindrical or conical vessel into which the solid and liquid ingredients are put, and a receiver for collecting the product. Fig. 79 represents the most simple form of the apparatus adapted for the preparation of tinctures. A, is a

*Fig. 79.*

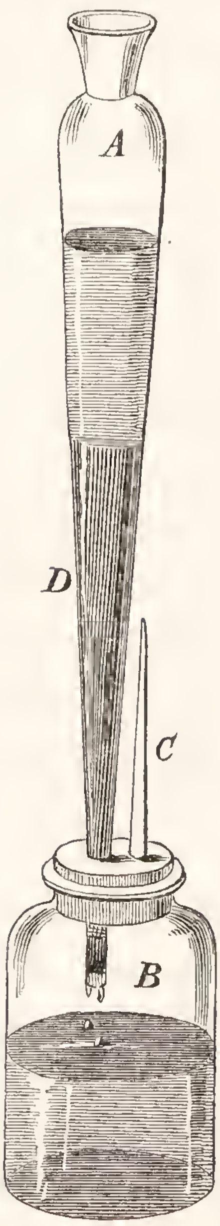
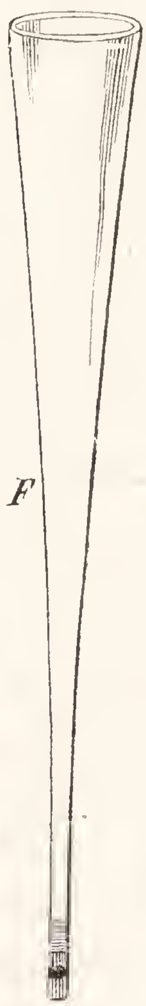


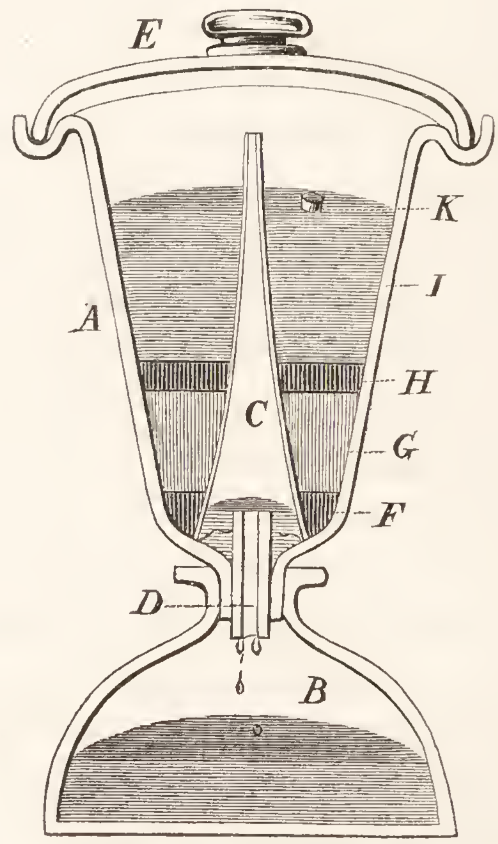

*Fig. 80.*


*Fig. 81.*




Displacement Apparatus.

*Fig. 82.*




Gilbertson's Displacement Apparatus.

glass adapter, which is selected of suitable size. The lower extremity of this is partially stopped with a cork cut as represented in fig. 80. A layer of coarsely pounded glass is put over the cork, and above this a layer of clean sand, thus forming a strainer for arresting the passage of the solid particles of the materials to be operated upon. The end of the adapter is fitted, by means of a perforated cork, into the mouth of a bottle. A glass tube, one end of which is drawn to a capillary opening, is also fixed in the cork as shewn at C, so as to allow the air to escape out of the bottle as the liquid drops in. The solid ingredients to be operated upon, previously reduced to powder, are placed in the vessel A, above the sand, as shewn at D, and the spirit is poured over the surface of these, and allowed to percolate through. A piece of bladder may be tied over the mouth of the vessel at A, to prevent the evaporation of spirit, but a few pin-holes must be made in the bladder, to admit of the ingress of air as the liquid passes into the receiver below.

The neck of a broken retort, cut as represented by fig. 81, may be substituted for the adapter ; in fact, any cylindrical or conical vessel of convenient size might be used, provided that a suitable strainer can be fixed to the lower extremity, and efficient means adopted for preventing the loss of spirit by evaporation.

But, of all the several kinds of apparatus which have been suggested, I have found none so generally convenient and efficient as that represented by fig. 82. This form of apparatus was contrived by Mr. Gilbertson, of Ludgate Hill, by whom it is sold. It consists of a conical vessel (A), with a water-joint rim at the top, into which the cover E fits. A tube (D) is ground to fit into the opening in the bottom, and over the end of this tube is placed a conical tube (C), the lower end of which has several notches cut in it, so that the liquid can pass under it when placed as shewn in the drawing. The lower extremity of the vessel A is ground to fit into the mouth of the receiver (B).

In using the apparatus, the cover (E) is removed, and some dry, clean sand is poured into the vessel A, so as to form a layer (F) at the bottom. Over this the solid ingredients to be operated upon (G) are carefully packed, and a layer of sand (H) is placed over these. The spirit (I) is then poured over the surface of the sand, care being taken not to disturb the ingredients below. The best method of guarding against the disturbance of the dry ingredients, on pouring the spirit in, is to place a flat cork (K) on the sand, and to direct the stream of liquid on to the cork, which will float on the surface of the liquid when introduced ; the force of the current will be thus broken, and the operator enabled to pour in the whole quantity of spirit required, without affecting the position of the solid ingredients. The cover is then to be put on, and a little water poured into the groove, so as to render the joint air-tight. The spirit will percolate slowly through the different strata of dry ingredients until it reaches the bottom, then, passing under the tube C, it will ultimately drop down, through the tube D, into the receiver, while, at the same time, an equal volume of air passes up through the tubes to supply its place in the upper vessel, and equalise the pressure. Thus arranged, the apparatus is perfectly air-tight, so that no loss from evaporation can occur, however long the process may be in operation. The form and size of the apparatus, also, are such as to admit of the solid ingredients being properly packed in the vessel A, upon the skilful performance of which the success of the process principally depends. In most cases it is desirable to use these ingredients in fine powder, and, in some instances, they may be advantageously mixed with coarse sand, which, by separating the particles, will facilitate the percolation of the liquid. If the ingredients be properly packed, the spirit, when first added, will be slowly absorbed by the powder, and will descend equally on every side, forming a line round the circumference of the vessel, which will gradually pass downwards until the tincture begins to flow through the tube D. Some experience and judgment are required in regulating the degree of pressure to be applied in packing the powders, or, if necessary, mixing them with sand, so as to ensure a regular and continued percolation; and, as differences in the nature of the substances operated upon, the degree of comminution to which they have been subjected, and the form and size of the apparatus employed, so far influence the results as to occasion the necessity for some modifications in the method of operating, no precise instructions can be given that would be applicable to all cases.

The process answers remarkably well for extracting the whole of the soluble matter from ginger, Cayenne pepper, cantharides, ipecacuanha, and other substances, from which occasionally concentrated tinctures are required to be made. There is probably no case in which the result is more satisfactory than in the preparation of *Essence of ginger*. The ginger should be used in fine powder; indeed, in all cases in which substances such as those above named are operated upon, I consider it essential to the complete success of the process that they should be in a state of minute division. The powder being introduced into the displacement apparatus, and carefully packed with a slight pressure, so that there shall be no open spaces or channels through which the liquid can pass more freely than through other parts, the layer of sand is placed over the surface of it, and, by means of the cork float, a portion of spirit, rather more than equal in weight to the ginger used, is introduced. The absorption of the spirit will immediately commence, and if the line indicating the division between the part of the powder which is wetted by the spirit and that which remains dry form a pretty uniform circle round the cylinder, and progress downward uninterruptedly as the absorption proceeds; and, further, if this descent of the spirit through the ginger take place at the rate of about an inch in five minutes, it may be inferred that the powder has been well packed, and equally compressed in all parts. The quantity of spirit mentioned will be just that which the ginger and the sand will be capable of absorbing, without any, or more than a few drops, passing into the receiver. When the absorption is finished, the apparatus should be allowed to stand without further addition of spirit for an hour or two, so that complete penetration of the particles of ginger, and solution of all the soluble parts, by the spirit, may take place. At the conclusion of this maceration, the displacement of the tincture is to be effected, by carefully pouring another portion of spirit, equal to that previously absorbed by the solid ingredients, into the upper part of the cylinder, using the cork float as before, so as to prevent any disturbance of the moist ingredients below. The liquid, which was previously retained in contact with the particles of solid matter by the force of capillary attraction, is now forced downwards by the pressure of the column of liquid above; it will begin, therefore, to flow through the tube D, into the receiver B, and, if all the conditions mentioned have been properly observed, this displacement of the saturated tincture by the superincumbent spirit will take place without the occurrence of more than a very slight admixture of the two liquids. The progress of this part of the process will be indicated by a line shewing where the two liquids join, the liquid above this line being nearly pure spirit, while that below it is a dark-coloured tincture. When this line has reached the bottom of the cylinder, the tincture formed by the solvent action of the first portion of spirit on the ginger will have been displaced, as completely as the process will admit. It will be found, however, that the displacement is not perfect, and this arises principally from the circumstance that the particles of which the powdered ginger is composed are porous. The spirit first added fills the pores of each particle, as well as the interstices between the different particles; but, as the former are smaller and more confined than the latter, the second portion of spirit, or displacing column, passes more freely through the interstices than through the minute pores of the particles; and, therefore, while the tincture filling the interstices is completely, that contained in the pores is but partially displaced. It will be observed, on close examination, during the process, that the line of demarcation between the two columns of liquid, to which allusion has already been made, becomes somewhat less defined and distinct as it approaches the bottom of the cylinder, a shading in the upper column being perceptible, which is occasioned by the diffusion and accumulation of the contents of the minute pores in the displacing liquid. Thus, a part of the tincture first formed will be mixed with the second portion of spirit added, or that used for the purpose of displacement, until the minutest pores have at length been emptied of their original contents. In order to recover the whole of the soluble matter, therefore, it will be necessary to displace at least a part of the second portion of spirit; but the tincture thus procured will be much weaker than the preceding.

In operating in this way, nearly the whole of the active and soluble constituents of the ginger are obtained in solution in the first portion of tincture displaced, and, by continuing the process until a quantity of tincture rather less than double the weight of the ginger has passed into the receiver, the solid residue will be so completely exhausted as not to retain the slightest taste or smell.

But although a very concentrated solution is thus obtained, and the whole of the soluble matter is recovered, the process would not be an economical one if the spirit used for displacing the tincture were not recoverable. The displacement of this spirit by means of water is, therefore, the next step in the process. This is done by pouring water over the surface of the solid residue, in the same manner as the spirit was previously added. Pure spirit will in the first instance flow into the receiver as the column of water descends; but long before the whole of the spirit present has been thus recovered, it will be found to have an admixture of water with it, which will progressively increase in quantity. In fact, the displacement of spirit by water is less complete than that of a tincture by spirit. In the latter case, as already stated, the porosity of the solid ingredients presents the principal impediment to the attainment of a perfect result; but in the former case, in addition to this, there are two other causes of obstruction. These are, first, the tendency to combination which exists between spirit and water; and, secondly, the tendency to change places, which the water and spirit will have under the circumstances of their position, in consequence of the greater specific gravity of the former. The whole of the spirit may, however, be recovered, partly in its original state of concentration, and partly diluted to a greater or less extent with water. This unavoidable dilution of the spirit during its recovery is a great defect in the process of displacement, for it generally happens that the recovered spirit is too much contaminated by the solid ingredients to admit of its being used for other purposes without being purified by distillation, and in its diluted state it cannot even be employed in repeating the process for the same tincture.

The preparation of *Essence of Ginger*, in the manner here described, affords a good illustration of the application of the process of displacement under favourable circumstances. The substance acted on may be used, as it ought to be, in the state of fine powder; this powder readily gives up the whole of its soluble constituents to spirit; when moistened with spirit, it forms a mass through which percolation takes place with facility; and the extraction of the soluble parts does not cause much contraction of the volume of the solid matter. In cases where these conditions are not so well fulfilled, the application of the process will be less satisfactory, or some modifications of the process will be required. If the substance to be acted upon cannot be used in the state of fine powder, the interstices between the particles will necessarily be larger and more unequal, the pores and vessels contained within the particles will be more closed and confined, and the disparity between the size of the interstices and that of the pores and vessels will be greater; so that the liquid once absorbed into these pores and vessels will be removed with greater difficulty, while that occupying the interstices will flow with increased facility. If the soluble constituents are not easily extracted by the solvent employed, as is the case in treating *ergot of rye* with spirit, perfect exhaustion of the solid ingredients may not be effected in the time usually occupied by this process.

If the solid ingredients, when moistened with spirit, form a tenacious mass, the liquid will sometimes not percolate through this, or will percolate very slowly, so that it becomes necessary to mix the ingredients with coarse sand or pounded glass, to separate the particles and facilitate percolation.

Moreover, if the extraction of the soluble parts causes much contraction of the volume of the solid matter, it will be difficult, if not impossible, to prevent the formation of fissures through which the percolating liquid will almost exclusively run. In this case, an admixture of sand will lessen the evil.

The process, however, modified according to circumstances, may be applied, with greater or less advantage, in the preparation of most of the tinctures used in medicine, as stated by the authors of the "Edinburgh Pharmacopœia."

In reviewing the several advantages and disadvantages which attach respectively to the two processes which are recognised in the British Pharmacopœias, namely, *the process of maceration*, and *the* *process of displacement*, it would appear, on the one hand, that the objections to the process of maceration apply more strongly to its adoption on the small, than on the large scale; and, on the other hand, that the process of displacement is less applicable to operations on the large, than on the small scale.

When tinctures are made in large quantities, percolation is never likely to supersede maceration, on account of any practical advantages it may possess. If the prescribed directions be duly attended to, the process of maceration is unexceptionable. This process is more simple than the other; the mode of operating is more uniform,—it is, in fact, always the same; it requires less of skill and dexterity in conducting it; it requires less constant attention during its progress, which, in operating on large quantities, is a consideration; and, finally, the apparatus required is less complicated.

When only small quantities of tincture are made at a time, and kept in stock, the adoption of the process of displacement will often be found convenient and advantageous. It offers the means of making a tincture in two or three hours, which by the other process would require as many weeks. The process being thus completed in so short a time, for the quantity contemplated might be made at one operation, it would not be so likely as the other to experience neglect during the performance of it, or a deviation from the prescribed instructions; the product would therefore be more uniform. Finally, in many cases, the tincture and spirit may be removed from the dregs more completely, in operating on small quantities, by this process, than by the other.

Even in those establishments where tinctures are generally made by maceration, the process of displacement will be found useful as a resort in cases of emergency, and for the preparation of some particular tinctures.]

## THE PRESS.

The press is used in pharmaceutical laboratories for effecting the separation of liquids from solids, where much force is required. In the use of this instrument, the power of the human arm is increased, by mechanical means, at the expense of time and space. The screw and the lever are generally applied for this purpose.

Bramah's hydraulic press is but rarely used in the laboratory, the circumstances under which it would have to be employed being such as to cause frequent derangements of its complicated structure, and these derangements requiring the assistance of a class of mechanists who are not to be met with in every locality.

The screw-press, being less complicated than Bramah's, is not so liable to accidents. Consisting only of solid parts, it is less affected by being left unused for some time. Its construction is simple and easily comprehended by any person, and the repairs which it may require can be executed by the common mechanists in wood and iron.

There are two kinds of screw-press,—one having a single screw, and the other two screws. The screw in the former is vertical, effecting a downward pressure on the bag, which is placed horizontally. In the latter the screw acts horizontally, while the bag is placed in a vertical position.

Opinions are divided as to the relative advantages of these two kinds of press. There is no doubt that the single-screw-press, as commonly constructed, is inferior to the double-screw-press; but I think I shall be able to shew that the former may, by an improved construction, be rendered quite as useful and compact as the latter.

The following are the objections which principally apply to the single-screw-press as usually constructed :—

1. The press-block attached to the screw frequently loses its hoirzontal position, being turned to one side in consequence of some defect in filling or placing the bag, so that it becomes necessary in the middle of an operation to unscrew the press and re-arrange the bag. If this be neglected, the press-block will come in contact with the sides of the box, thus causing violent friction and partial resistance ; the screw itself is also liable to be injured from its being forced out of the perpendicular.

2. The expressed liquid does not run off freely from a press-box placed horizontally. If the press be so arranged that it may be tilted, it would be necessary that the means by which it is fixed to the wall should be moveable ; and, as the press cannot be used while in the tilted position, much trouble would be involved in thus repeatedly moving the press every time it is used.

3. The use of this kind of press is not free from some danger. The entire force of the lever is directed horizontally, and is sustained by the fastening of the press to the wall. If the application of much force should cause the fastening to give way, or the lever to break, the operator may suffer serious injury; and damage in other respects would necessarily be incurred. Accidents from this cause are not unfrequent.

4. With this press the male screw alone moves, while the female screw or nut remains stationary. Under these circumstances the screw suffers a severe torsion, as the tangential impulse received

at one end is communicated to the other through the whole length of the screw; and it is much more likely in this way to suffer injury, than would be the case if the male screw were fixed, and the female screw or nut moveable.

Let us now consider what advantages are possessed by the double-screw-press, as compared with that last noticed.

1. The press-bag is very easily placed in its right position, as the two screws are visible between the side plates, and afford a measure by which to adjust the bag. Should there, however, be any inequality in the tightening of the screws, this may be easily rectified, by applying more force at that end of the press-plate which had least progressed. To admit of this inequality in the progression of the two ends of the press-plate, it is desirable that the nuts should be rather loose.

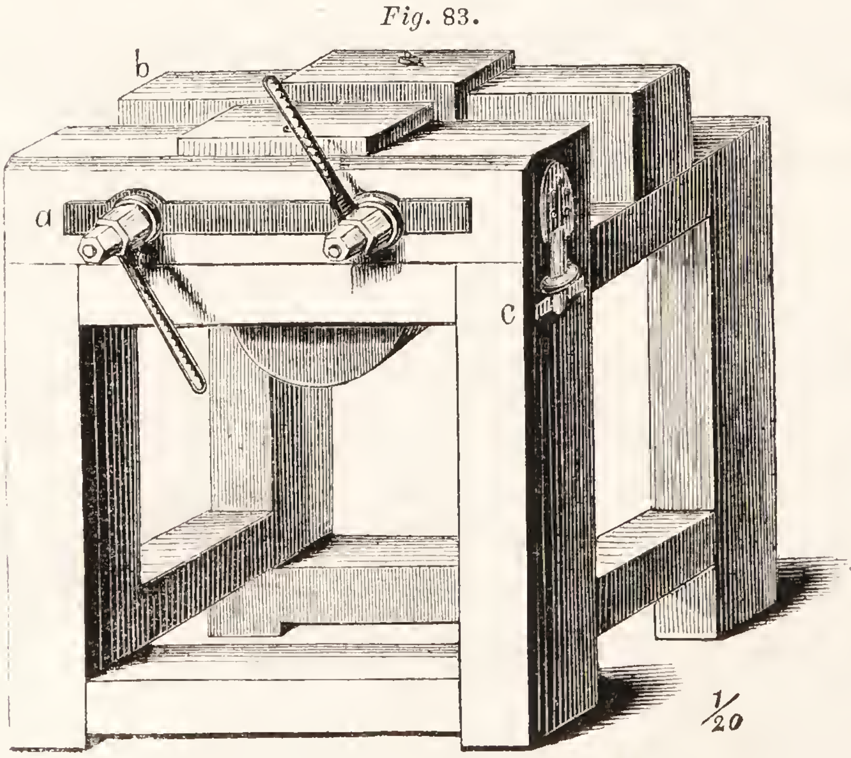
2. The expressed fluids run down the vertical sides of the press-plates and from the sides of the bag without any impediment; no provision for tilting the press is required; and the fastenings by which the press is fixed to the wall need not be so strong as in the case of the single-screw-press. With careful management, the press need not even be fixed to the wall at all.

3. This kind of press occupies less room than the other, and, when not in use, it may be converted into a temporary table, or removed altogether out of the way.

4. The use of this press is unattended by the same danger of injury to the operator, as in the case of the single-screw-press.

5. The power of the screw is applied in the most advantageous manner, the male screw being fixed, while the female screw or nut is moved.

*Fig.* 83.




Double-Screw, or Horizontal Press.

6. The press-plates may be easily covered with different materials, best suited for the purposes to which the press is applied. Thus cast iron may be used for fixed oils, pine wood for the coloured juices of fruit, and tin for tinctures and other alcoholic or aqueous solutions. It is much easier to cover the press-plates with these

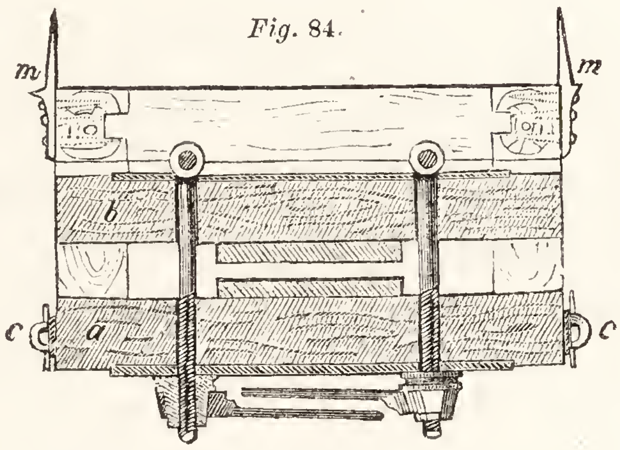
materials, than it would be to line the press-box and block used with the vertical press in a similar manner.

Having thus noticed the principle of the screw-press, and the relative advantages and disadvantages of the two kinds which are used, it remains to treat of the construction and application of these presses.

Fig. 83 represents a double-screw-press in perspective, drawn to one-twentieth the real size. The drawing has been made from a press, which, after many alterations, has assumed the form and dimensions indicated. This press has been used for the last ten years, without requiring any repairs.

The dimensions appear to be such as best to adapt it for the requirements of a laboratory, where either large or small quantities of materials are operated upon, and any deviations from these dimensions would probably entail inconveniences which may not be foreseen.

*Fig. 84.*

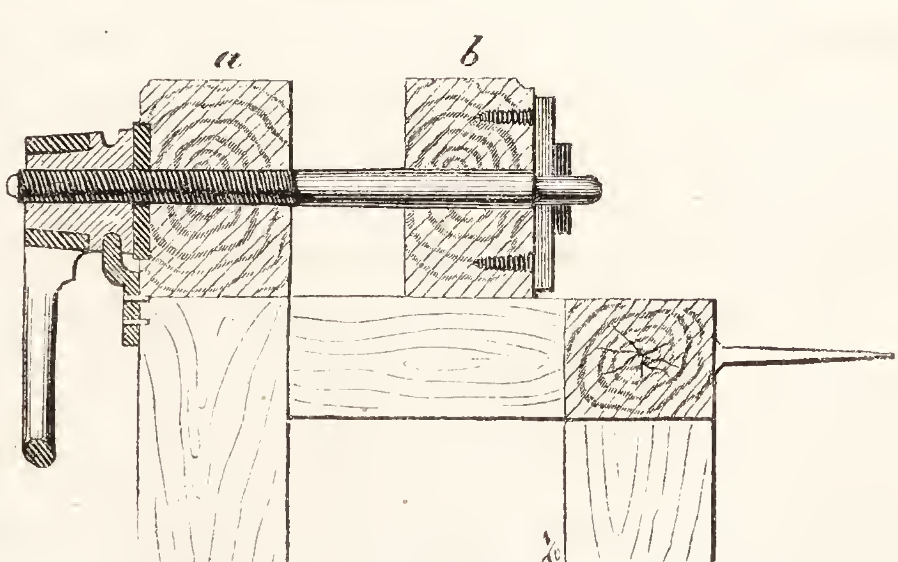



Section of Press.

Fig. 84 represents a transverse horizontal section of the press, through the screws, as seen from above.

Fig. 85 is a vertical section through one of the screws, as seen from one side.

*Fig. 85.*




Section of Press.

The press consists essentially of two parts, — the stand or support, and the press which rests on the top of it. The stand is an oblong framework of wood, the height of which is such as to admit of the application of the full force of the arm to the screws. This framework is made of oak, or other durable wood, and it should be well put together, with a view to the attainment of strength.

The stand may be fixed to the wall against which it is intended to be placed by two fastenings, one at each end, as shewn at *m*, *m*, fig. 84. In some cases, however, it may be found convenient to be able to move the press; and, to admit of this, a different kind of fastening from that represented in the drawing must be used.

The press itself consists, in the first place, of two blocks of good beech-wood, free from knots, as shewn in figs. 83, 84, 85, at *a*, *b*. These blocks of wood are thirty-two inches in length, eight inches and a half in height, and four inches in width, or thickness. The front block is fixed at each end to the framework, in such a manner that by merely knocking out a bolt, as shewn at *c*, figs. 83 and 84, it may be removed at any time, and again fixed in its place with the greatest facility. The other block (*b*) is moveable, being made to slide on the top of the framework of the stand.

But the most essential and important parts of the press are the screws, by which the pressure is effected. These should combine as much strength, and as little friction, as are compatible with the full attainment of the required object. If the size of the screws be unnecessarily augmented, the friction will be increased, yet they must be sufficiently large to ensure the required strength. English cast steel, which has been submitted to a low red heat in a charcoal fire, is the best material of which to make the screws. The entire length of the screws is seventeen inches, but the thread of the screw extends over about one-half only of this length.

There are two forms which are given to the thread or worm of a screw: the first presents a sharp edge externally, and forms, in section, a triangle, attached by one of its sides to the cylinder of the screw; the second presents a flattened surface externally, and forms, in section, a square, attached to the cylinder by one of its faces. Of these two forms, the first imparts the greater strength, for supposing the inclination of the plane to be equal in both, the triangular thread will be attached to the cylinder by a base which will be twice the size of that of the square thread.

The tendency of the application of the motive power to the screw is either to tear the thread from the cylinder, or to advance the outer edge along the inclined plane. The thread itself, therefore, is a lever, the extreme fulcrum of which is on its outer edge; and, as the strength of the lever ought to increase with increase of length, the greatest strength is required at the end next the cylinder, where the power is applied.

In like manner, this form gives the greatest strength to the female screw, or nut, which consists of a triangular thread attached to the inner surface of a hollow cylinder.

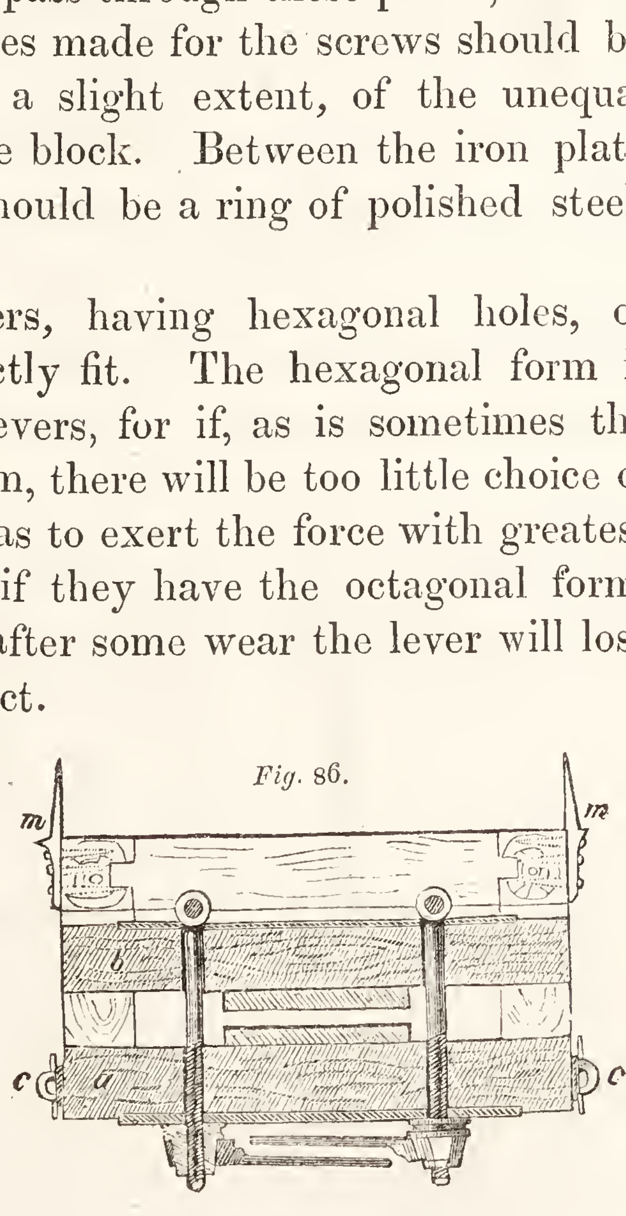
The space between the edges of two neighbouring threads is called the groove, and the depth of the thread is calculated from the outer edge to the cylinder. A good screw ought to be so cut that the depth of the groove shall be greater than the base of the thread. A transverse section of the thread, therefore, would represent, not an equilateral, but an isosceles triangle, the most acute angle of which forms the outer edge. In determining the proper depth and width for the groove of a screw, a due proportion must be observed between the thickness of the entire body of the screw and the dimensions of the thread. If the groove be cut too deep in proportion to the size of the cylinder, the latter will be incapable of offering a power of resistance equal to that of the thread; and, on the other hand, if it be made too shallow, the cylinder would bear a force greater than the thread could sustain. Supposing the original size of the cylinder from which the screw is to be cut to be one inch in diameter, the groove should be one line and a half in width, and two lines in depth, thus leaving eight lines or two-thirds of an inch as the diameter of the remaining cylinder.

Each of the press-plates, or blocks of wood, (*a*, *b*, figs. 83, 84, 85,) is strengthened by a strong plate of iron, fixed as shewn at *a*, fig. 83. The screws of the press pass through these plates, as well as through the blocks, and the holes made for the screws should be rather oblong, so as to admit, to a slight extent, of the unequal progression of the two ends of the block. Between the iron plate and the nut of the screw there should be a ring of polished steel, forming a sort of washer.

The nuts are turned by levers, having hexagonal holes, or sockets, into which the nuts exactly fit. The hexagonal form is the best for the sockets of the levers, for if, as is sometimes the case, they have a quadrangular form, there will be too little choice of position in fitting the lever on, so as to exert the force with greatest effect; while, on the other hand, if they have the octagonal form, the angles will be so obtuse, that after some wear the lever will lose its purchase, and turn without effect.

Two short levers are used in the first instance, which may be turned quickly, and afford sufficient power when much pressure is not required. The manner in which these levers are made to clear each other is shewn in fig. 86, their length being such that each may describe a complete circle without touching the screw of the other.

*Fig.* 86.




SECTION OF PRESS.

The proper forcing lever (fig. 87) should be from thirty to forty inches in length, and should have a strong hexagonal socket. It must be bent as shewn in the drawing, so as to admit (when fixed on one screw) of its passing the end of the other even when the press is quite closed. The lever should be made of a bar of iron having greater width than thickness; and the narrow side should be presented in the direction of its movement, so as to give the greatest possible strength compatible with its bulk and weight. Round bars are more easily bent, and ought not to be used.

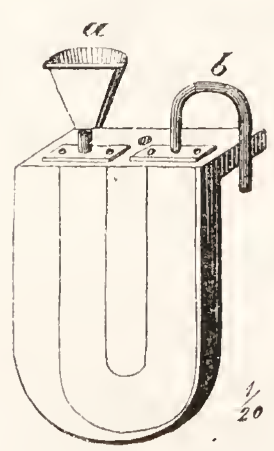
*Fig.* 87.

Lever of Press.

Only one long lever is used, this being applied alternately to the two screws; but care must be taken that the press-plates be kept as nearly parallel as possible.

The shape and size of the blocks of wood forming the press-plates have been already noticed. These are lined, on the sides which come in contact with the substances to be pressed, with tin plates, which, however, may be removed, and some other material substituted, better suited for the expression of any particular substance that may be operated upon. Thus, for substances containing mineral or other acids, such as the juices of fruits, &c., deal boards previously well soaked in water may be used; and, for fixed oils, iron plates will be found to answer best. When iron plates are used, it will sometimes be found convenient to have them hollow, as represented in fig. 88. A partition, not reaching quite to the bottom, divides the hollow part of this plate in the middle. This partition has the double object of strengthening the plate, and of causing a current of hot water, when poured in through the funnel (*a*), to pass to the bottom of the plate, and flow out through the syphon (*b*), the top of the funnel being higher than the highest point of the syphon.

*Fig.* 88.




Iron Press-Plate.

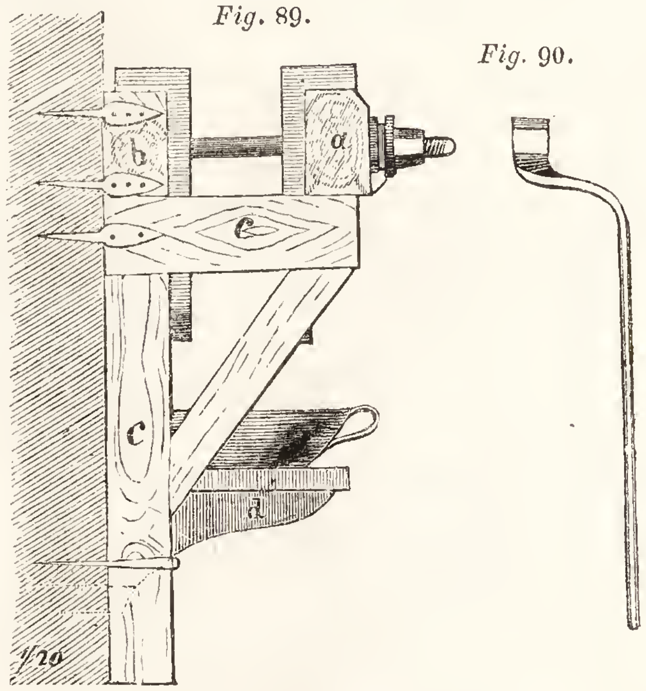
With this arrangement, the press-plates are easily kept warm, for the expression of any particular substances, by supplying them with boiling water. In the expression of butter of cacao, oil of eggs, almond oil, and indeed most solid and liquid fats, [also plasters, resins, and gum-resins,] it will be found advantageous to employ more or less heat in the process. These plates may be eleven inches and a half wide, from thirteen to fifteen inches deep, and about one inch and a half thick. The hollow space may occupy about half an inch of the thickness, leaving half an inch for the thickness of the iron.

This kind of press is in very general use, although not always constructed precisely according to the instructions here given. Having a complete framework and stand of its own, which adapts it for use, even without being fixed to a wall, it may be moved from place to place in the laboratory.

In those cases, however, where the means of moving the press is not a consideration, it may be found more convenient to attach it to a different kind of framework, which would occupy less space.

Fig. 89 represents a press, having all the essential parts of that last described, but with certain modifications in the method of fixing it. Thus, the press-block (*b*), as well as the framework or support (*c*, *c*), are securely fastened against a wall, in the manner represented in the drawing; and a shelf (*d*) is also fixed below the press, for the reception of a vessel to receive the expressed liquor. The form of the bent lever is further illustrated by fig. 90.

*Fig.* 89. *Fig.* 90.



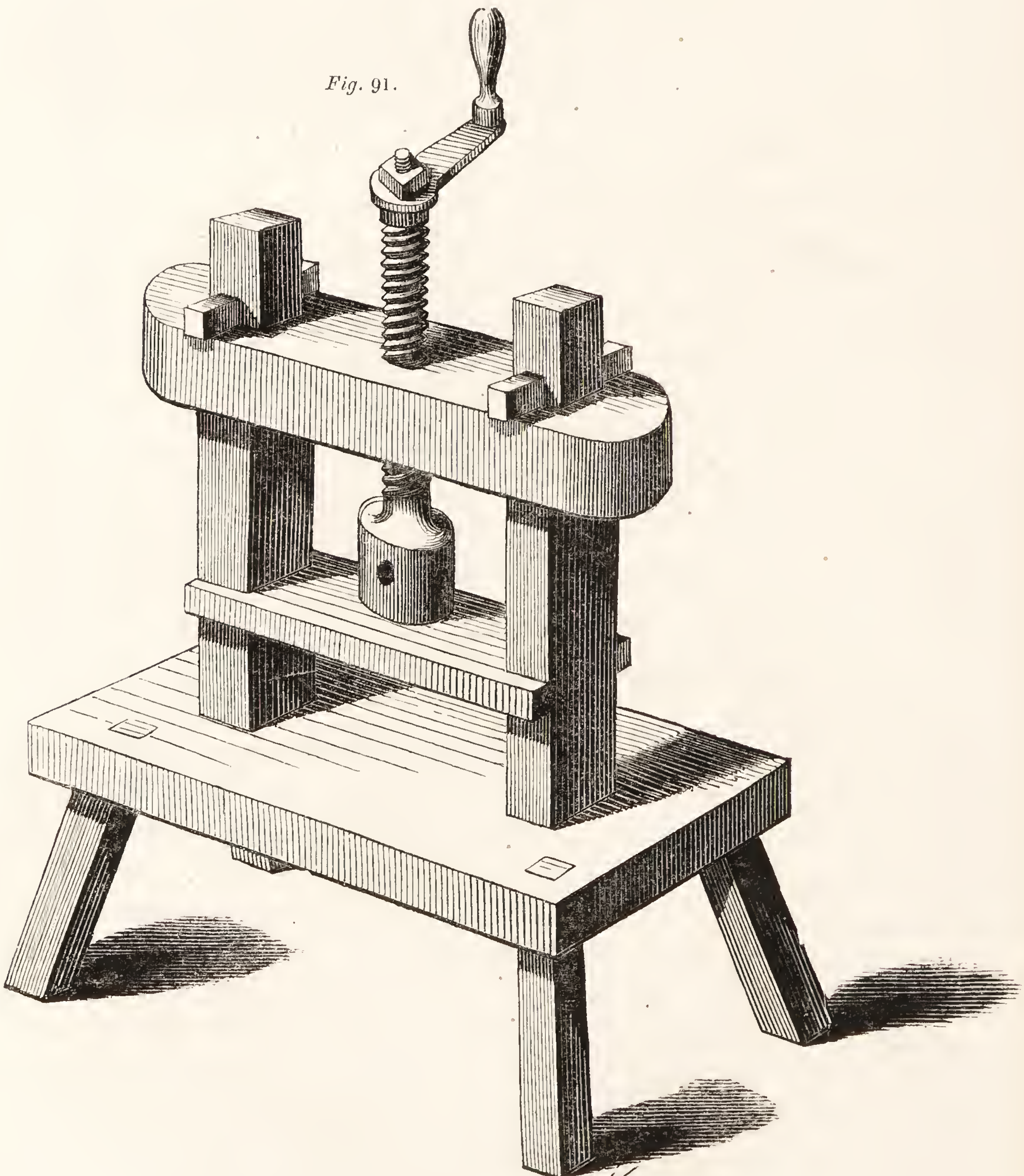

Double-Screw, or Horizontal Press.

It is sometimes urged, as an objection against these double-screw or horizontal presses, that, as there are two screws to be turned, which can only be worked alternately, more time is occupied in the process than is the case with the single-screw-press; and, unless great care be taken, the screws may be injured by causing one end of the press-plate to progress too much in advance of the other.

These objections are certainly well founded, but they may be entirely obviated by making a very simple addition to the apparatus in the following manner:—Three cog-wheels are to be selected, of such diameter that two of them being fixed on the nuts of the two press-screws, the third shall exactly occupy the space between them. These cog-wheels must all work in gear; the two which are attached to the screws must be precisely similar, but the third or centre one may be of different size, provided the cogs or teeth correspond. This last must work on a strong pivot fixed to the plate of iron, which, as already stated, is attached to the front of the press-block to increase its strength. By this means, on turning the centre wheel, the two screws will be worked simultaneously; but while an advantage is thus gained, in some respects, there is, on the other hand, a disadvantage in the loss of power, to compensate for which a longer lever must be employed.

There are, however, many advocates for the *single-screw* or *vertical press*; and as this certainly has some advantages, I will now describe the best method of constructing it.

*Fig.* 91.



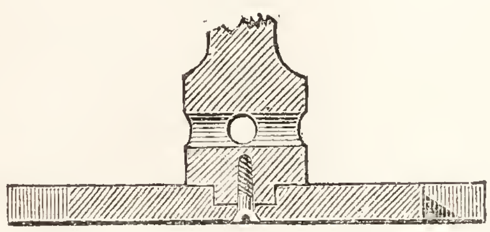
Wooden Single-Screw, or Vertical Press.

The greatest fault in the single-screw-press, as commonly met with, is, that the screw is sometimes turned from the perpendicular and forced into a more or less oblique direction, in consequence of inequalities in the resistance offered by the substance pressed. This may be obviated by adopting a suitable method of guiding and confining the direction of the screw.

As these presses may be made entirely of wood, at little expense, I will first describe the most approved kind of wooden press.

Fig. 91 represents one of these presses, drawn to one-fifteenth its real size. It consists of a low table or stand, in the thick top of which the framework of the press is fixed. The screw should be made of the best dry beech-wood, and should terminate at the bottom in a stout cylindrical knob, through which two holes are bored at right angles to each other for the reception of the lever. A vertical section of this enlarged termination of the screw, together with the press-plate, is represented in fig. 92, where it will be seen that the former works in a hole in the centre of the latter, which prevents it from slipping to either side. Some hard soap should be put into this hole, to counteract the friction that would otherwise occur.

*Fig.* 92.

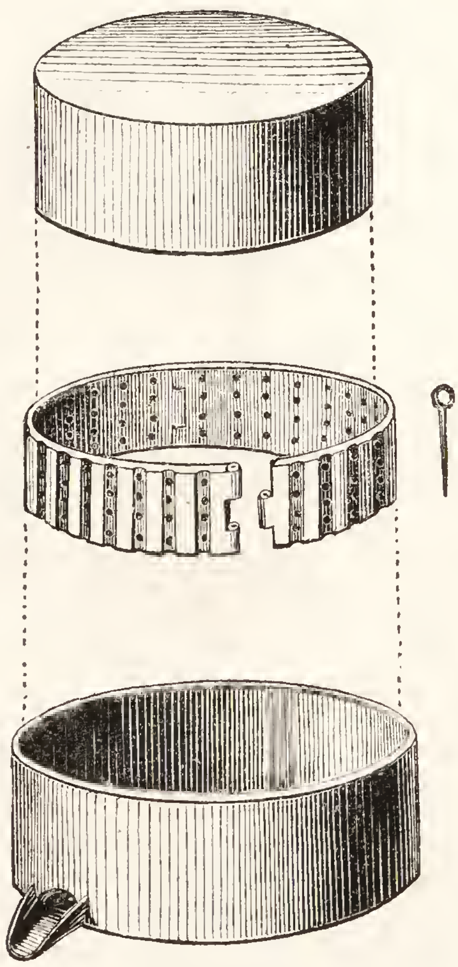


The press-plate is guided by two arms, which embrace the uprights of the framework, and keep it in the horizontal position. At the top of the screw there is a handle, which serves for screwing or unscrewing the press expeditiously when the long lever is not required.

*Fig.* 93.

*Fig.* 94.

*Fig.* 95.

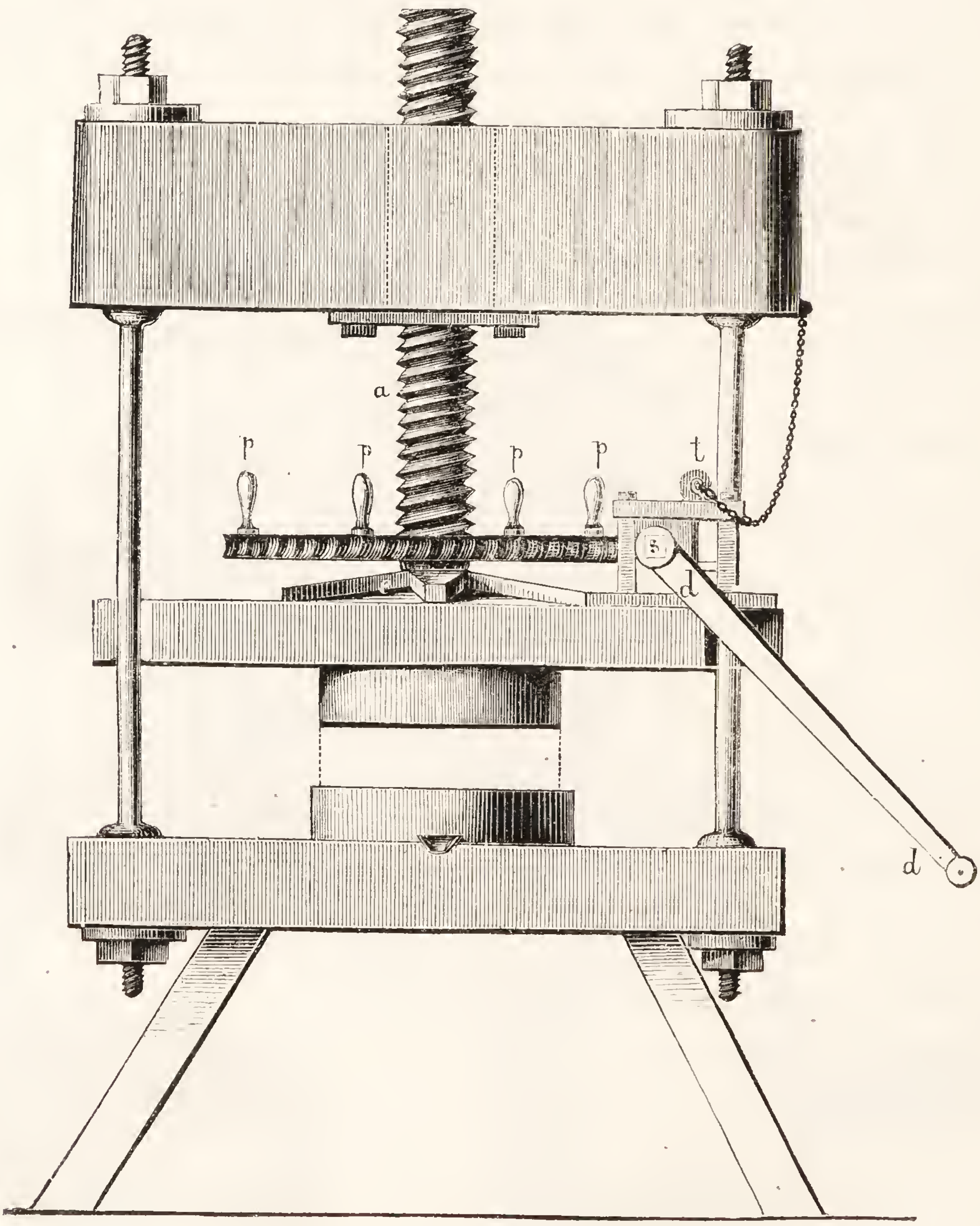


Press-Box.

It will be evident that the press-bag could not be placed immediately on this press, as here represented, as there is no provision for collecting the expressed liquid, or guiding it into any vessel. A particular apparatus will be required for this purpose. This consists, first, of a low cylindrical vessel (fig. 95) made of copper well tinned. If the bag be so small as not to come in contact with the sides of this vessel while being pressed, it may be introduced without further provision. The wooden block, (fig. 93,) which is covered with tin plate, is placed on the bag, and they are then put under the screw to receive the required pressure.

Should the bag be likely to come in contact with the sides of the press-box, it will be desirable to use a perforated internal case (fig. 94). This is made in two parts, being united on one side by a hinge, and temporarily joined on the opposite side by a pin, as shewn in the drawing. The inner surface of this cylindrical case is smooth, but the outer surface is grooved, the holes through which the expressed liquid is intended to pass being made into these grooves.

*Fig.* 96.




SINGLE-SCREW, OR VERTICAL PRESS.

The power of the screw-press may be greatly increased by substituting for the simple lever a cog-wheel, attached to the screw of the press, and worked by an endless screw, as shewn in fig. 96. In this drawing, *a* represents the press-screw, to the lower end of which the cog-wheel is securely fixed; and the endless screw (*s*), which is turned by the lever (*d d*), bites into the teeth of the latter.

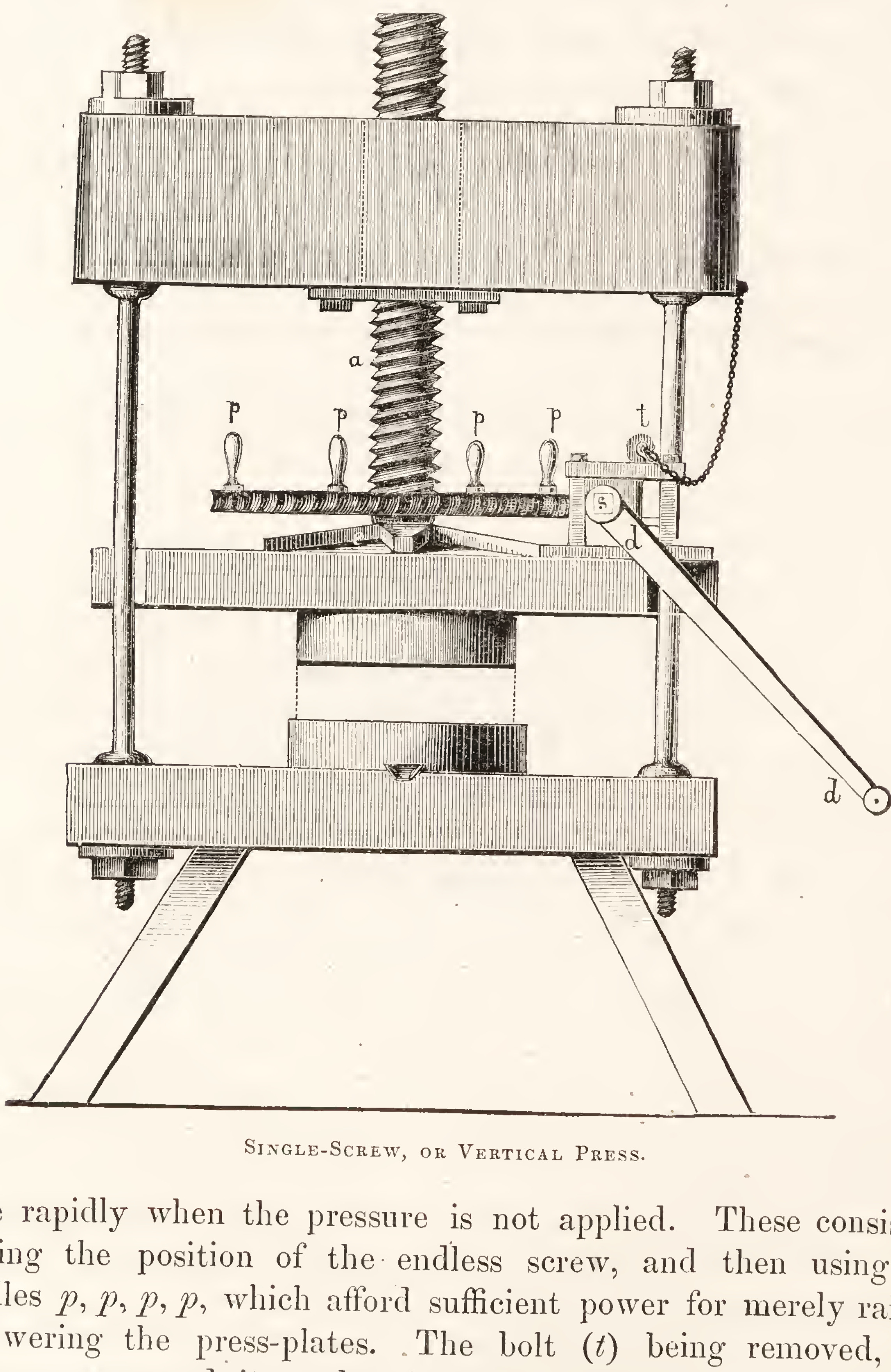
Under this arrangement power is gained in two ways. The lever or handle (*d d*) produces an increase of power in proportion as its arm is longer than the radius of the endless screw (*s*); and this screw increases the power in proportion as its circumference is greater than the width of its grooves. These two increments, multiplied the one into the other, will give the first product. Then, in the next place, the cog-wheel which is fixed to the screw acts as a lever, producing an increase of power in proportion as its diameter is greater than that of the screw; and the latter again increases the power in proportion as its circumference exceeds the width of its grooves. These latter increments, multiplied together, give the second product, and the two products multiplied together give the sum total of the increase of power over that exerted at the lever.

Thus, assuming, for the sake of illustration, that the arm of the lever (*d d*) is twelve times the length of the radius of the endless screw (*s*), and that the grooves in the latter are one-tenth its circumference, the increase of power in these parts will be $10 \times 12 = 120$. Then, assuming the diameter of the cog-wheel to be eight times that of the screw *a*, and the width of the grooves in the latter to be one-tenth its circumference, the increase of power here will be $8 \times 10 = 80$. And now, if these two products be multiplied together, we shall have $120 \times 80 = 9600$ as the sum total of the rate of increase of power.

If we further assume, that a man in working the press applies a force equal to 100lb. to the lever, the theoretical amount of pressure exerted by the screw would be $9600 \times 100 = 960{,}000$lb.; but from this we must deduct the loss from friction. It will thus be seen, that, by a trifling addition to the mechanism of the machine, an immense increase of power may be gained. But in proportion as the power of the press is increased, the strength of its different parts must be augmented. If it be intended to apply a pressure such as that above calculated, it will be necessary to replace the wooden screw and connecting pieces by those of iron, as indeed is represented in the drawing fig. 96. It is also necessary to bear in mind, that with every increase of power gained by mechanical means there is necessarily a corresponding loss of time in accomplishing the required object.

With the press, fig. 97, the screw *a* makes but one revolution with each revolution of the cog-wheel; and to effect this, the endless screw, if it consist of a single thread, will require to be turned as many times as there are teeth to the cog-wheel. The process of screwing or unscrewing the press would, therefore, be a very slow and tedious one if there were not some means of performing it independently of the use of the handle *d d*. Such means, however, are provided, by which the screw can be turned

*Fig.* 97.

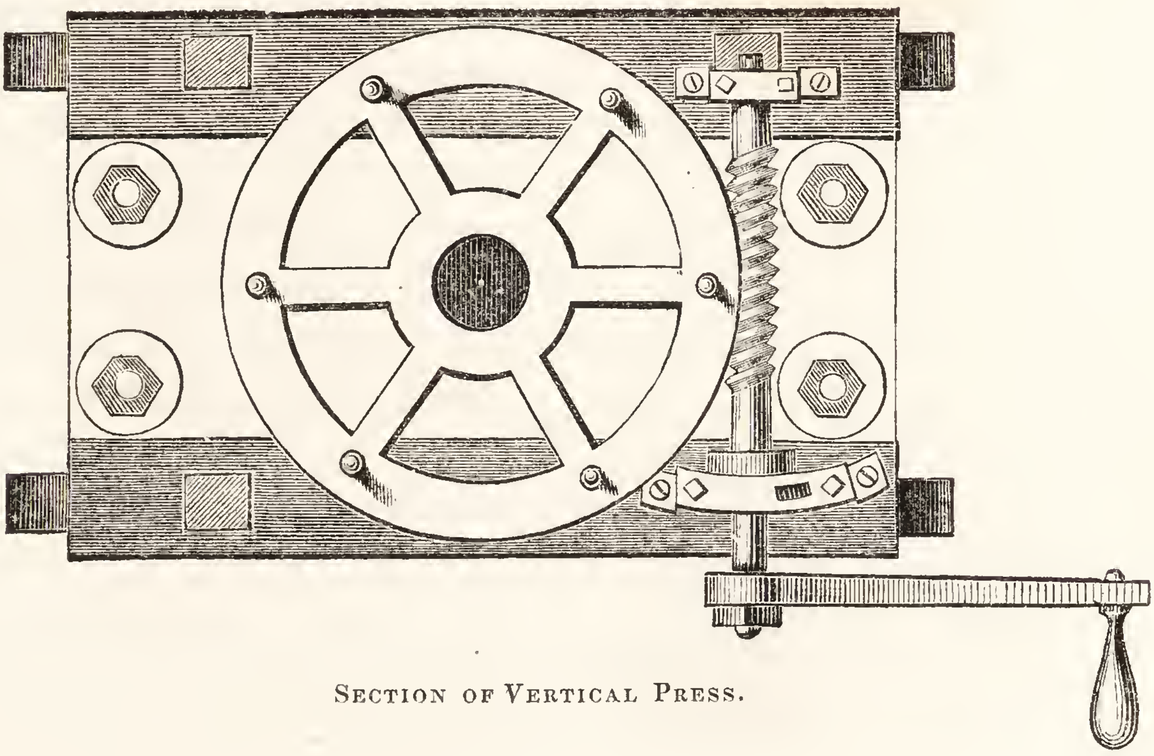



SINGLE-SCREW, OR VERTICAL PRESS.

more rapidly when the pressure is not applied. These consist in shifting the position of the endless screw, and then using the handles *p*, *p*, *p*, *p*, which afford sufficient power for merely raising or lowering the press-plates. The bolt (*t*) being removed, the endless screw and its socket is slipped back, so as no longer to be in gear with the cog-wheel, while the screw is turned expeditiously; and when the full force of the pressure is required, they are restored to their original position, and the handle *d d* is used.

Fig. 98 is a vertical section of this press, in which the position of some of the parts is more clearly shewn than in the preceding drawing.

*Fig.* 98.



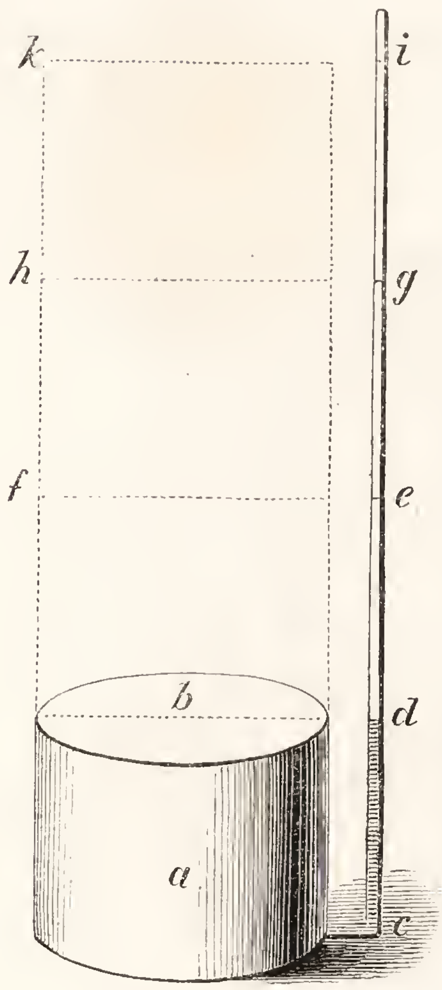
SECTION OF VERTICAL PRESS.

[*Bramah's Hydraulic Press*, although hitherto but rarely employed in phamaceutical laboratories, is nevertheless getting into more general use. The power obtained by a press of this description is much greater than that afforded by a screw-press occupying the same space, and this power is obtained at a smaller expense of labour. These advantages have determined a preference in favour of the hydraulic press, in cases where very great power is required, as, for instance, in the expression of fixed oils from seeds, &c.

The press itself consists of two cylinders, of unequal size, containing water, and connected together by a tube. The smaller cylinder is fitted up as a force-pump, while the larger one is provided with a solid piston, working through a water-tight collar. According to a well-known law of hydrostatics, any pressure applied by the piston of the force-pump is communicated through the liquid, equally, in every direction, and is exerted against the piston of the larger cylinder with an increase of power in proportion to the relative sizes of the two pistons.

The principle may be thus illustrated: *a*, fig. 99, represents a cylinder twelve inches in diameter, to which is attached a tube (*c*, *i*), a quarter of an inch in diameter, and forming, with the cylinder, an inverted syphon. If the cylinder (*a*) be filled with water, the liquid will rise in the tube to the point *d*, thus standing at the same height in both limbs of the syphon. If, now, the top of the cylinder (*b*) be enclosed, and water poured into the tube until it rises to *e*, there will be a pressure exerted against *b* equal to the weight of the column of water (*d*, *e*) multiplied by 2304, or the number of times the area of the tube is contained in that of the cylinder. Every additional increase in the column of water in the tube will cause an increase, in the above proportion, in the pressure against *b*; so that, when the water in the tube stands at *i*, the pressure against *b* will be that of the weight of a column of water having the area of the cylinder *a*, and the height of *k*. The force, in this case, is produced by the weight of the column of water *d i*; but the same effect would take place, if, instead of this column of water, pressure to the same extent were applied at *d* by means of a piston, or in any other way. The weight of the column of water *d i* is one ounce, and this is capable of producing a pressure against *b* equal to 2304 oz. If, instead of the weight of an ounce of water applied at *d*, pressure were applied there by a piston worked with a lever, as in the case of a pump, it would be easy to make the pressure at *d* equal to a ton, and then we should have a force exerted against *b* equal to 2304 tons.

*Fig. 99.*



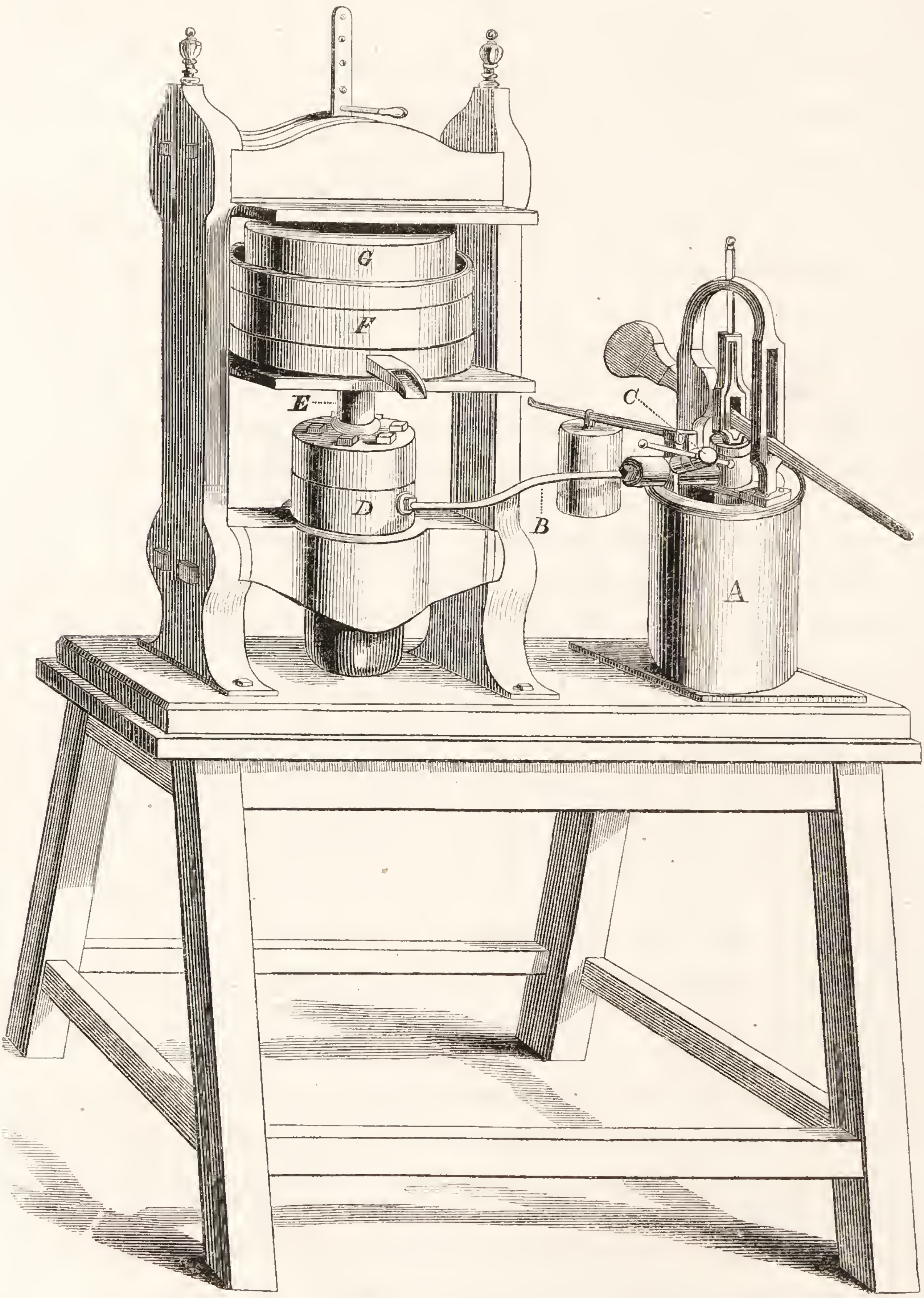

In Bramah's hydraulic press the pressure is applied at *d* by the piston of a forcing-pump, and the accumulated force is made available at *b* by having there a moveable piston working through a water-tight collar; so that, if the above proportions be maintained between the dimensions of the parts, a downward pressure of a ton, applied at *d*, will produce an upward pressure of about 2000 tons at *b*; the only deduction to be made from the theoretical increase of power being that for loss from friction.

The principle upon which this means of accumulating power is founded was well understood before Mr. Bramah so happily applied it in the construction of his press. The same principle is involved in Count Real's press, described at page 59. It may be thus expressed:—Pressure is exerted in liquids equally in every direction; and the pressure which the bottom or sides of a vessel containing a liquid sustains will be in proportion to their extent of surface, and to the perpendicular height of the column of liquid above, without reference to the capacity of the vessel or the quantity of liquid it contains. Thus, the same pressure is exerted on the bottom of the cylinder *a*, (fig. 99,) when the water stands in the tube at *i*, as would be the case if the cylinder were extended to *k*, and filled with water.

Bramah's merit consisted in the application of a well-known principle for the economical production of immense power available for mechanical purposes. This application was made the subject of a patent in 1795, in the specification of which Mr. Bramah describes his press as a *hydra-mechanical engine*. But, although the application of the principle was secured by this patent, a difficulty was at first experienced in the construction of the machine, which greatly detracted from the value of the discovery. It was found impossible, by any means then known, to make the packing of the collar, through which the piston of the large cylinder of the press moves, so tight as to prevent the escape of water when the full pressure of the machine was applied, without at the same time rendering the piston immoveable by the unaided power of the operator when the pressure was taken off. At length, however, a method of packing the piston was discovered by the original patentee, which completely removed this difficulty. This method consists in the use of a leather collar, the construction and application of which is as simple as the principle of its action is scientific; and so perfectly satisfactory is the effect of this contrivance, that it leaves nothing to be desired.

Fig. 100 represents a small hydraulic press, which I have been accustomed to use for several years. The framework of the press is made of cast iron, and it rests on a strong wooden stand. A, is a cistern containing water, in which is placed a small forcing-pump worked by a lever-handle, which may be lengthened when more power is required. This pump communicates with the strong cast-iron cylinder (D), by means of the metallic tube (B). The piston (E), sometimes called the *ram*, moves through a water-tight collar, which is secured in its place by the cap of the cylinder; and, as the piston rises, it carries with it the iron plate, called the *follower*, on which the substance to be pressed is placed. The pressure is effected against the head of the press, where there is also another iron plate, which is supported there by a bolt secured above, as shewn in the drawing. The forcing-pump is furnished with a safety-valve for controlling the pressure, and a valve for removing the pressure by allowing the water to run back from the cylinder (D) into the cistern (A). These are shewn at C.

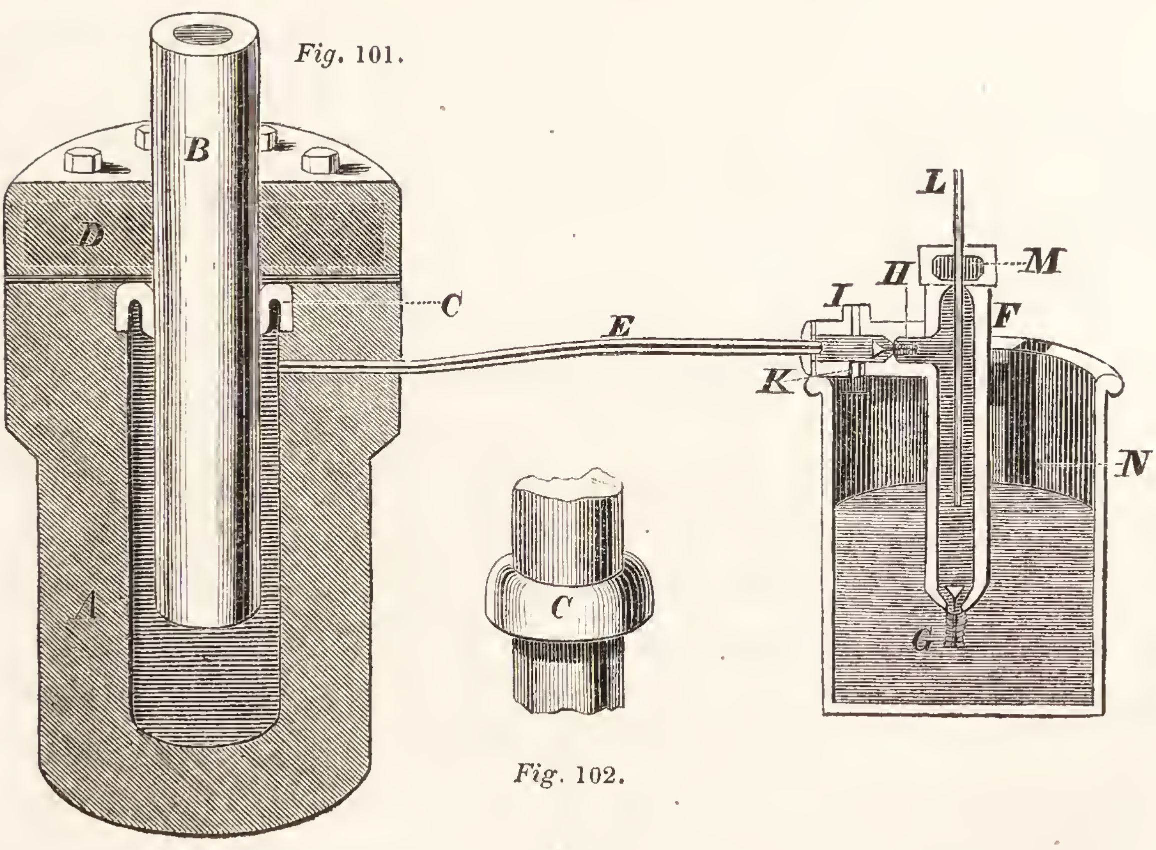
*Fig.* 100.




BRAMAH'S HYDRAULIC PRESS.

Fig. 101 will further illustrate the construction of some of the parts of this machine, which are here shewn in section. N is the cistern of water; F, the cylinder of the forcing-pump; L, the piston of the pump, which is a solid rod working through a common stuffing-box (M). G is the valve admitting water into the cylinder of the pump as the piston rises, but resisting its return into the cistern as the piston is depressed. H is the valve admitting water from the cylinder of the pump into the tube E when the piston is depressed, but resisting its return through the same channel. I is the opening closed by the safety-valve, which allows the escape of water when the pressure in the press exceeds that exerted by the weight attached to the valve. K is the opening for allowing the water to run out of the cylinder of the press when it is desired to remove the pressure, this being effected by unscrewing a plug that closes this opening. A is the strong cylinder of the press, into the cavity of which the solid piston or ram (B) passes. C is the leather collar, closely embracing the piston, and secured in its place by the cap (D), which is fastened with screws to the top of the cylinder. There is a depression in the top of the piston, into which a corresponding projection, attached to the bottom of the iron plate or follower, fits, so as to form the platform on which the press-box is placed, as shewn in fig. 100.

A perspective view of the leather collar, with the piston passing through it, is shewn in fig. 102; while C, fig. 101, shews it in sec-




Section of Hydraulic Pump.

tion. This collar is made of thick leather, and its peculiar form is given to it by pressing the leather, previously softened by immersion in water, into a circular groove, and afterwards cutting a hole in the centre to fit the piston.

It will be seen, from the section, fig. 101, that the outer fold of the collar fits into a notch in the cylinder made for its reception, while the inner fold embraces the piston, to which its sharp edge fits closely on every side.

The great advantage of this kind of packing is, that the tightness with which the piston is embraced by the collar will be in proportion to the pressure of the water; for, in accordance with the principle already stated, that pressure in liquids is equal in all directions, the water filling the space between the two folds of the collar will exert a lateral pressure, which will always resist the passage of the liquid between the collar and the piston. This lateral pressure upon the folds of the collar, by which the packing is tightened, will increase with every increase of power applied to the press, and it will also decrease as soon as the power is removed, so that when the water is let off the collar will relax the tightness of its grasp, and the piston (B) will descend into the cylinder by its own weight.

The piston (B, fig. 101) is frequently made of cast iron; and where the press is in constant use, this may probably answer very well; but under other circumstances it is objectionable, inasmuch as the iron becomes oxidised, and the piston does not then pass freely through the collar. I have found it necessary to have the iron-piston, which my press originally had, replaced by one made of gun-metal, and since this substitution it has never got out of order.

A manufacturer of these presses states, that the lowest price at which a press, such as that I have described, and of a suitable size for pharmaceutical purposes, could be made, would be from twenty to thirty guineas.

## THE PROCESS OF EXPRESSION.

In using any one of the presses here described, some means are frequently required, beyond those hitherto noticed, for confining the solid part of the substance to be pressed during the process of expression. When a press-box, such as that figured at page 105, is employed, the substance is not unfrequently put directly into the inner case of the box without anything intervening; sometimes, however, the substance is enclosed in a *press-cloth* or *bag*, previously to its introduction into the box, and there are cases in which this method of operating is necessary.

The *tincture-presses* most commonly used by pharmaceutists who operate upon small quantities of ingredients at a time, are constructed with a view to their employment without a press-cloth or bag, or at least, with such only as shall act as a strainer, it being important in these cases to avoid using a thick cloth or bag, which would cause loss by absorbing part of the liquor.

It is customary with large presses to use a press-cloth or bag, and this practice is adopted even with small presses, when the substance to be pressed is of a pulpy nature.

The bags and cloths used for this purpose are made of different materials, the object being to have them sufficiently strong to bear the force exerted laterally during the process of expression, while, at the same time, they are not so thick or porous as to absorb much of the liquid.

*Press-bags* are very commonly made of horse-hair cloth, a material which possesses great strength and durability; and, although this cloth is necessarily rather thick, yet it does not absorb liquids to so great an extent as cloths made of ligneous fibre, or even of wool. A horse-hair bag, after having been used, may, therefore, be more completely freed from any impregnation of the substance operated upon, than the other kinds of straining cloth.

The principal objections to the horse-hair cloth are, that it is always coarse, thick, and stiff. It appears that the strong hair employed in making it, cannot be manufactured, or, at least, is not manufactured, into fine and flexible cloth. This cloth, therefore, can only be used advantageously in the form of a bag, and it is inapplicable even for a *small* bag.

*Strong canvas*, or *unbleached linen cloth*, is sometimes substituted for horse-hair, but is inferior in every respect excepting in regard to the closeness of its texture and its flexibility; in these respects it is better adapted for operations on a small scale.

*Woollen cloth* is manufactured with a view to its application in the process of expression, and is sold for this purpose by the dealers in straining-cloths, sieves, and other articles of this kind used by druggists. This is the material generally employed in the expression of fixed oils, such as castor-oil, oil of almonds, &c. The seeds from which these oils are pressed, are first crushed by passing them between two cylinders turning in opposite directions, and placed nearly in contact with each other, the distance being regulated so as to produce the required degree of disintigration. The crushed seeds are then folded in square pieces of the woollen press-cloth, so as to form flattened cakes; and a number of these are placed one over another, with intervening plates of tin or tinned copper, forming a pile between the follower and the head-plate of the press.

In conducting the process of expression, the substance to be pressed being confined in the manner best suited to the circumstances of the case, the pressure must be *gradually applied*. If the substance be in a soft and pulpy state, it will be necessary to begin with a very slight pressure, for as the force applied will, in this case, be communicated equally in every direction, according to the law of hydrostatics, the bag or cloth would inevitably give way, or the substance escape through the apertures intended for the flow of the liquid, if much force were exerted. When part of the liquid has been pressed out, and the remaining substance has become more firm, increased pressure may be applied, and ultimately, as the contents of the bag become solid, the full force of the press may be safely exerted.

The effect of applying pressure in this way, to a substance consisting of solid and liquid particles, is, to cause the nearer approach of the former to each other, while the latter are displaced and forced out through the apertures provided for this purpose. Much force is required to overcome the resistance offered by the pressure of the liquid, and also by the elasticity of the solid particles themselves. Great compression cannot be effected suddenly, with the means usually resorted to, continued application of the pressure for sometime being necessary, so that the solid particles may approach nearer and nearer as the elasticity by which they were kept apart is gradually overcome and destroyed. Thus, after effecting as much compression as the means provided will admit at one effort, if the press with its contents be left unrelaxed for a few minutes, it will be found, at the expiration of this time, that further compression may be effected by the renewed application of the same power. It is by following up the effects in this way, with intervals of cessation in the application of new force, that the required object is ultimately attained.

To accomplish the object efficiently by these means, it is necessary that the press should be capable of maintaining unrelaxed the degree of compression which has been produced at each successive effort, and that it should not allow the particles, by their elastic force, to regain, to any extent, their original condition. This quality is possessed to a greater extent by the *screw-press* than by the *hydraulic-press*. The former will maintain for an indefinite length of time any degree of compression which may have been given to the substance placed in it; but not so the latter. The pressure in the hydraulic-press, being communicated through a liquid, and maintained by the action of valves, it is found practically impossible, with the kind of skill usually bestowed in the manufacture of these presses, to prevent a slight leakage, which causes a relaxation of the pressure when the pump is not in action. It is necessary, therefore, more frequently to renew the force, in conducting the process of expression with the hydraulic-press, than is the case with the screw-press.]

## FURNACE-OPERATIONS.

### OPERATIONS OF GLOWING OR HEATING TO REDNESS.

The heating of a body until it becomes luminous, is called *glowing* (gluhen) or *heating to redness.* All solid bodies, when they acquire a certain temperature, become luminous, and the temperature is often estimated by the intensity of the light which is emitted; thus the terms *red-heat*, *cherry-red-heat*, and *white-heat*, are used to designate degrees of temperature, which cannot be conveniently measured by the instruments commonly used for such purposes. *Red-heat* is the lowest temperature contemplated in these operations; it is produced by the slow combustion of fuel maintained in a furnace or stove without any strong draught of air. *White-heat* is the most intense heat that can be obtained in a furnace, aided by a powerful draught or artificial blast. *Cherry-red-heat* is intermediate between the two others; it is the most useful for many chemical purposes. [Professor Daniell, by the use of his pyrometer, estimated the temperature at which solid bodies begin to be luminous, at between 800° and 900° of Fahrenheit's scale; he has represented a *red-heat* as equal to 980° Fahr.; a *white-heat* may be represented as equal to about 3000° Fahr.; and a *cherry-red-heat* about midway between the two.]

We shall have occasion here to treat of the practical means by which these degrees of heat may be obtained. As a general rule, it is considered desirable, in pharmaceutical laboratories, to avoid, as much as possible, having recourse to operations requiring these high temperatures, for as they occur but rarely, the fire has to be lighted expressly for each process, in a furnace previously cold, and therefore requiring some time and expenditure of fuel to get it into a state fit for use. On this account, and also on account of the loss incurred from the fracture of crucibles, and unavoidable waste of the materials operated upon, many substances which, in their preparation, were formerly heated to redness, are now prepared by a less expensive and troublesome process. Yet there still are cases in which recourse is obliged to be had to this method of operating, and therefore the implements for conducting it ought not to be wanting in a well-appointed laboratory.

*Fuel.*—*Charcoal* is the most convenient fuel to use in these operations. It ignites easily, will burn readily in stoves of all kinds, whatever their construction may be, and leaves no slag. It presents the advantages, therefore, of being more cleanly, and more easily managed, than other kinds of fuel; but on the other hand, it is more expensive, (especially in England,) and it burns away more quickly.

*Common Mineral Coal* is cheaper than charcoal; it requires a stronger draught to maintain its combustion, and it leaves slags and a greater amount of ash, which tend to block up the grate; it affords, however, a stronger heat.

*Coke*, that is, coal deprived of its gaseous and sulphurous constituents, affords, when the combustion is maintained with a sufficient draught or blast of air, a stronger heat than any other kind of fuel. It supports combustion for a long time, and therefore a fire does not require to be fed so often with this fuel as it would if charcoal were used, which is a great advantage in many operations. There is a marked distinction between a coke fire and a charcoal fire, which is worthy of notice. In a coke fire there is very little flame, and this scarcely extends beyond the fuel itself, while charcoal burns with a considerable flame, resulting from the combustion of carbonic oxide gas. The reason of this is, evidently, that the carbonic acid produced by the combustion is not so readily converted into carbonic oxide by passing through red-hot coke as through the more easily oxidisable charcoal. From the same cause the heat is most intense in a coke fire at the place of the draught, while in a charcoal fire it is distributed more equally throughout. On this account, as well as for other reasons, a coke fire is economical, as there is a smaller consumption of fuel, arising from the production of carbonic oxide in the part of the furnace not used. Moreover, charcoal burns with a crackling noise, and throws off a great number of sparks, which are troublesome, and even dangerous to the eyes of the operator, an inconvenience not experienced in the use of coke; and as the latter burns only at a strong heat, the combustion soon slackens, and ceases when the blowing is suspended or the draught checked at the conclusion of a process, and the unconsumed fuel is thus saved for another operation.

[There are two kinds of coke used in this country, which are distinguished as *gas-coke* and *oven-coke*. The former is obtained as a secondary product in the manufacture of coal-gas; the latter is made by a distinct process in ovens constructed expressly with a view to the production of a good heat-producing fuel. The properties of these two kinds of coke differ so considerably that they cannot be indiscriminately employed for the same purposes.

*Gas-coke* is much more easily combustible than oven-coke, that is to say, it burns at a lower temperature. When mixed with a small quantity of coal, it may be burned, as it frequently is burned, in open stoves, and even without this admixture it forms an excellent fuel for close stoves or furnaces, even for those in which there is not a strong draught.

*Oven-coke* can only be burned in furnaces having a strong draught; indeed, an artificial blast is generally required to ensure its active combustion. When burned under these circumstances, however, the combustion is more enduring, and the heat produced more intense, than would be the case if gas-coke were used. It forms the best fuel, therefore, for air or blast furnaces, and is generally employed where intense heat is required, as, for instance, in the smelting of iron.]

*Wood*, *peat*, or *brown coal*, if used in the processes now under consideration, are employed in a different manner from that adopted with the fuels previously noticed. The crucible containing the substance to be acted upon is not placed immediately in contact with the ignited fuel, but merely exposed to the flame resulting from its combustion; these fuels, therefore, require a furnace of particular construction, which will be described hereafter. Peat and brown coal should be well dried before being used, and even then are only fit for use in these operations, when they burn with very little residue.

*Crucibles.*—In conducting the process of *glowing*, the substance to be heated to redness is generally put into a crucible. The crucibles used for this purpose have either round or triangular mouths. There is no particular reason for giving the preference to one rather than the other of these forms, unless it be that in some cases the round crucible may be better suited to the shape of the furnace into which it is intended to be introduced. The best crucibles for the purposes here contemplated are those made at Hesse, called *Hessean crucibles.* These are so good and cheap that there is little inducement for substituting any other kind. Black-lead crucibles are much less frequently used, being more expensive, and not so generally applicable.

[Hessean crucibles are commonly used in England, and are generally better than any others met with. Among those made in this country, the Cornish crucibles are the best, and some of these are, perhaps, not inferior to the Hessean.]

It usually happens that the crucible is destroyed during the process, or rendered unfit for use on any subsequent occasion. This is especially the case when the substance operated upon undergoes fusion. When it remains unfused, in the state of powder, as is the case with the oxides of zinc, iron, and copper, &c., the same crucible may, with careful and judicious management, be made to serve for two or three operations.

The crucible ought not to be placed immediately on the grate or bars of the furnace, but on a stand provided for its reception. Stands, composed of the same materials as the crucibles, are made for this purpose, but, in the absence of such, a piece of brick, or an old crucible placed bottom upwards, may be used. When pieces of brick are used, as these are often to a certain extent fusible, and would in such case adhere to the bottom of the crucible, thus occasioning inconvenience on withdrawing it from the fire, it is desirable to guard against such result by putting a layer of sand or bone-ash between the crucible and its stand.

A little management is required in putting the crucible into the fire. It ought not to be exposed to a strong heat without previous preparation, for if it be too suddenly heated it will almost inevitably crack from unequal contraction. The cold crucible should, therefore, be gradually warmed by placing it on the top of the furnace, or in any suitable place for this purpose, previously to its introduction to the fire. The fracture of a crucible is sometimes caused by putting into it pieces of metal, which are intended to be fused, in such a way that, extending across the crucible from one side to the other, and fitting in tightly while cold, there is no room left for their expansion when heated.

Small crucibles having a capacity equal to about four ounces, may, in most cases, be heated in any one of the laboratory furnaces that may be in use for other purposes. Indeed, crucibles of six or twelve ounces' capacity may often be heated in this way, or at least by the use of a small portable furnace. When the crucible has a capacity of a pound or more, it becomes necessary to use a furnace constructed expressly for such operations. There are several kinds of furnace used for this purpose, but the *wind-furnace*, which is the oldest, is still generally preferred: it affords the means of efficiently heating crucibles of any size.

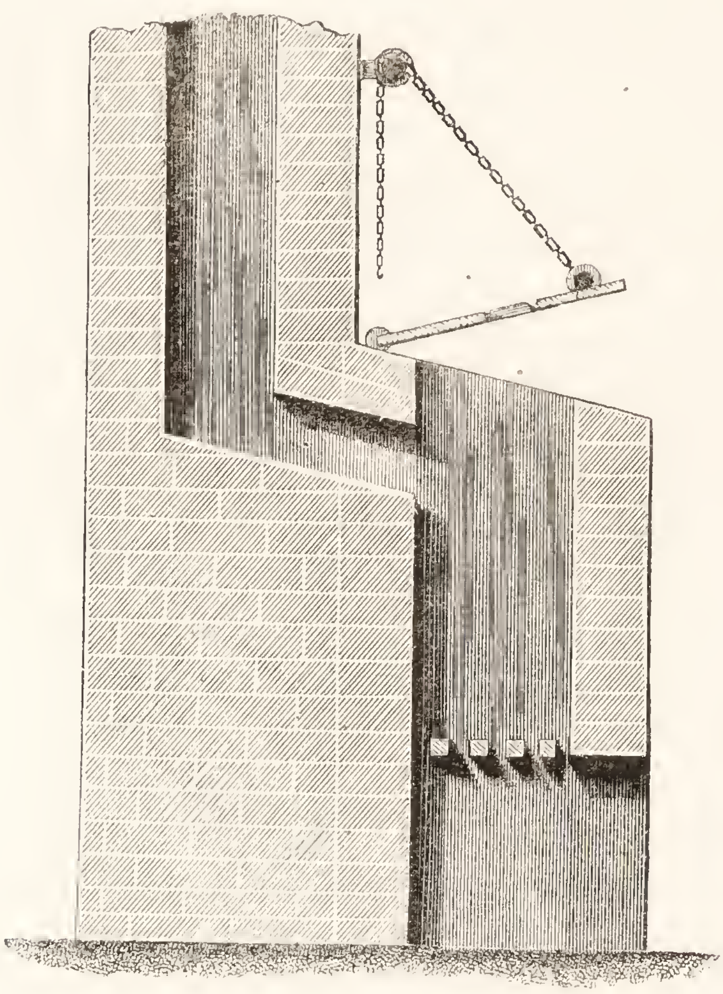
*The air or wind-furnace.*—This furnace should be constructed of the best fire-bricks, and it should be connected with a high chimney, so as to ensure a good draught. The interior of the furnace may be made either square or round, each of these forms having its own peculiar advantages and defects. The round form is convenient for the reception of a crucible, and economical in the consumption of fuel, for the corners in the square furnace contribute little to the available heat when used for these operations; but it is not so easily constructed as the other, unless fire-bricks, shaped for the purpose, are employed, and these cannot always be obtained. There are some processes, however, in which the square furnace is more convenient than the round, and as the former of these is always more easily built than the other, and especially with bricks of the usual shape, preference is generally given to this form.

In erecting a wind-furnace, it is desirable to select a situation for it in which there is easy access to a suitable chimney without carrying the flue horizontally for any distance, or having any sharp angles that might impede the draught. It has been recommended, that this furnace should be built over an underground-vault or cellar, so that by breaking through the arch of the vault a supply of air may be obtained from below for the fire. This plan, however, presents few advantages, and is subject to some objections. I prefer having the draught-hole of the furnace made in the floor of the laboratory, beneath and in front of the furnace, the part projecting beyond the furnace being covered with an iron grating through which the air is admitted.

The grate or bars of the furnace ought to be as near the floor as possible, so that the whole elevation should not be inconveniently high, and that the operator may be able to introduce or remove crucibles and other apparatus through the opening at the top. The draught-hole or ash-hole may be either on a level with the floor, as shewn in figs. 103 and 104, or it may be immediately under the floor, as already mentioned, and projecting in front of the furnace, with a moveable iron grating over it, which may be taken up to remove the ashes from beneath. The mouth of the furnace is covered with a cast-iron plate, coated on the inside with fire-clay to protect it from the action of the fire, and fixed as shewn in the drawings. This plate is raised and lowered by means of a chain passing over a pulley, when the crucible is introduced or removed, or fresh fuel is supplied to the fire. There is a small hole in the centre of the iron plate through which the progress of any operation which is going on in the furnace can be observed. Fig. 103 represents a vertical section, and fig. 104 a front view of this furnace with the cover partly raised.

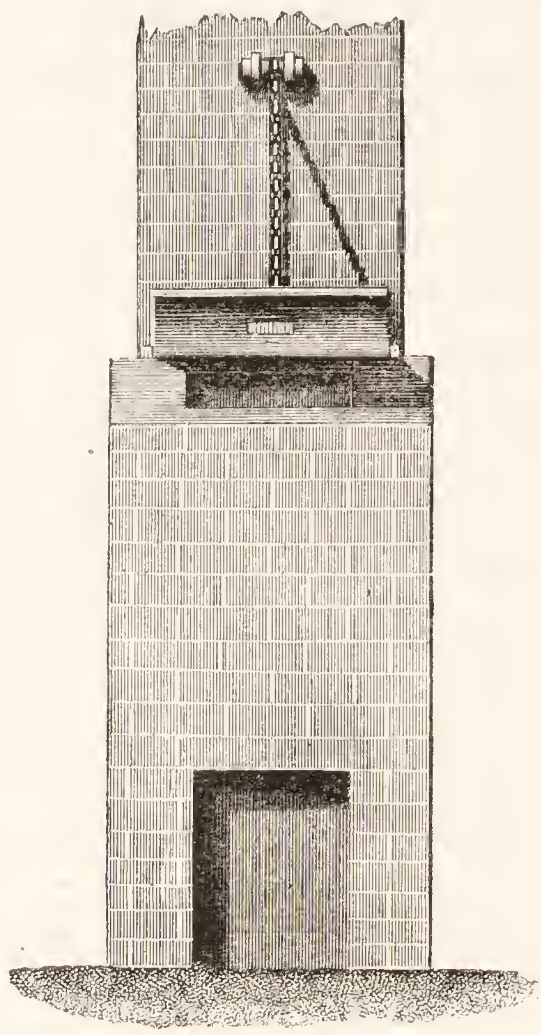
The furnace-bars are sometimes made of wrought, sometimes of cast-iron. The latter are certainly to be preferred, inasmuch as they are cheaper, and are made of a more suitable form than those of wrought-iron. They are now generally made much deeper and more massive than formerly; and when thus formed they possess

*Fig. 103.*



AIR-FURNACE.

*Fig. 104.*



AIR-FURNACE.

the advantage of lasting much longer, and of improving the draught of the furnace, by forming a good and efficient heating surface, in passing over which the air becomes warmed before coming into contact with the ignited fuel. It has been proved, in the process of smelting with the hot-blast, that the intensity of the heat produced by combustion is increased when the air supplied to the fuel is previously warmed.

The best form for furnace-bars is shewn in figs. 105, 106, and 107. Fig. 105 represents a lateral view of the bar; fig. 106 represents it as seen from above; and fig. 107 a transverse section through the middle of the bar, in the direction of the line *a b*. The ends are quadrangular, and the bar is wider here than in the intervening part, as shewn in fig. 106, so that when the bars are placed with the ends close to each other, there is a suitable space left for the admission of air. The lower side of the bar forms an elliptical curve, and it is narrower on this side than at the top, as shewn in figs. 105 and 107, this form being given to it to increase the draught, and to extend the heated surface over which the air has to pass.

This form of fire-bar, which is called *fish-bellied*, is found to be very advantageous. The heat of the strongest fires, which would melt bars of the old form, or so soften them that they would bend and become useless, produces little or no injurious effect upon these. The heat communicated from the burning fuel to the upper surface of the bar is rapidly distributed by conduction throughout the whole mass of metal, and as a current of air is at the same time passing in contact with this, the heat seldom becomes so much concentrated as to heat the lower side of the bars even to redness.

*Fig.* 105.

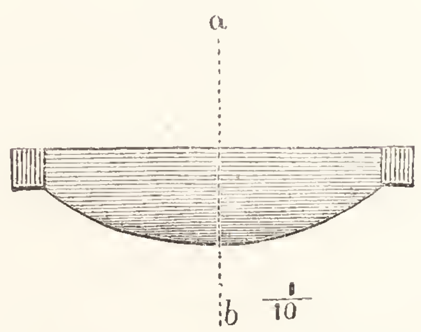



*Fig.* 106.

*Fig.* 107.

There is usually a square opening in the front wall of the wind-furnace, which is formed in building it, and then stopped up with bricks or a stone, which fits into it, so that it may be used, for any particular purpose, to allow the neck of a retort, or a tube, to pass through; but this is seldom required in strictly pharmaceutical processes.

The heated air and products of combustion of the furnace pass into the chimney through a rather contracted flue, which is called the *fox*. This contraction promotes a more complete combustion of gases, which otherwise would pass into the chimney without yielding the full amount of heat that they are capable of producing, and by the generation of which, the heat, and consequently the draught of the chimney, is increased. A sliding door, called a *damper*, is sometimes fixed in this part of the flue, by which means the opening may be contracted or enlarged at pleasure.

In the air or wind-furnace, a strong draught and active combustion are produced at the expense of much fuel, which is necessarily consumed in heating the chimney, so as to get the furnace into vigorous operation. It has been found from actual trial, that if the fuel used for this purpose were lighted under a boiler, and the steam generated applied to a steam-engine, the power thus produced would be capable of putting into motion with equal force ten or twelve times as much air as that which passes through the chimney of the wind-furnace. It is evident, therefore, that a great saving in expense might be effected by substituting steam, or some other power, for the means provided in the wind-furnace, in getting the required draught or current of air.

The operations in a pharmaceutical laboratory are not generally of sufficient extent to require the application of a steam-engine, but, in the absence of this, the power of the human arm, which is not otherwise put into requisition during the heating of a body in the furnace, might be applied to mechanical means for effecting a current of air.

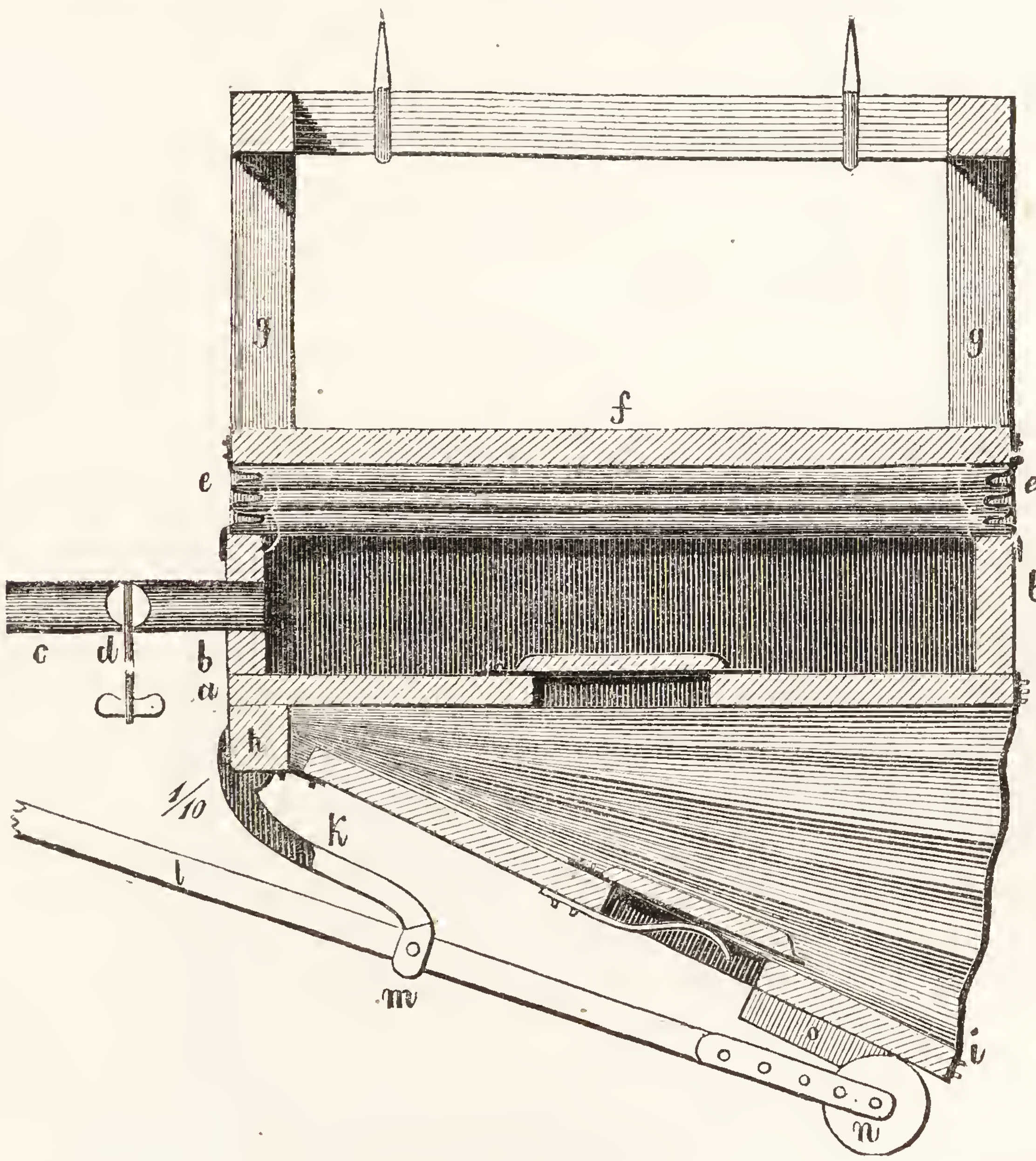
The *bellows* is the implement through which the power of the arm is generally applied in creating a draught for a furnace. By the use of this implement, time, fuel, and space, are economised. Time is gained, inasmuch as, by a few strong blasts, a draught may be created which, without this means, would only be attained after the fire had burned for some time. For the same reason, fuel would be economised; and as a tall chimney is not necessary when the draught is created by mechanical means, space might be economised, when this is a consideration, by substituting a small portable *blast-furnace* for the fixed and more bulky wind-furnace. I removed the wind-furnace from my laboratory ten years ago, and substituting a portable blast-furnace, which, when not in use, may be put into any unoccupied corner, have never experienced inconvenience from the change.

It has now to be considered what is the best construction for the *bellows* and the *blast-furnace*. The forge-bellows, as usually constructed, has certain defects, which, however, may be easily obviated. The wedge-form has probably been given to the common bellows from an erroneous notion that the air would more easily and forcibly enter the pipe when directed in this way, than would otherwise be the case; but this form is objectionable, and ought to be abandoned, such a geometrical shape being substituted as shall unite the greatest cubical contents with the smallest extent of lateral surface. Amongst the rectilinear figures, that which answers best to the required conditions will, in a transverse section of the bellows, represent a square.

When the board constituting the upper part of the bellows, or that to which the weight is attached, is fixed on one side by a hinge, according to the usual construction, it will necessarily shift its position in reference to the horizon at every point through which it passes in rising and falling; and the pressure exerted by the weight will vary with all these alterations of position, being least available when the bellows is opened widest, from the weight being then thrown more on to the side fixed to the hinge, where it produces no effect, and increasing as the board becomes more nearly restored to the horizontal position. This loss, and constant variation of pressure, arising from one side of the moveable top being fixed, is a great defect; it may be obviated by doing away with the hinge, and making the top to rise horizontally, the leather being attached on all sides in equal folds, as it is in the accordion and other similar instruments.

*The double bellows* consists of two chambers, into the lower of which the air is first drawn; and from this it is subsequently transferred through a valve into the upper chamber, which serves as a sort of regulator, by which the intermitting puffs of the single bellows are changed to a continuous and uniform current of air. The partition between the two chambers is permanently fixed to a firm frame-work, as shewn at *g*, *g*, fig. 108, the frame being just large enough to admit of the bulging out of the leather during the working of the bellows.

*Fig.* 108.




The Double Bellows.

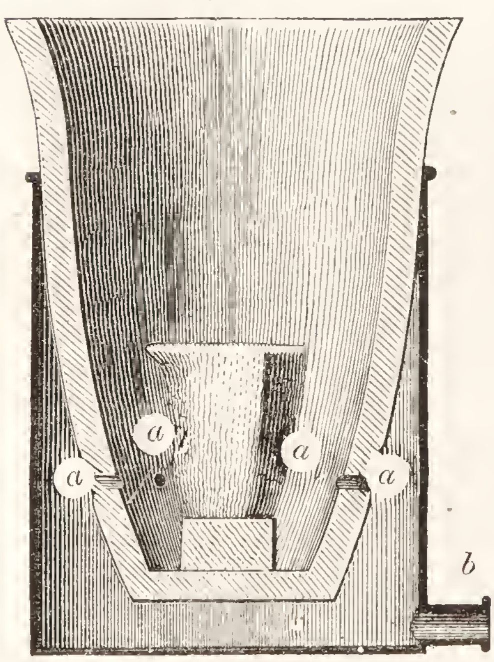
The fixed partition, with its valve, are represented at *a*, *a*, and immediately above this there are two boards (*b*, *b*), into one of which the air-pipe (*c*), with its turning valve (*d*), is inserted. The folded leather (*e*, *e*), which, when expanded, forms the upper chamber, is fixed to the boards (*b*, *b*) below, and above to the board (*f*), which forms the top of the bellows. The leather (*e*, *e*) of the upper chamber is shewn in a state of collapse. The frame-work (*g*, *g*,) as represented in the drawing, is intended to be fixed to the ceiling.

The lower, or supply chamber, is fixed at one end to a piece of wood (*h*), to which the bottom board (*i*), with its valve, is attached by hinges. The iron arm (*k*) is also attached to *h*, and this forms a stationary fulcrum (*m*) for the lever (*l*), by which the board (*i*) is raised. There is a small roller (*n*) at the end of the lever to lessen the friction, and this roller works in a groove formed by two pieces of wood, one of which is shewn at *o*. A flat plate of cast-iron may be fixed on the board (*f*) to give the required pressure to the air.

The *furnaces* which are adapted for use in those cases where the draught is promoted by means of a bellows, have now to be described.

*Crucible Furnace.*—The smallest furnace of this kind is such as may be made out of a large black-lead crucible. This furnace is represented in fig. 109. About three inches from the bottom of the crucible, four or six holes (*a*, *a*, *a*, *a*,) are made with a gimlet, horizontally through its side. This is easily done with black-lead crucibles, in consequence of their soft texture, but those made of hard materials would not admit of it. The crucible, thus prepared, is encased by a cylinder made of sheet-iron, into which it fits tightly at the top, while from the tapering shape of the lower part of the crucible, a vacant space is left in the bottom of the cylinder, as shewn in the drawing. There is a pipe (*b*) at the bottom of the cylinder, which is connected with the tube of the bellows, and a blast is thus directed into the vacant space in the cylinder, from whence it passes through the holes *a*, *a*, *a*, *a*, to supply the combustion in the black-lead crucible.

*Fig.* 109.



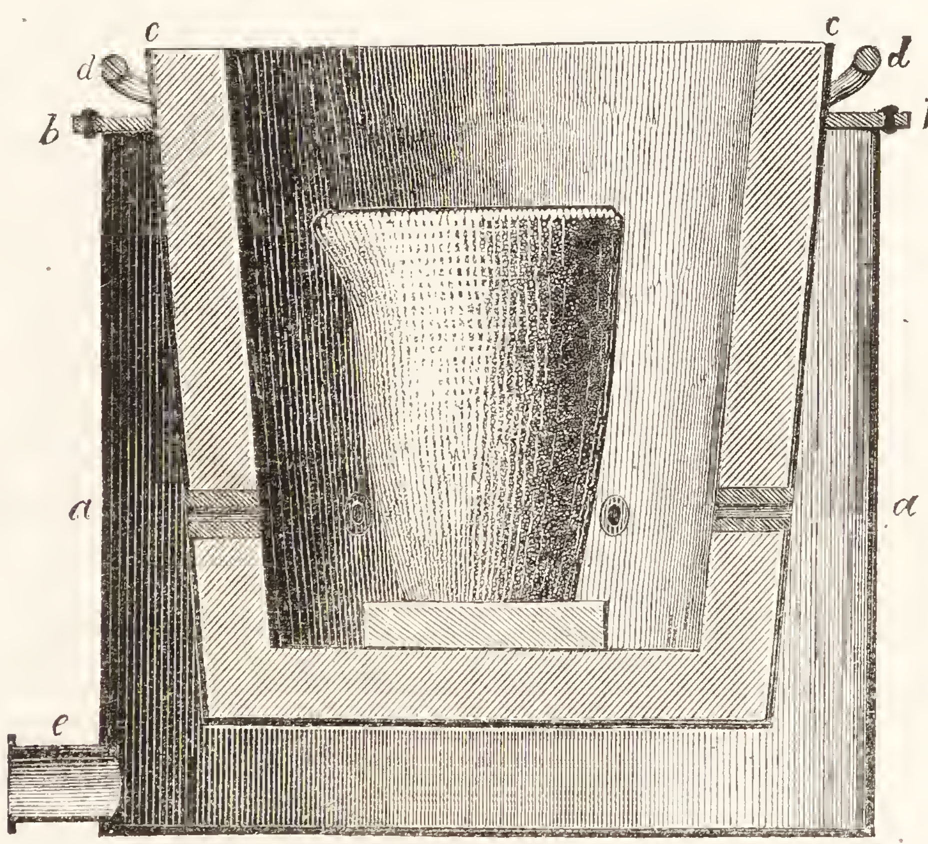

CRUCIBLE FURNACE.

I have a furnace of this kind in use, the cylinder of which is eight inches in diameter, and ten inches high. A crucible of twelve ounces' capacity may be brought to a full white-heat in this furnace, and when it has been kept in operation for some little time, the draught becomes really a hot-blast, from the air being in contact with the heated metal previous to its entering the fire. With a coke-fire the flame scarcely extends a foot above the fuel, but the heat and light are so intense that the eye cannot endure it, and neither crucible nor fuel are distinguishable. Care must be taken that the support for the crucible does not consist of any fusible material, such as common brick, for in such case it would inevitably adhere to it, and there would be danger of breaking the crucible in attempting to separate them.

*Seftstroem's Furnaces.*—These are constructed on the same principle as that last described, but they are made of any required size, and may therefore be used for those operations requiring a larger fire than the crucible-furnace admits of.

The outer case or cylinder (*a a*), fig. 110, is made of stout sheet iron. It is somewhat contracted at the top by means of a ring (*b b*), which is rivetted on, and into this ring a second cylinder (*c c*) fits, as shewn in the drawing. The second cylinder is made of the same material as the first; it has two handles at *d d*, and is slightly conical, so that, without being a permanent fixture, it fits tightly into the ring, being inserted up to the points at which the handles are attached, and it may be removed at any time to facilitate the clearing away of obstructions from the air-holes, or to remedy other defects.

*Fig.* 110.




SEFTSTROEM'S FURNACE.

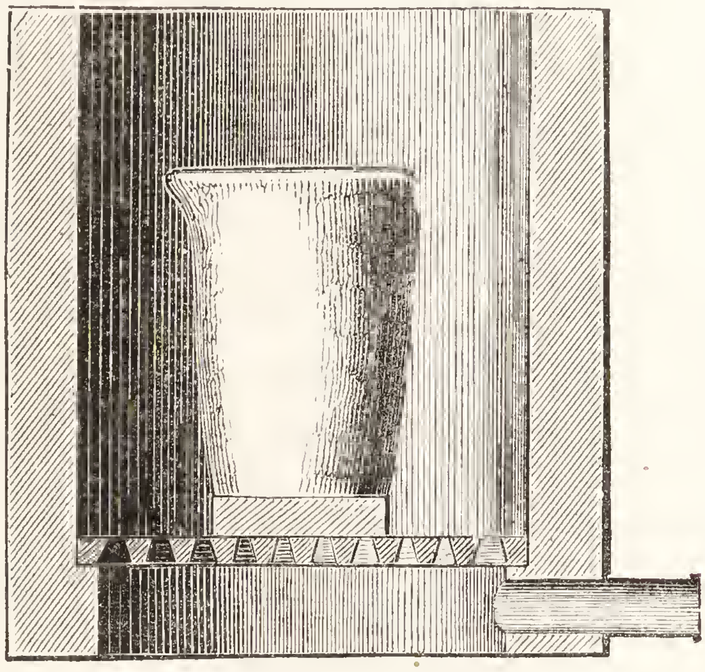
The inner cylinder has six or eight tubes, about half an inch in diameter, and two inches in length, fixed by means of rivets at equal distances from each other round its circumference, about five or six inches from the bottom, and projecting inwards. The inner surface of this cylinder is lined with fire-clay to the thickness of the projecting tubes, which, after carefully drying it by exposure to the air, and filling up any cracks that may be formed during this part of the process, is finally hardened by the heat of an operation such as the furnace is intended for. Before submitting it to a strong heat, it is important that the clay should be well dried spontaneously, and the clay mixture used should be such as will not contract much in drying. The best mixture for the purpose is made by incorporating old broken crucibles, or burnt clay, reduced to powder, with the moist and unburnt fire-clay (Stourbridge clay), adding as much of the former as can be introduced without destroying the adhesiveness of the resulting mass.

The outer cylinder has a tube (*e*) near the bottom, to which the pipe of the bellows is attached. During the action of the bellows the air is compressed in the space between the two cylinders, and is thus forced through the tubes into the fire contained in the inner cylinder. From the length of these tubes, and the conducting power of the iron of which they are made, the air thus entering the fire is previously well warmed, so as to assume the character of a hot-blast more completely than is the case with the *crucible furnace* previously noticed. The air entering in separate horizontal currents, from every side produces a most intense heat in this part of the furnace; and not only is this heat the strongest that a furnace can afford, but being of equal intensity on all sides, the crucibles exposed to it are less liable to crack than would otherwise be the case. The surface of the clay-coating of the furnace generally becomes glazed, from the action of the heat on the materials used in contact with the ashes of the fuel. Even Hessean crucibles sometimes collapse in the heat of this furnace. This intense heat is seldom or never required for pharmaceutical purposes, but lower degrees of heat may be obtained by regulating the supply of air.

If a piece of brick be used to form a stand for the crucible, it will be necessary to interpose a stratum of sand between it and the bottom of the crucible, to prevent them from adhering together.

*Common Blast Furnace.*—A furnace, the construction of which would be cheaper and easier than that of either of the foregoing, may be made by using a cylinder, similar to the outer cylinder of fig. 109, or fig. 110, and merely coating the inside of it with fire-clay, making a projection near the bottom for the reception of a set of fire-bars, on which the fire is to be placed, while the pipe for conveying the air enters immediately under this. Fire-bars, suitable for the purpose, may be obtained ready-made at any ironmonger's. A furnace of this kind is represented in fig. 111. It will be sufficiently powerful for most pharmaceutical purposes, and will occupy less space in proportion to its capacity than those represented in figs. 109 and 110.

*Fig.* 111.



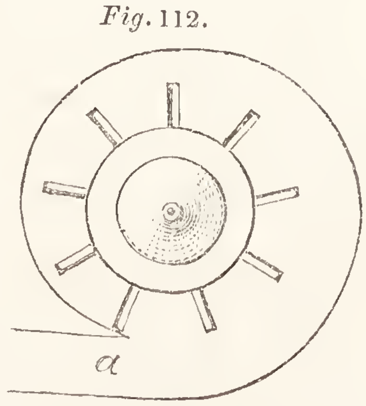
Common Blast Furnace.

In using these furnaces, the fire should be first ignited with charcoal, and afterwards supplied with coke, broken into small pieces about the size of a walnut.

It will be necessary to adopt some means for preserving the iron cylinders of these furnaces, or, at least, those parts of them that are exposed to the air, from being rapidly destroyed by rust, as they inevitably would be if put into a damp place without protection from the air. The difficulty of accomplishing this object, constitutes one of the greatest objections to this kind of furnace. There is no better method of protecting them than by coating the iron-work with coal-tar or solution of asphaltum, and renewing this from time to time as it is destroyed by the heat.

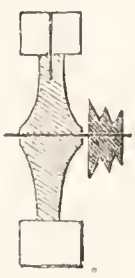
*The Centrifugal Blower.*—Instead of the double bellows, the centrifugal blower may be sometimes used with advantage, especially as it occupies less space, and, as usually constructed, is less expensive. It consists of a number of vanes or fanners, radiating from a horizontal shaft or axle, and enclosed within a cylindrical box. On the two opposite sides of the box, and immediately surrounding the axle of the fanners, open spaces are left for the entrance of the air, which, when put into motion by the rapid rotation of the fanners, is propelled by the centrifugal force through a tube attached to the circumference of the box. Fig. 112 represents a section of this part of the apparatus, shewing the position of the fanners in the box, and the tube *a*, through which the air is discharged. It will be observed that the fanners nearly touch the

*Fig.* 112.



circumference of the box at the point *a*, but at no other part, by

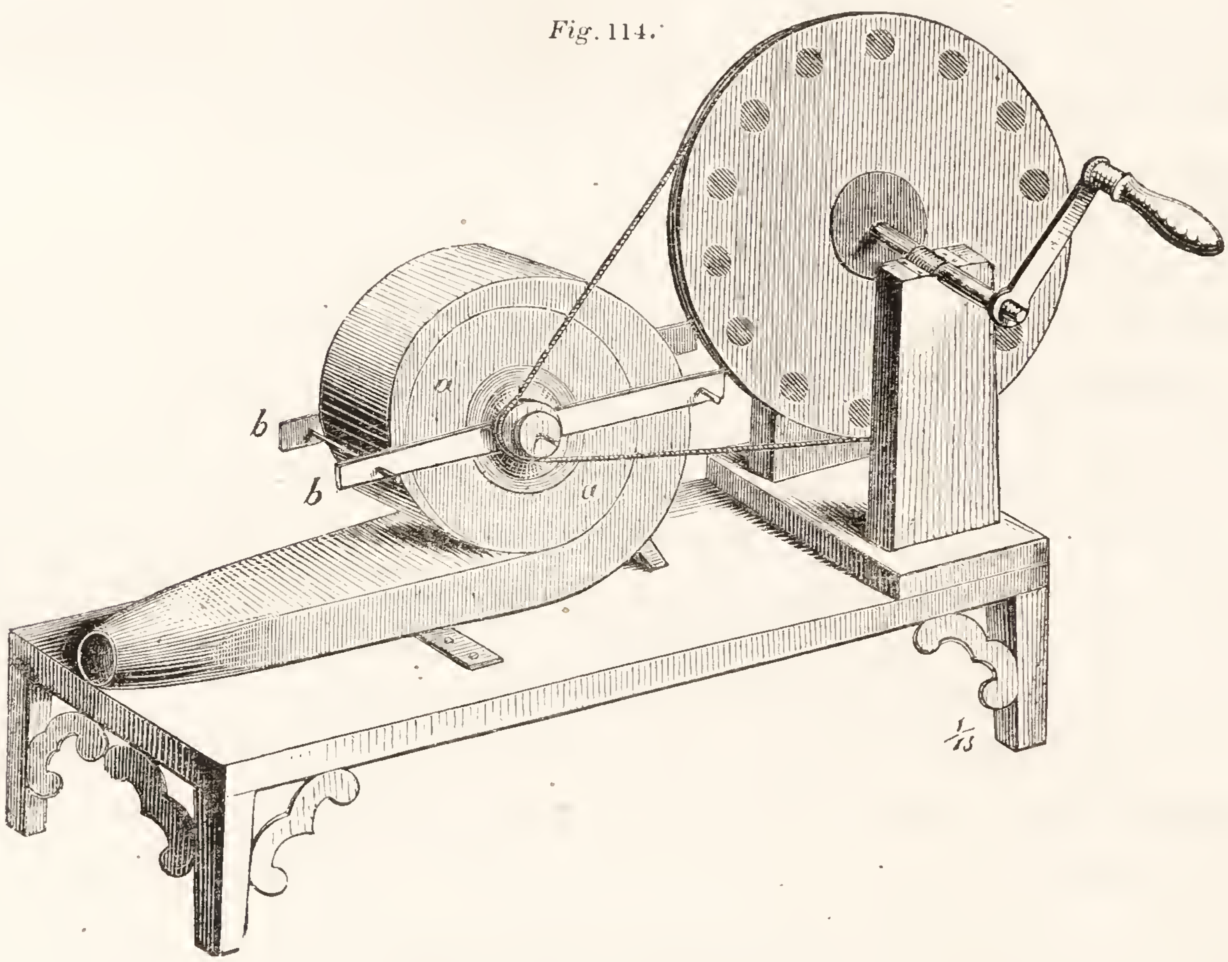
*Fig.* 113.



which means a greater current of air is propelled into the tube. Fig. 113 represents a vertical section of the fanner, made in a direction at right angles with that of the section shewn in fig. 112. The block of wood is here shewn, attached to the end of the axle, on the outside of the box, on which the cord works which gives motion to the fanners.

The apparatus, complete, is represented in fig. 114, which is drawn to about the one-fifteenth or one-twentieth the real size of the apparatus, as usually employed. [An apparatus similar in principle, but somewhat differently constructed, is described at page 80.]

*Fig.* 114.



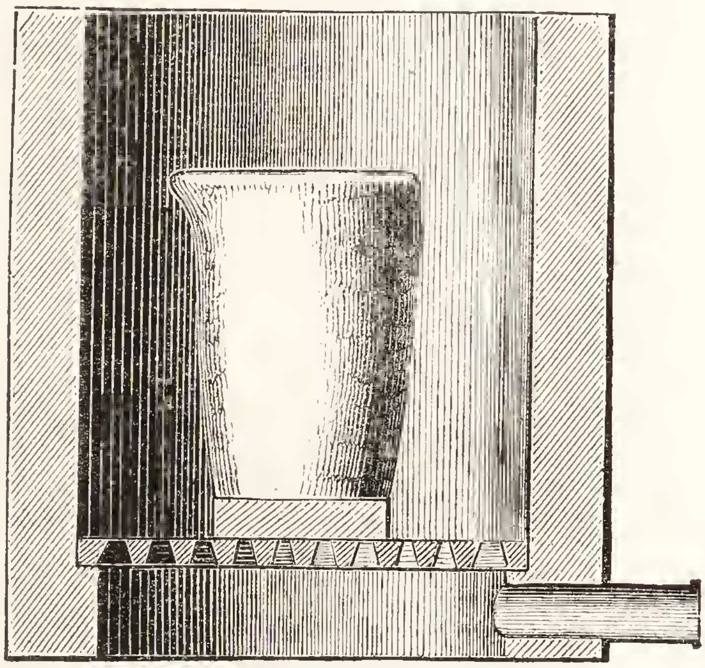

THE CENTRIFUGAL BLOWER.

This blower will be found very convenient for sending a strong current of air through a portable furnace, as it may be used in any situation in which it may be most convenient to place the furnace; and when not in use it may be hung against the wall, or put into another apartment.

The kind of furnace represented in fig. 115, will be found to be that best suited for use with the centrifugal blower. The air-pipe of the furnace should be of pretty large dimensions, and the bars of the grate should be thick, and not too close together.

One great advantage in this means of forcing a current of air into a blast-furnace is, that when the apparatus is attached to the air-pipe of the furnace, it occasions no obstruction to the free ingress of air while the blower itself is not in operation. In this respect it differs from the bellows, which, when not in action, stops all access of air to the bottom of the fire.

*Fig.* 115.



Common Blast Furnace.

*Flame Furnace, or Reverberatory Furnace.* — There are some operations in which it is found advantageous to expose the vessel to be heated to the action of the flame and hot air of the fire without being in contact with the ignited fuel. Furnaces constructed for this purpose are sometimes called *flame furnaces.* They are extensively used in chemical manufactories, but in these cases the substances operated upon are not generally contained in crucibles, but exposed on a horizontal bed of the furnace, over which the flame of the fire passes. The furnaces used in the manufacture of soda, and in the process of puddling iron, are of the kind here alluded to. When intended for pharmaceutical purposes, however, the construction is somewhat different from that adopted in the foregoing cases.

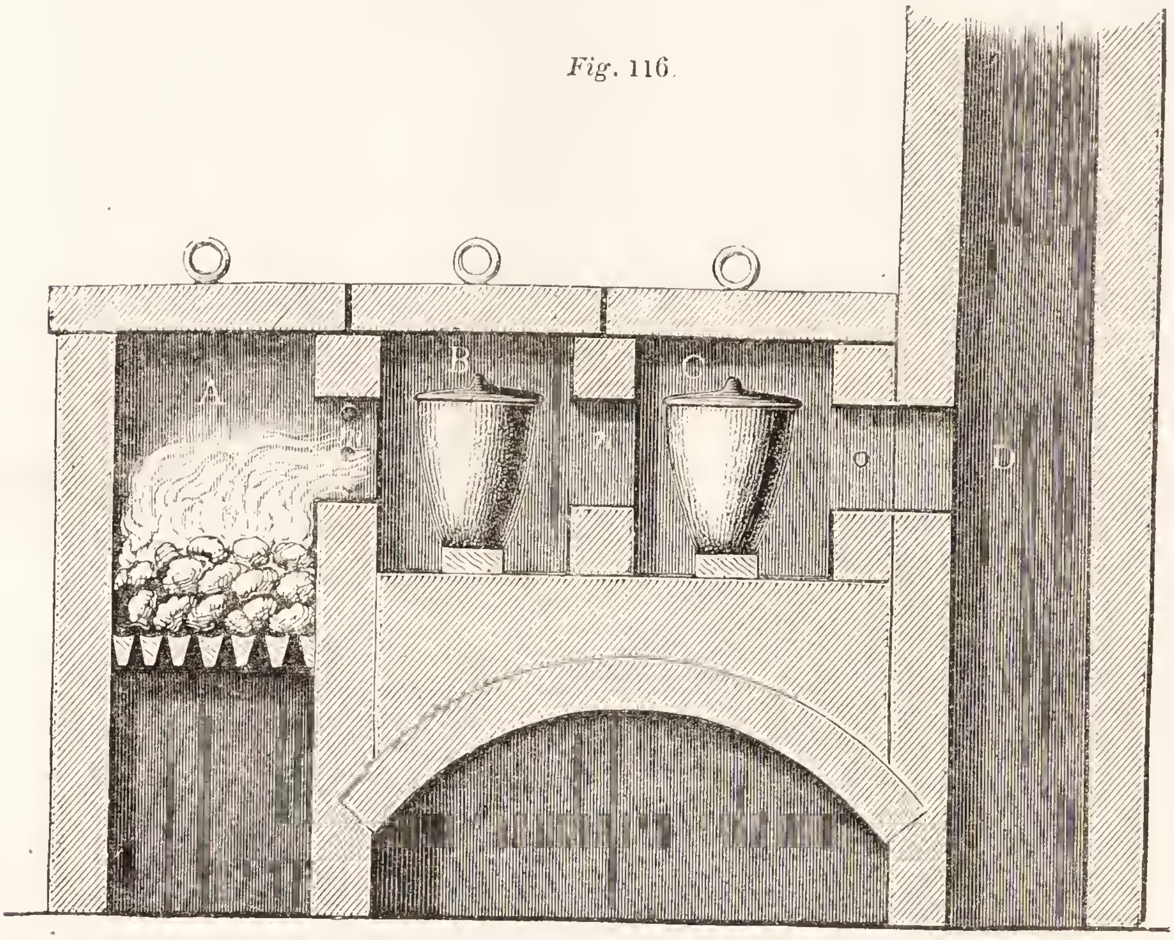
The fuel used in furnaces of this kind should be rich in hydrogen. Wood, peat, or brown coal, may be employed, but not charcoal or coke, because these latter do not burn with sufficient length of flame.

A flame-furnace has been erected in the laboratory at Giessen, where it has been found to answer remarkably well for the preparation of potassium. It possesses this great advantage, that the wrought-iron retort, employed in the process, not being in contact with the fuel, is not, as it otherwise would be, converted into the more fusible cast-iron, by the absorption of carbon. The dry wood which is employed as fuel, is burnt in a separate fire-place, and the flame from this is conducted through a narrow channel into the chamber containing the wrought-iron vessel, where it plays upon the latter with an intensity of heat which may be compared to that of the flame of a large blow-pipe.

In the mint at Carlsruhe, these furnaces are used for melting the various metals in crucibles, two or more of which are submitted to different degrees of heat, according as their proximity to the fire is greater or less.

Fig. 116 represents one of these furnaces constructed for the

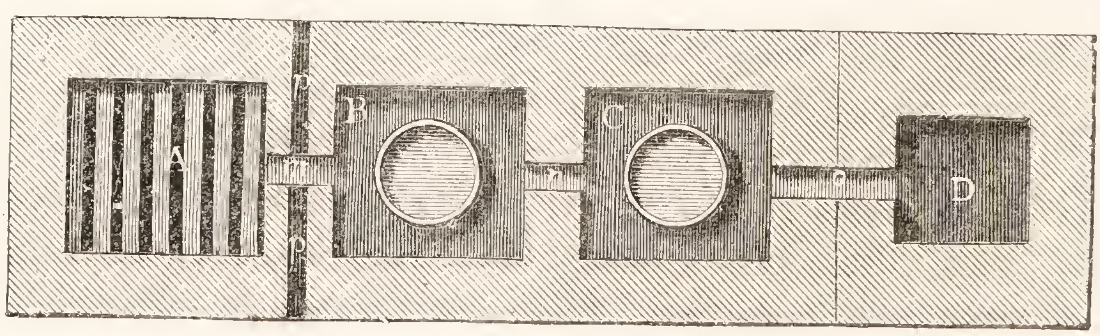
*Fig.* 116.




FLAME-FURNACE.

reception of two crucibles. In the space A the fuel is burnt, which must consist of dry wood, peat, or good coals. The flame passes through the narrow shaft (*m*), where it mixes with atmospheric air, which is admitted here through several small holes placed as shewn in the drawing, and which are also further represented at *p p* in fig. 117.

*Fig.* 117.



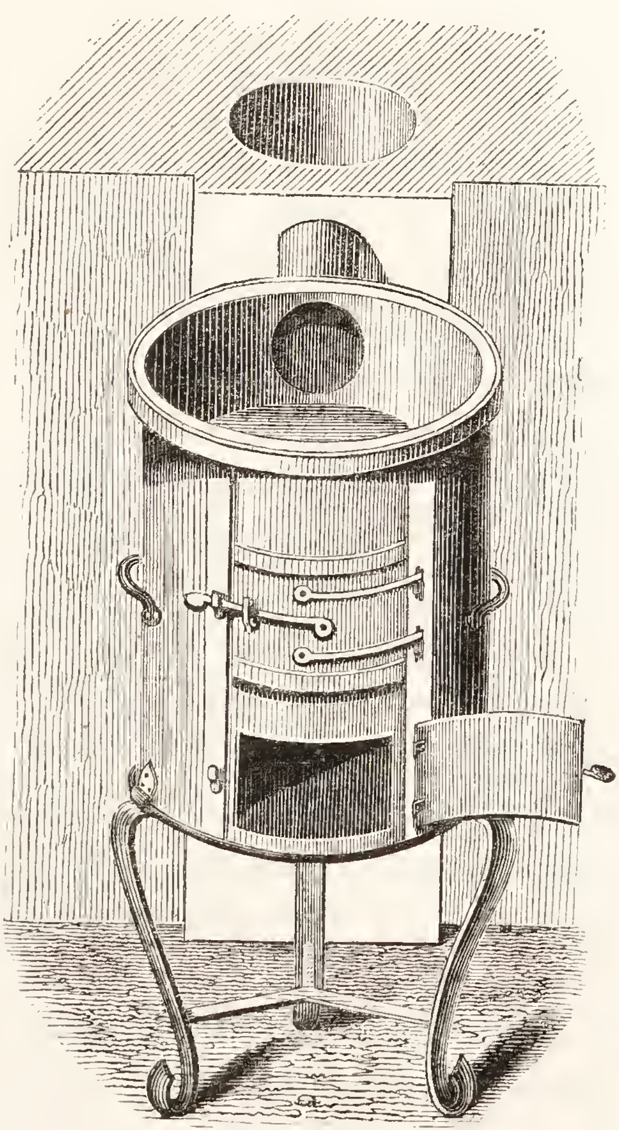

By opening or closing these holes, the supply of atmospheric oxygen may be regulated so as to prevent any deposition of carbon, and to produce the greatest degree of heat. The flame, after playing round the crucible in the space B, passes through the contracted channel (*n*) into the second space C, where it again expands and envelopes the crucible placed there, and finally escapes into the chimney (D). The flame and heat are often sufficient to admit of heating even a third crucible, when provision is made for that number.

These furnaces offer a great facility for the removal and re-introduction of crucibles, as these operations do not at all interfere with the fire. In ordinary cases, when the crucible is surrounded by the fuel, on removing the former, the fuel falls into its place, and interferes with the convenient introduction of another crucible. It is also advantageous to have a graduated heat to which the crucibles can be successively introduced.

These furnaces should be built with the best fire-bricks, cemented together with fire-clay. The circular air-holes *p*, *p*, are made by inserting round bars of iron in the brickwork, and afterwards pulling these out before the cement has hardened.

*Common Portable Furnaces.*—In some cases a common portable furnace may be made to serve a great many useful purposes, even superseding, in very small establishments, the necessity for more costly and bulky apparatus. Fig. 118, represents a furnace of this kind. It is intended to be placed against a chimney, into which the flue is inserted. Fig. 119, is a vertical section made through the fire-place, and fig. 120, a horizontal section.

*Fig.* 118.



COMMON PORTABLE FURNACE.

Vessels of the form represented in fig. 121, may be used for boiling any liquids over this furnace.

Distillation is best effected by substituting a sand-pot for the boiler, and placing a retort in the sand.

There should also be an iron cover for the top of the furnace, to be put on when neither of the other vessels is required, and this cover should consist of two or more rings with a central piece, as shewn at C, fig. 4, page 5, so that, by removing one or more of these, an opening of greater or lesser magnitude may be effected here, which would be found convenient in conducting crucible operations.

*Fig.* 119.

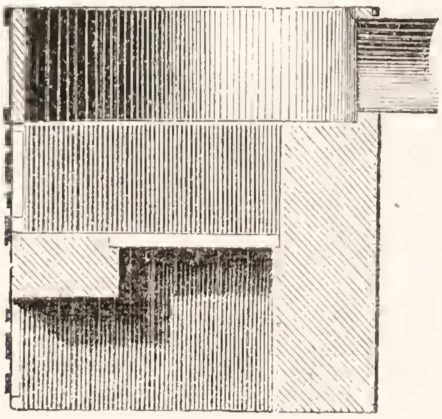


*Fig.* 120.

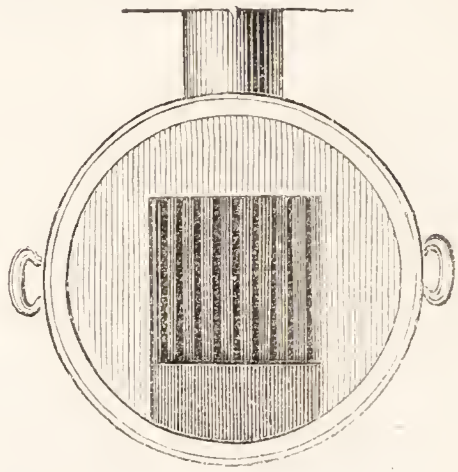
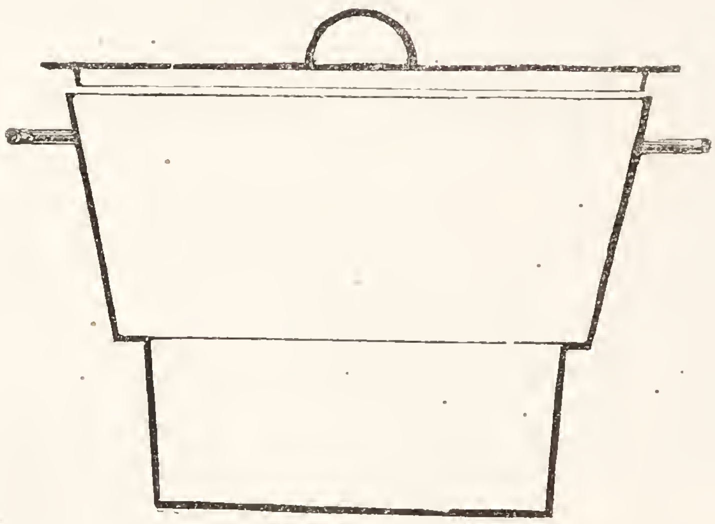


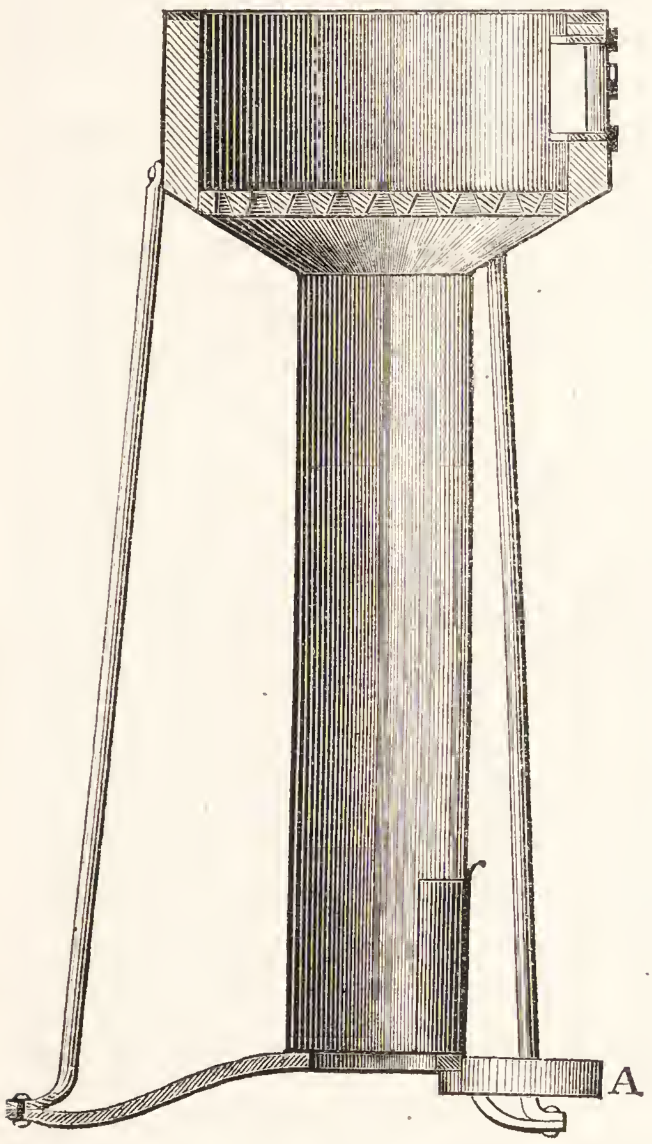
*Fig.* 121.



There is another *common portable furnace* which it may be well to describe. It is used without a chimney, and charcoal is, therefore, the only fuel that can be conveniently burnt in it, but it possesses this advantage, that it may be placed in any part of the laboratory, and moved about at pleasure. Figs. 122 and 123 represent this furnace. Fig. 122 is a vertical section, shewing the position of the grate, which is fixed at the bottom of a larger, and immediately over a smaller, cylinder, both of which are made of sheet-iron. The upper cylinder, which forms the fire-place, should be lined with clay. It is furnished with a small door through which fresh fuel may be introduced when the top is covered with any apparatus. The lower cylinder, which forms the channel through which air is supplied to the fire, extends nearly to the ground. At its lower extremity it is rivetted to a tripod stand as shewn in fig. 123, from the three extremities of which rods of iron extend upwards to the larger cylinder, so as to give to it greater firmness and stability. At the bottom of the smaller cylinder there is a sliding-door, shewn in fig. 122, by opening or shutting which the supply of air to the fire is regulated. The ashes fall through the lower cylinder, and are received on to a tray (A, fig.

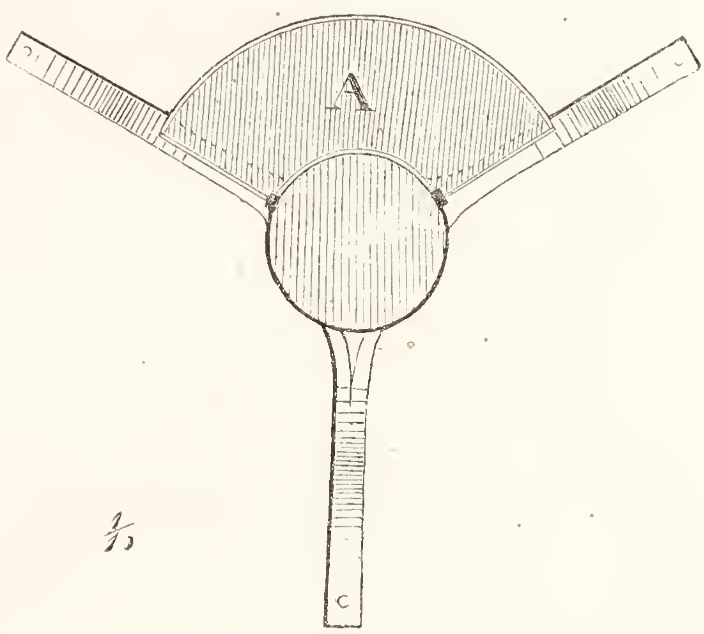
123) in front of the door. The air having to pass over the hot ashes and through the cylinder, which acquires heat by conduction, enters the fire at a temperature well suited for active combustion.

*Fig.* 122.




COMMON PORTABLE FURNACE.

*Fig.* 123.




This furnace is applicable to a great number of processes where only a moderate heat is required.

DISTILLATION.

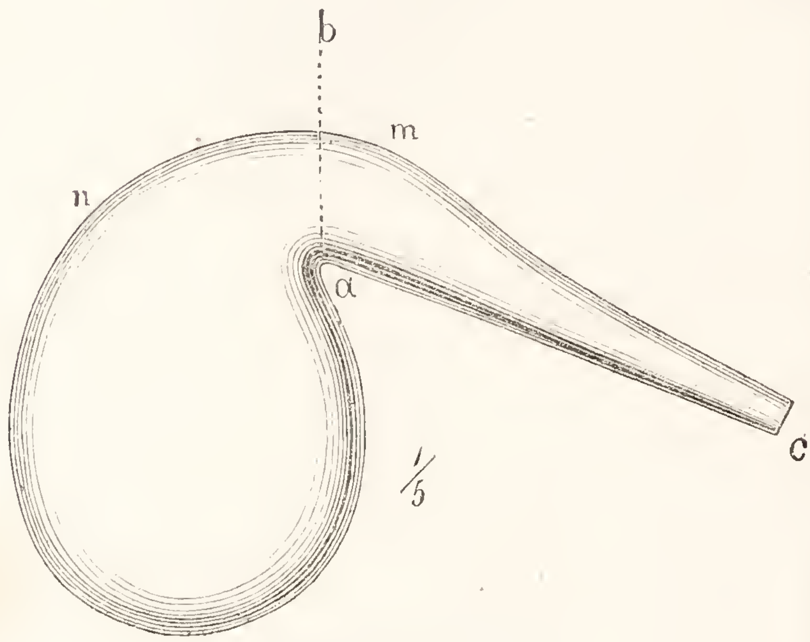
The separation of more volatile liquids from those that are less volatile, is effected by the process of *distillation*. This process involves, first, the volatilization of the distilled product by the application of heat, and, secondly, its condensation in a separate part of the apparatus.

The methods of effecting distillation on the large scale, and by the application of steam, have already been explained in connexion with the description of stills and steam apparatus. We have now more particularly to treat of distillation as conducted in retorts, and other apparatus of a similar kind.

In the first place, then, the proper form of the distillatory vessel should be considered. In the distillation of liquids which boil only at a high temperature, the shape of the retort has considerable influence on the result, as much of the vapour often condenses in the top and neck of the retort, and, if the form of this part be defective, the condensed liquor runs back into the body of the vessel.

Fig. 124 represents a well-formed retort. Holding it so that the axis of its body shall be vertical, and imagining a perpendicular line from the commencement of the neck at *a* in the direction *a b*, the angle *b a c*, should be an obtuse angle, and the line *a c* should be straight. The line *a b* should cut the top of the retort at its highest point, or, at least, the top ought not to rise from this point in the direction of the beak. The diameter of the neck should contract rather suddenly at *m*, and afterwards gradually to the end, so as to admit of its being introduced some way into the mouth of the receiver or condenser.

*Fig.* 124.




WELL-FORMED RETORT.

The bottom of the retort should be spherical, and the thickness of the glass as equal as possible in this part, and it should be free from air bubbles or other imperfections. It is also desirable that the glass should not be thick in this part, and that it should not be too thin at *n*, which is usually the weakest part of the vessel, from its having been drawn out here in bending it to give it the required form. From this the name *retort* is derived (from *retorqueo*, to bend back).

Figs. 125 and 126 represent two badly-formed retorts. In each of these the highest point is beyond the line *a*, so that the liquid which condenses in the space between *a* and *b* will run back into the body of the retort.

These retorts, however, are not useless. They should not be selected for the distillation of the mineral acids, or of liquids generally which have a high boiling point, and are at the same time easily condensed; but they may be used without disadvantage in the distillation of some easily volatilized substances.

The receiver is a wide-necked globular glass vessel, the neck of which is made to widen gradually outwards, so that it may fit on to the tapering beak of the retort.

*Fig* 125.

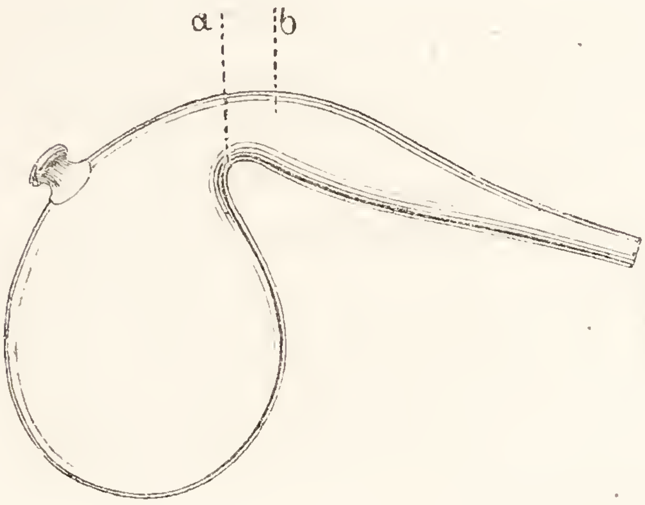
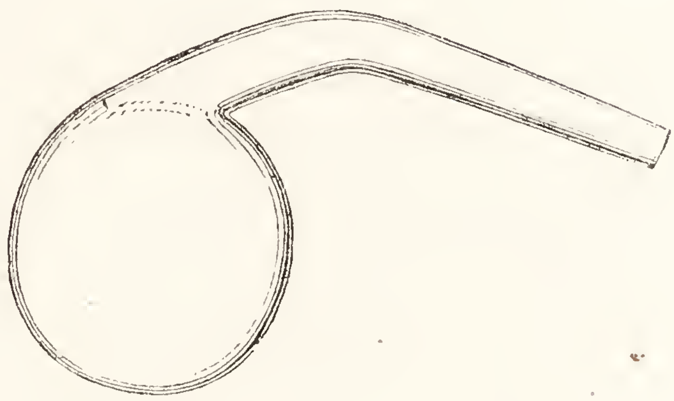


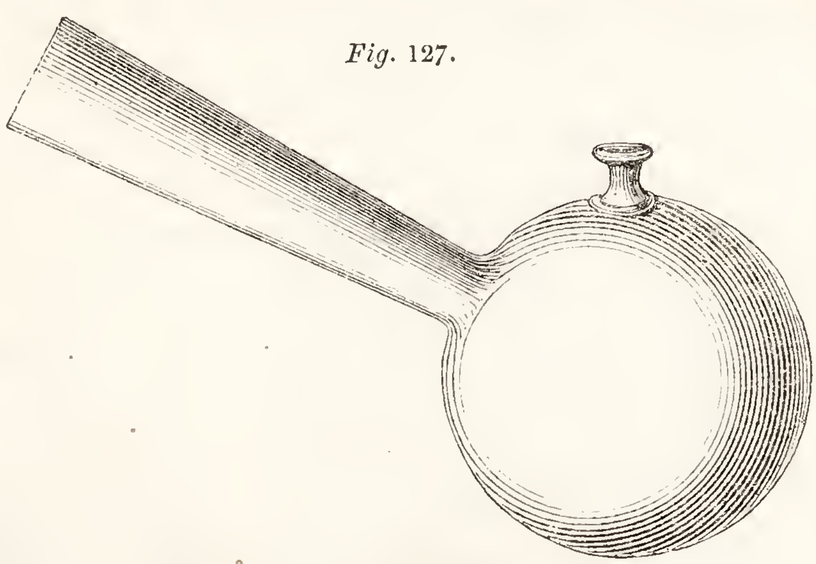

*Fig*. 126.



BADLY-FORMED RETORTS.

Its proper form is indicated in fig. 127. When tubulated, the opening should be in that part of the globe that will be uppermost when the neck is attached to the retort, as shewn in the drawing.

*Fig*. 127.



TUBULATED RECEIVER.

The glass of which these vessels, and especially retorts, are made, ought not to be very thick, as in this case they are very liable to crack when exposed to sudden alterations of temperature. Thin glass is much less likely to break from these causes, but if it be very thin, the vessels will be deficient in strength, and will be liable to be broken by the slightest tap against any hard substance. Of the two evils, the latter is perhaps that which ought most to be avoided, as it will be found that a much greater number of these vessels are broken in cleaning them and in other manipulations, from want of sufficient strength, than from any other cause.

The method of shortening the necks of retorts and receivers will be described in another place.

There are several ways of applying heat to retorts and distillatory vessels, either over the naked fire, or through the medium of sand or some liquid.

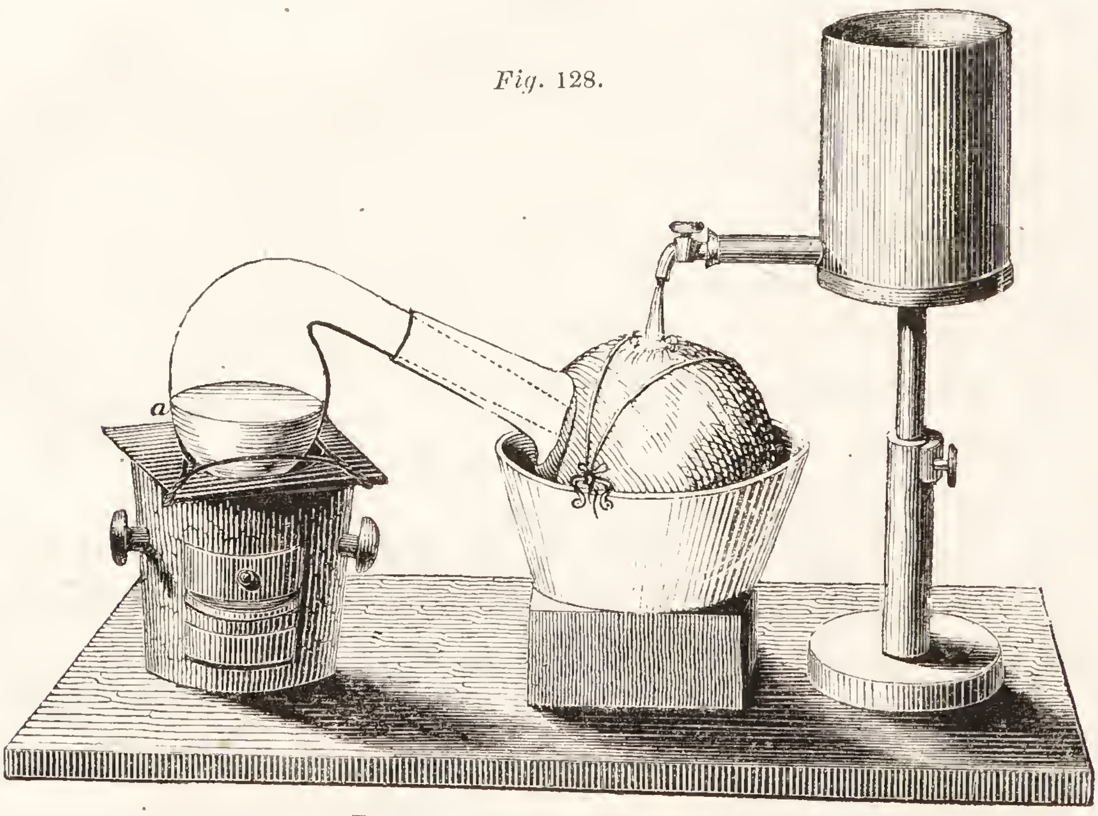
The usual method of exposing retorts over the naked fire, is to place them on an iron triangle, or on a piece of wire gauze. When the triangle alone is used, the vessel placed upon it touches only at three points, and there is often great danger of its breaking from the pressure at these points.

A much safer method of operating consists in placing a piece of strong wire-gauze over the triangle, previously giving to the former a concave surface adapting it for the reception of the retort, which, when placed here, receives more uniform support and protection from mechanical injuries. The wire-gauze also promotes a more equal distribution of the heat, and to a certain extent protects the vessel from the action of the lambent flame of the fire. The bottom of the retort, however, should not, in any case, be so near to the fire as to be within reach of the flame, for this would be very likely to cause a fracture.

Charcoal is the only fuel that should be used in these operations. Wood, coal, or peat, would cause the deposition of soot, which would be objectionable, and, moreover, these substances burn with a lambent flame, which would render the process very unsafe.

Fig. 128, represents the entire arrangement of apparatus for conducting the process of distillation in this way. In this instance, the retort is supported by a triangle, placed over the wire gauze.

*Fig.* 128.

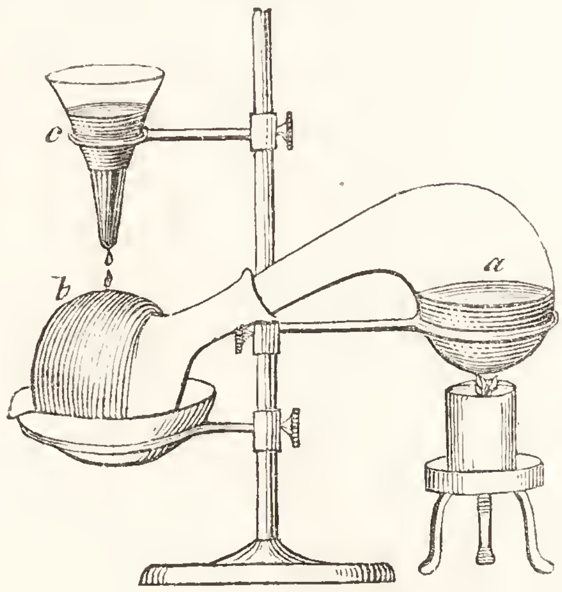



PROCESS OF DISTILLATION.

Fig. 129, represents another arrangement for conducting the same process on a smaller scale, a spirit-lamp being substituted for the furnace.

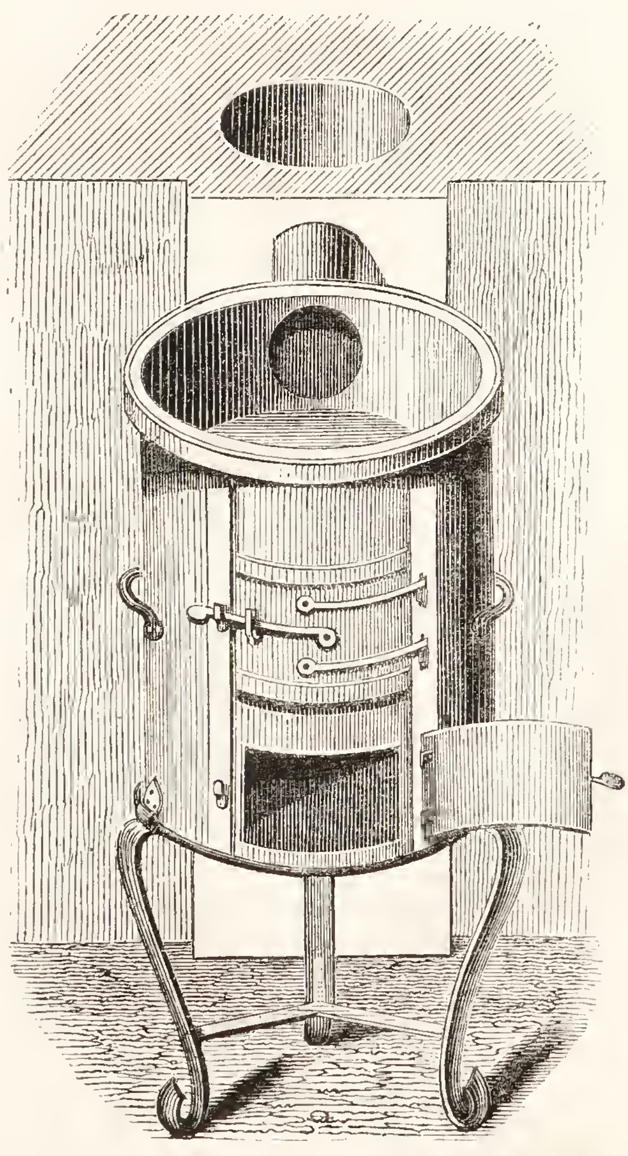
Liquid baths are seldom used for heating retorts, unless it be in the distillation of ether, or other very volatile liquids, in which cases a simple hot-water-bath may be employed. In the distillation of spirituous liquors, a concentrated solution of chloride of calcium, or chloride of potassium, salts which often result as secondary products from many processes, forms a good medium through which to convey the heat.

*Fig.* 129.




The retort should not be placed immediately on the bottom of the vessel containing these liquids, but on some kind of stand or support which shall admit of the free circulation of the liquid beneath it. When water alone is used as the bath, the retort may be placed on a wisp of straw, which will form a good bed for it.

*Fig.* 130.

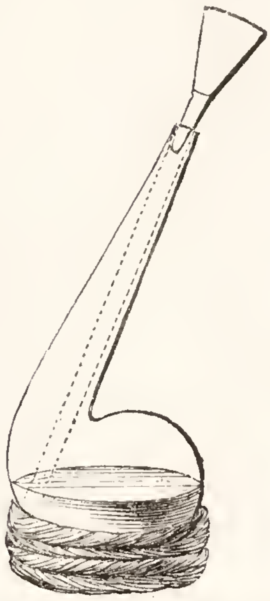


During the process of distillation, the retort becoming lighter from the loss of liquid which has distilled over, sometimes floats in the bath, and thus rising from its bed, or stand, is liable to cause a disarrangement of the connections of the apparatus, or even to occasion a fracture in the neck of the receiver. These evils may be avoided by tying down the retort with a piece of flexible copper-wire.

The most convenient kind of bath for conveying heat to the retort, is the sand-bath. This should consist of coarse sand, the grains of which are clean and of equal size, having been freed from dirt, dust, and stones, by washing and passing it through sieves. A cast-iron pot will form a suitable vessel for containing the sand, and the furnace, fig. 130, into the top of which the sand-bath may be fitted, will afford the required heat.

The retort should be charged previously to its being put into the sand-bath. Salts and powders are introduced by means of a long paper tube, as shewn in fig. 131, and liquids are poured in through a funnel of a peculiar form (fig. 132) intended for this particular

*Fig.* 131.



Method of Charging a Retort.

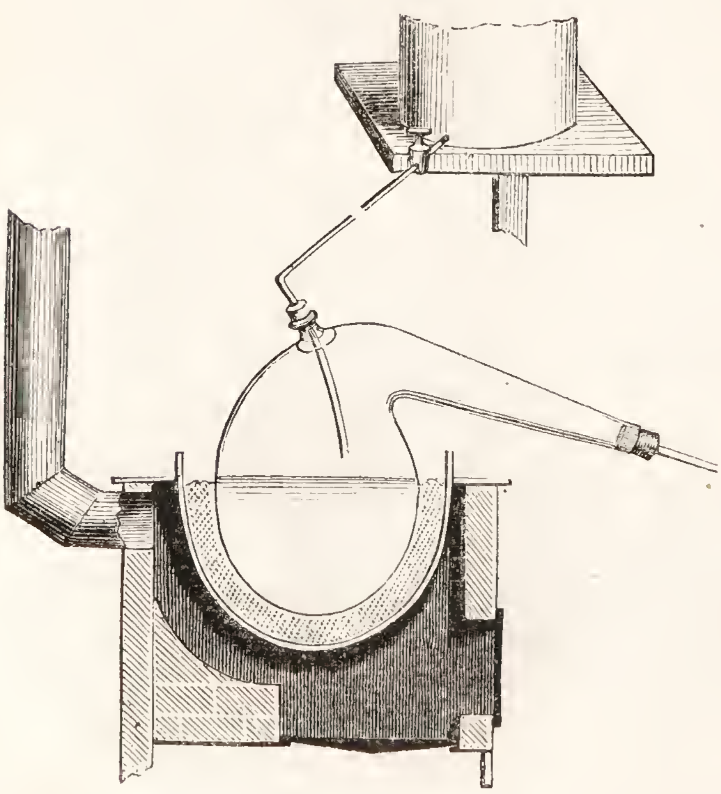
*Fig.* 132.


Retort Funnel.

purpose. The ingredients may be thus introduced without any part of them adhering to, or even being allowed to come in contact with, the neck of the retort.

The retort being thus charged, is, in the next place, inserted in the sand-bath. The sand is removed from the iron pot, with the exception of a layer, about two inches in thickness, at the bottom, on which the retort is placed, and the surrounding space is then filled up with sand so as to form a stratum of equal thickness on all sides. This part of the arrangement is shewn in fig. 133, which represents a section of the furnace, sand-bath, and retort.

*Fig.* 133.



The receiver is now attached to the neck of the retort. When a receiver is used without any intermediate condenser, it should be placed in a large earthenware basin, or in a shallow tub, in which cold water may be applied to it. The receiver should rest on a cloth or wisp of straw, and should be secured in its place with string or wire to prevent its floating as the water used for cooling it increases in quantity.

In most cases it will be found desirable to use a tubulated receiver, so as to allow any uncondensable vapours to escape through a bent tube attached to the tubulus. If a plain receiver be used, the connexion between the beak of the retort and the mouth of the receiver, must be such as to admit of the escape of air or gases here, for in all cases the contained air of the vessels will undergo expansion on the application of heat, and the pressure which would be thus produced, if no provision were made for its escape, would probably cause a fracture in the weaker parts of the retort. In the distillation of nitric acid, it is customary to use a plain receiver, merely inserting the neck of the retort loosely into it, and taking care that it pass some way into the body of the receiver. In most other cases it is preferable to make a close connexion at the mouth of the receiver, and to allow uncondensed gases to escape at the tubulus.

The connection at the mouth of the receiver may be made in several different ways, but some soft substance should always be interposed between the retort and receiver, otherwise a fracture would be very likely to take place, if the two unyielding surfaces be brought into contact. A piece of folded paper is generally used as the interposed substance; and when this has been fixed in its place, some luting may be applied to the juncture on the outside, so as to render it airtight. A strip of sheet India-rubber is sometimes substituted for paper, and answers the purpose well, as it is less easily acted upon by chemical agents than paper is, and, moreover, it renders the connexion airtight without the use of luting. It will be obvious, however, that in the distillation of ether and essential oils, the use of caoutchouc would be inappropriate.

The top of the receiver is covered with a cloth, and cold water is allowed to fall on to this in a continuous stream, as shewn in figs. 128 and 129.

[There are some cases in which this method of effecting the condensation of distilled products will be found to be the best, as, for instance, in the distillation of liquids which are easily condensable, and in collecting which it is desirable to avoid any loss of the product from adhesion to the condenser, or any contact with organic substances such as would be used in making the connexions of more complicated apparatus.]

In most cases, however, in which substances are distilled from a retort, this arrangement would be subject to several objections. It would often be difficult to effect the condensation completely in this way, and sometimes the receiver, becoming much more heated in one part than another, may crack from the application of cold water. Then, again, the distilled product could not be removed from time to time during the progress of the operation, but, on the contrary, would be constantly exposed during this time to the hot vapours contained in the upper part of the receiver.

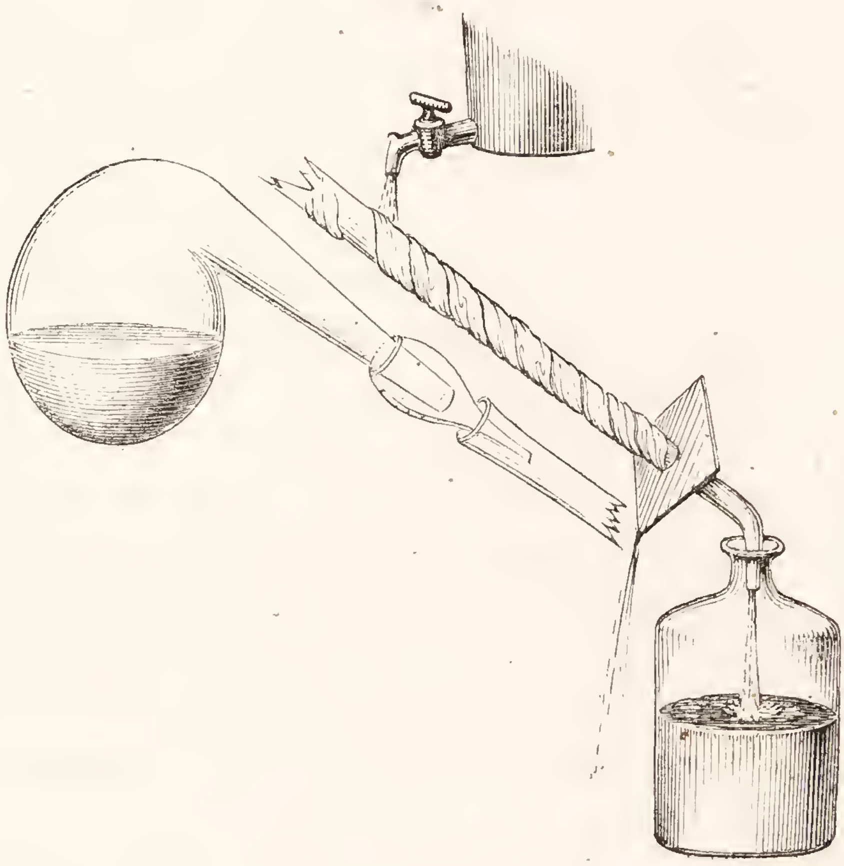
On account of these and other objections, apparatus designed expressly for effecting condensation are now commonly employed.

The most simple of these consists in lengthening the neck of the retort by interposing a tube between it and the receiver, and applying cold water to this tube by any suitable means. It may sometimes be found difficult, in the absence of apparatus made for the purpose, to find a tube one end of which will be large enough to receive the beak of the retort, while the other end is small enough to be inserted into the receiver. The apparatus called an *adapter* (fig. 134) is intended to be used in such cases. Figs. 135

*Fig.* 134.

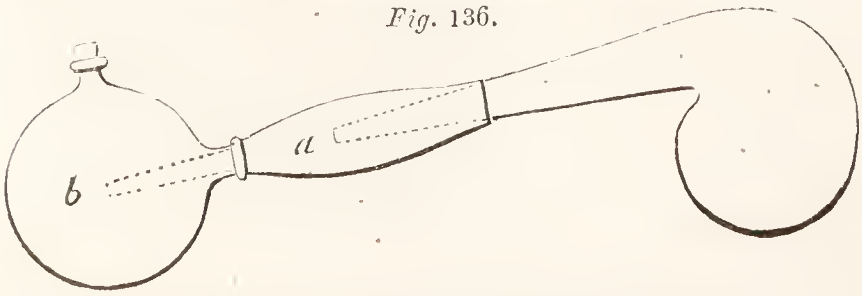
An Adapter.

*Fig.* 135.



and 136 represent arrangements in which the adapter is applied for connecting the retort and receiver.

*Fig.* 136.



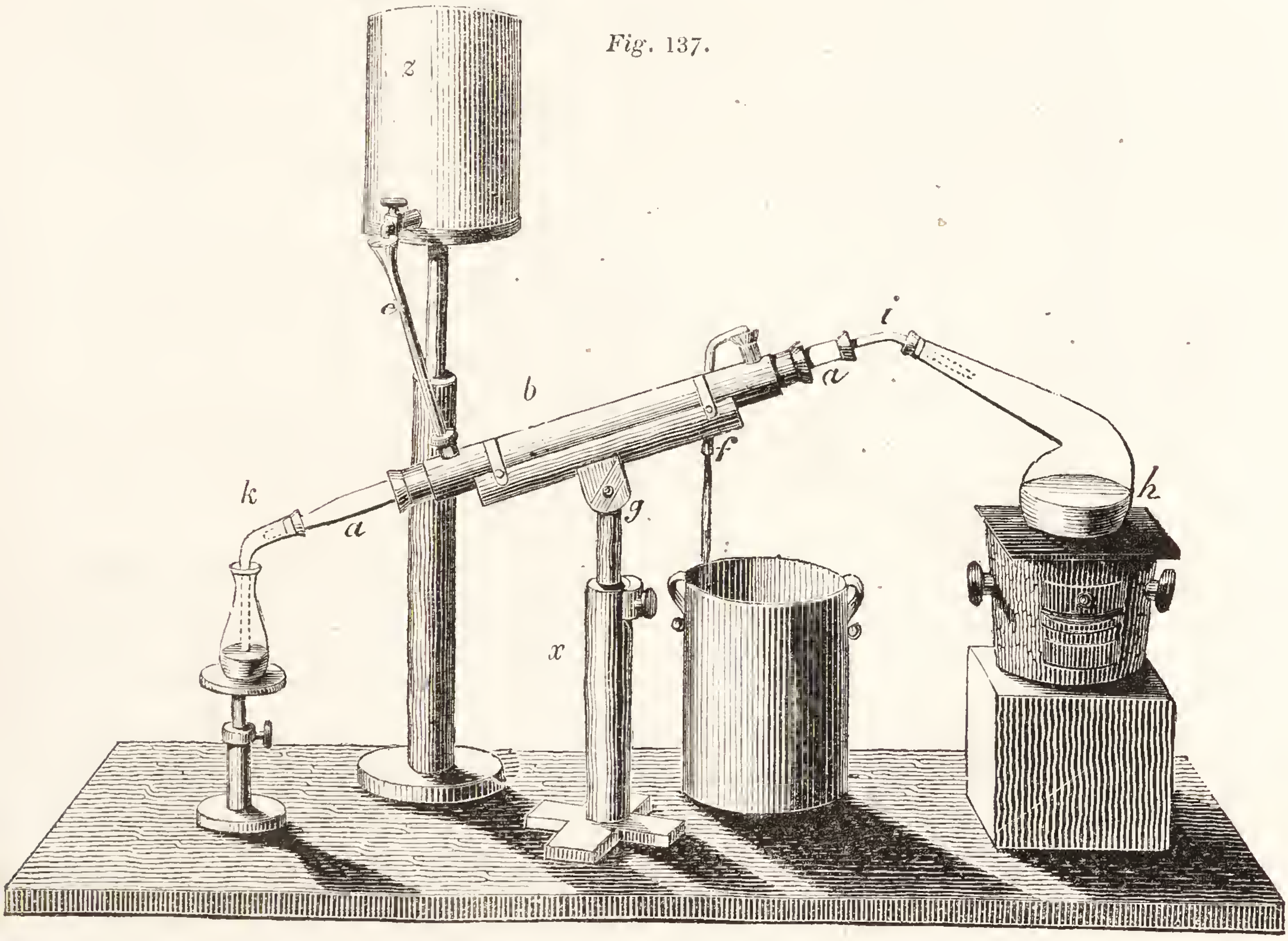

Retort with Receiver and Adapter.

In the absence of an adapter, a connecting piece may be made out of a phial of appropriate size, by cutting off the bottom and the rim of the neck. The method of cutting glass vessels of this kind will be described hereafter.

At the lower end of the condensing tube a piece of card is fixed as shewn in fig. 135, so as to prevent the water which is applied to the tube from running into the vessel in which the condensed liquor is collected. A strip of cloth is bound round the condensing tube, and a stream of cold water allowed to run over this as shewn in the drawing.

A more complete and efficient condenser is formed by causing the tube conveying the vapour to pass through another tube, the diameter of which is such as to leave a space between the two, through which a stream of water may be made to run. This kind of condenser, with the entire arrangement for conducting the process of distillation, is represented in fig. 137.

*Fig.* 137.




APPARATUS FOR DISTILLATION.

The glass tube (*a a*) is surrounded by a copper or brass tube (*b*), through the two ends of which the former is tightly inserted by means of perforated corks. This rests on a wooden stand (*x*), which admits of its being raised or lowered or turned in any direction.

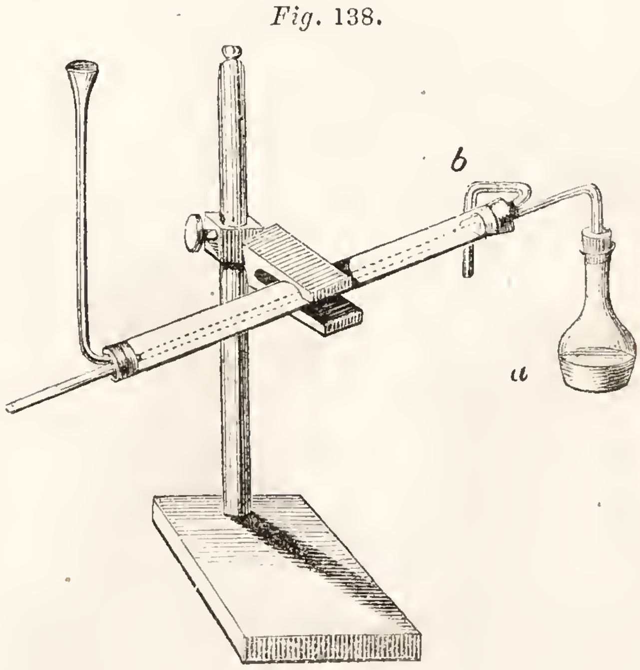
The retort (*h*) is placed over a charcoal fire, its neck being elevated as represented, and the beak connected with the condenser by means of a small tube (*i*), which is bent so as to form an obtuse angle, and which extends some distance into the neck of the retort.

This arrangement, originally suggested by Liebig, offers advantages in certain cases, inasmuch as none but the most volatile parts are distilled, and nothing can be mechanically carried over by spirting. The neck of the retort is surrounded by dry paper, wrapped round several times, so as to prevent condensation from taking place here to too great an extent.

In the distillation of less volatile liquids, or those in reference to which there is no danger of any portion being carried over by spirting, the neck of the retort may be inclined in the usual way, in which case the tube (*i*) should not be bent, or may be dispensed with altogether, the beak of the retort being inserted into the end of the condenser.

The water, used for the purpose of condensation, flows from a copper or tin vessel (*z*) through a stop-cock, by which the current is regulated, and is conveyed by the pipe *e* to the space between the tubes *a* and *b*, through which it runs in a continuous current, and finally escapes at *f* into a vessel placed for its reception.

*Fig.* 138.




The distilled product is conveyed through the bent tube (*k*) into a receiver.

This method of effecting condensation is quite efficient, and is very convenient.

Fig. 138 represents a similar arrangement on a smaller scale, in which all the tubes are of glass.

[*A flask and bent tube* may often be substituted for the retort with advantage. They form a more convenient and economical arrangement, and may be applied without objection in most processes of the kind now under consideration.

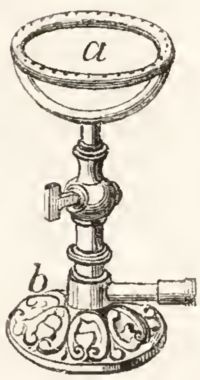
*The flame of a gas lamp* may also be advantageously substituted for the charcoal fire. It is much more manageable as a source of heat, and involves less trouble.

The following arrangements are those adopted in the Laboratory of the Pharmaceutical Society, where they were originally introduced.

*Gas-burners.*—The gas-burner generally used is that represented in fig. 139. It consists of a perforated ring (*a*), the diameter of which is two inches and three quarters; this is supported on a foot (*b*), and attached by a flexible tube to the gas-pipe, so that it may be moved to any part of the work-table to suit the arrangement of other apparatus.

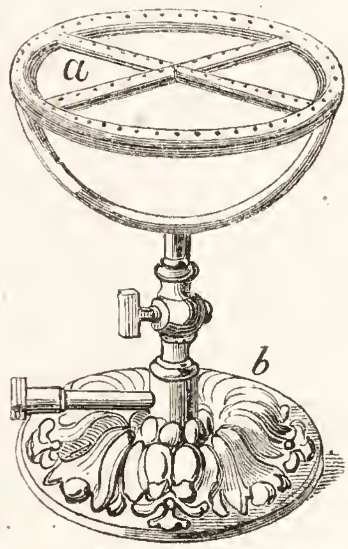
Fig. 140 represents a larger gas-burner, the diameter of which is six inches, but this is rarely required, excepting in some particular cases, in which it may be wished to have the heat diffused over a large surface. The smaller burner affords heat enough to boil a gallon or more of water in a metallic vessel.

*Fig.* 139.



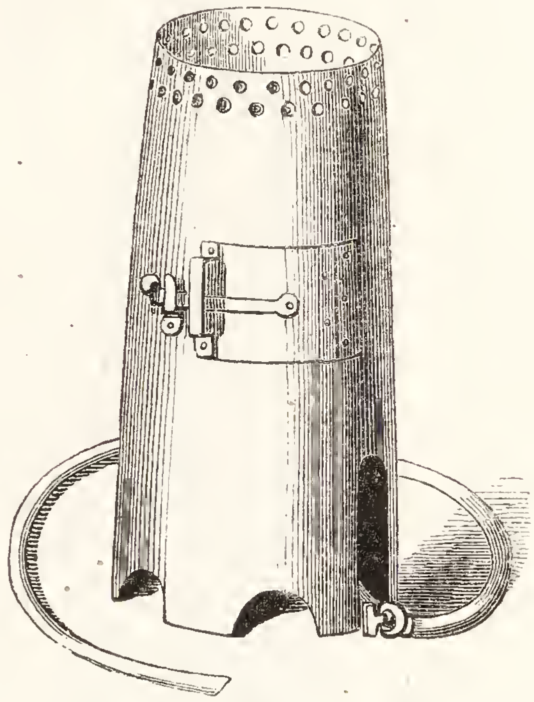

Gas Burner.

*Fig.* 140.




Gas Burner.

*Fig.* 141.



Gas Furnace.

*Gas-furnaces.*—The gas-furnace (fig. 141) is used to confine the heat of the flame from the gas-burner, to protect it from being blown about by currents of air, and at the same time to form a support for the vessel containing the liquid to be heated. This furnace consists of a slightly conical cylinder of sheet-iron, which is covered with black japan varnish to protect it from becoming corroded with rust. It is four and a half inches in diameter at the top, five and a half inches in diameter at the bottom, and ten inches in height. The air for supporting the combustion of the lamp is admitted through apertures at the bottom of the cylinder, while the hot air and products of combustion escape through a number of small holes near the top. There is a door on one side of the furnace, which is used for lighting the lamp when any apparatus is fixed over the opening above; there is also an aperture, extending from the bottom upwards to the height of about five inches, through which the flexible gas tube passes, and which admits of the lamp being placed on a block of wood, so as to bring the flame nearer to the top of the furnace when this is desired.

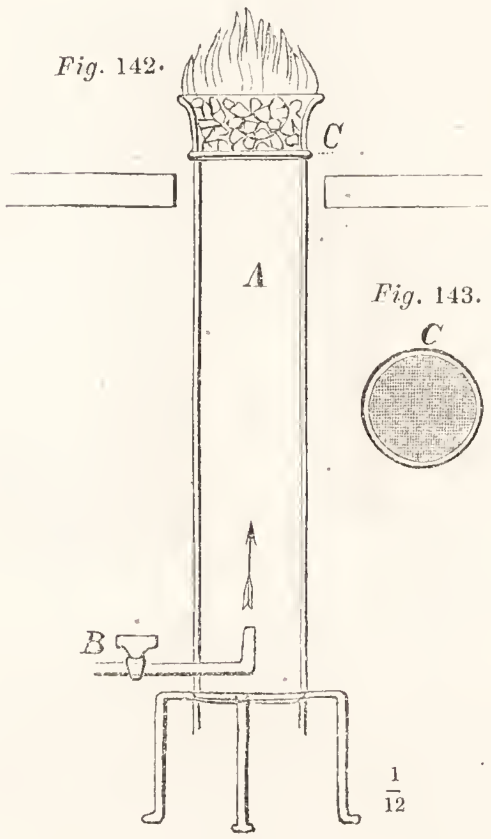
If the apparatus to be heated be large, or the gas-burner (fig.

140) be employed it will be necessary to use a furnace of larger dimensions than that described. In these cases the cylinder should be seven inches in diameter and twelve inches in height, and with a cylinder of this size it is unnecessary to have it larger at the bottom than at the top.

Retorts, flasks, or dishes, may be heated over these furnaces, and the operator, by regulating the supply of gas, will have complete control over the amount of heat applied.

The *mixed-gas furnace* (figs. 142 and 143), which is described at page 4, does not afford complete control over the intensity of the heat, and therefore is not generally applicable for the purpose contemplated. It gives a strong heat, and is perfectly free from smoke, but the size of the flame cannot be regulated at pleasure, as the flame of the gas-burner (fig. 139) can. The air being allowed free ingress at the bottom of the tube (A, fig. 142), requires the admixture of a constant quantity of gas issuing from the tube (B), to form a combustible mixture, which shall burn at the mouth of the tube. If the supply of gas be much diminished, the mixture ceases to be combustible, and the flame is extinguished. This defect might be remedied by providing means for regulating the supply of atmospheric air as well as of gas, but such addition would render the apparatus more complicated and expensive. The furnace (fig. 141) with the gas burner (fig. 139) will, therefore, be found to answer better in those processes where it is desirable to have complete control over the amount of heat applied.

Fig. 142. Fig. 143.

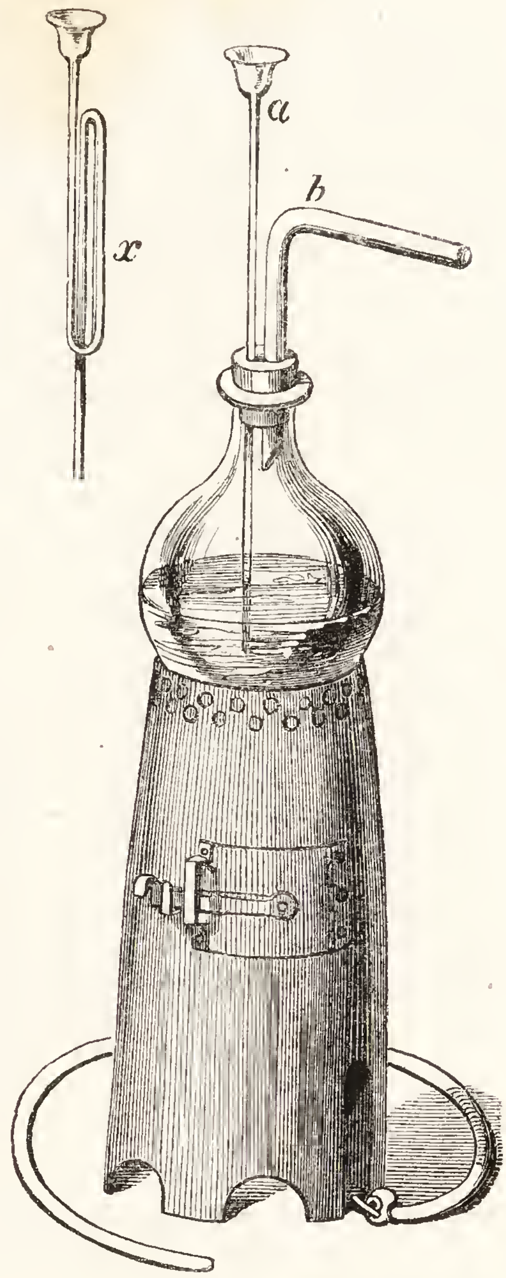



Mixed-Gas Furnace.

Fig. 145 represents the gas-furnace with a flask and bent tube, arranged for the process of distillation. The flask used for this purpose should be rather wide in the mouth, so as to receive a cork through which two tubes may be passed as shewn in the drawing. The diameter of the mouth should be from one inch and a half to one inch and three quarters.

It is sometimes desirable to have the neck of the flask rather longer than it is represented in fig. 145, and it may be extended to the length indicated in fig. 146. The tube-funnel (*a*, fig. 145) is intended for the introduction of fresh liquid into the flask during the progress of the distillation. Its lower extremity being immersed in the liquid, none of the vapour can escape through this tube. In cases where this arrangement cannot be conveniently adopted, the safety-tube (fig. 144) may be substituted for that shewn in fig. 145. This tube, being bent in the manner represented, retains a portion of liquid in the part *x*, which prevents the escape of vapour from the interior of the flask. Its lower extremity should extend only a little below the cork.

*Fig.* 144. *Fig.* 145.




GAS-FURNACE AND FLASK FOR DISTILLATION.

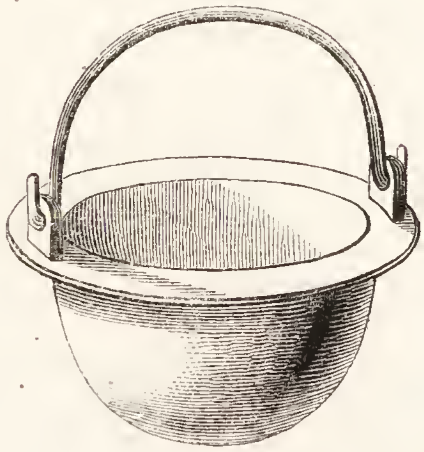
The *sand-bath* (fig. 147) is sometimes used with the larger sized gas-furnace, where it is desired to equalize the heat applied, or to render glass vessels less liable to fracture. The use of the sand-bath, however, is not unobjectionable in processes in which it is necessary carefully to regulate the heat, for if the sand acquires a temperature higher than is desirable, it retains it for some time after the flame of the lamp has been lowered.

The use of flasks coated on the outside with copper presents

*Fig.* 146.

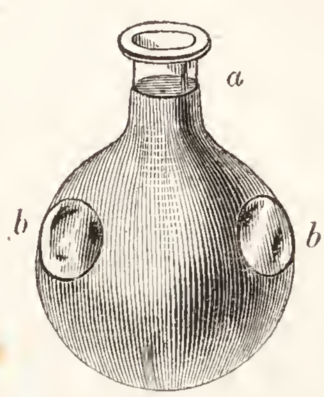
FLASK.

*Fig.* 147.



SAND-BATH.

*Fig.* 148.

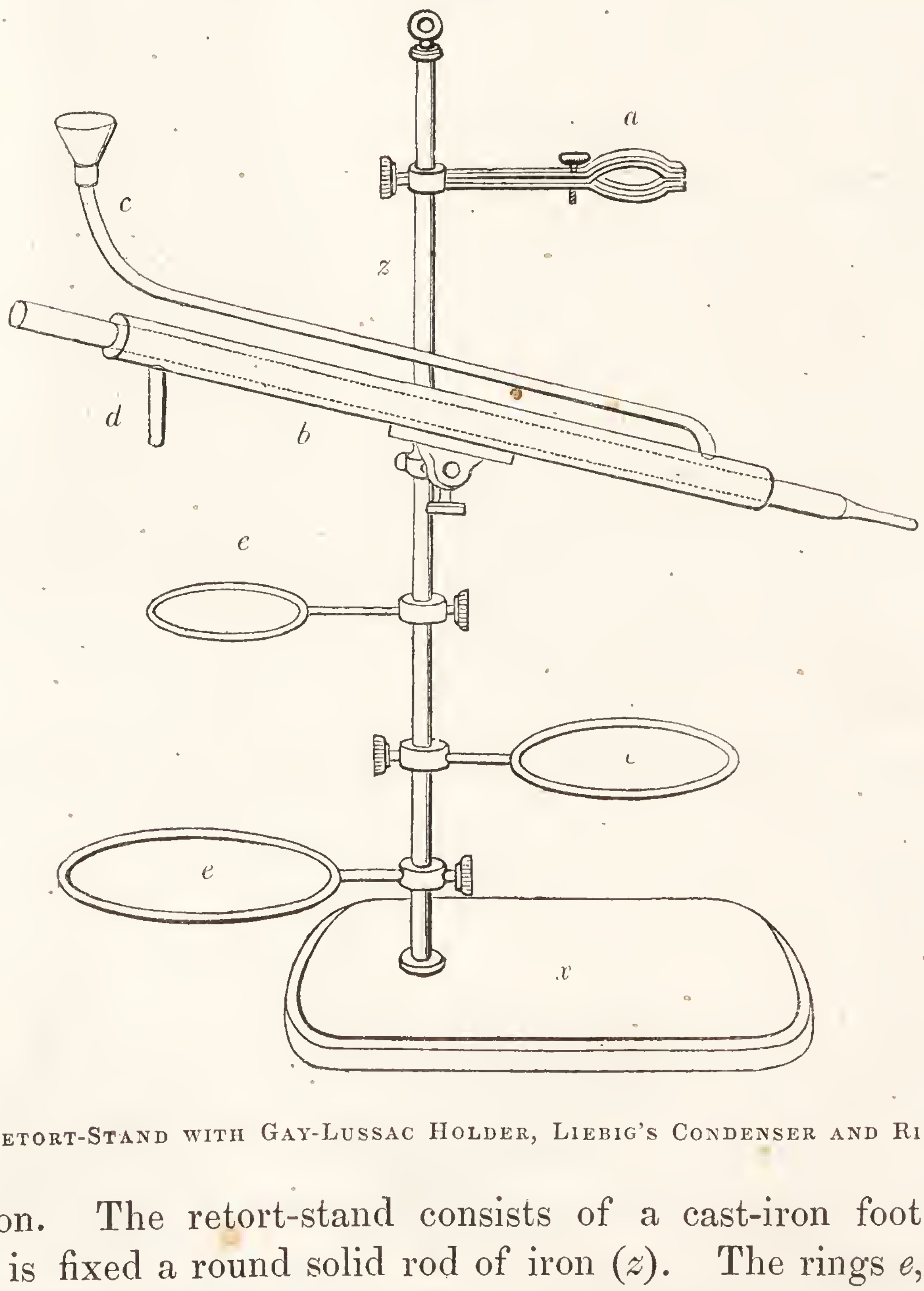



FLASK COATED WITH COPPER.

many advantages. I have used flasks of this kind for several years, having met with them, in the first instance, at the *Exposition* *of Works of Art* at Paris in 1844, and consider them to be of great value in the laboratory. The copper affords protection to the glass, while, from its good conducting power, it ensures a more equal distribution of the heat to all parts of the vessel. Fig. 148 represents one of these flasks, covered with copper to the mark *a* on the neck. There are three circular spaces left uncovered, two of which are shewn in the drawing at *b b*, so that the contents of the vessel can always be seen by the operator. The manner of coating these flasks will be described hereafter.

The *condenser* used in this arrangement is supported on a retort-stand, as shewn in fig. 149, having freedom of motion in every

*Fig.* 149.




RETORT-STAND WITH GAY-LUSSAC HOLDER, LIEBIG'S CONDENSER AND RINGS.

direction. The retort-stand consists of a cast-iron foot ($x$), in which is fixed a round solid rod of iron ($z$). The rings $e$, $e$, $e$, the Gay-Lussac holder ($a$), and the Liebig's condenser ($b$), with the exception of the inner tube of the last-mentioned, are made of brass. There is an advantage in having the vertical rod of the stand made of solid iron rather than of brass, and especially if the latter be hollow, as is generally the case, for the screws by which the different attachments are fixed at suitable heights to the rod, occasion indentations in the softer metal, which, from this cause, ultimately becomes so uneven as to render a readjustment of the positions of the different parts difficult. It is very important that each attachment, when the screw by which it is fixed is loosened, should move vertically or horizontally on the rod with perfect freedom, otherwise a sudden jerk may occasion the fracture of some part of the apparatus connected with it.

Cold water is supplied to the lower end of the condenser through the tube *c* from a vessel (fig. 150) which is made of copper or tin-plate. This cistern is furnished with a stop-cock (*b*), by which the stream of water is regulated. The heated water passes off from the condenser through the tube (*d*). The cistern (fig. 150), in addition to the stop-cock (*b*), has a tubular opening (*a*), which is usually stopped with a cork. The object of this is to admit of the insertion of a long tube, such as is shewn in fig. 151, by means of which a stream of water may be conveyed to some distance from the cistern.

*Fig.* 150.

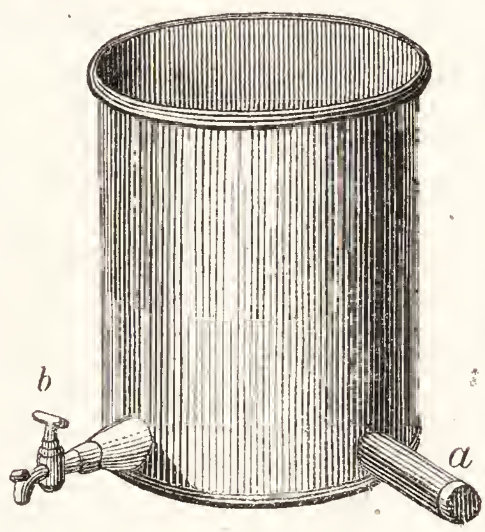
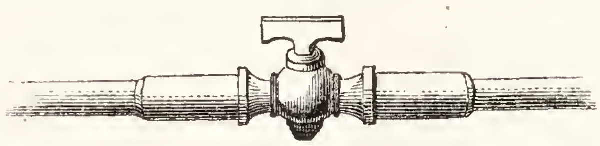



*Fig.* 151.

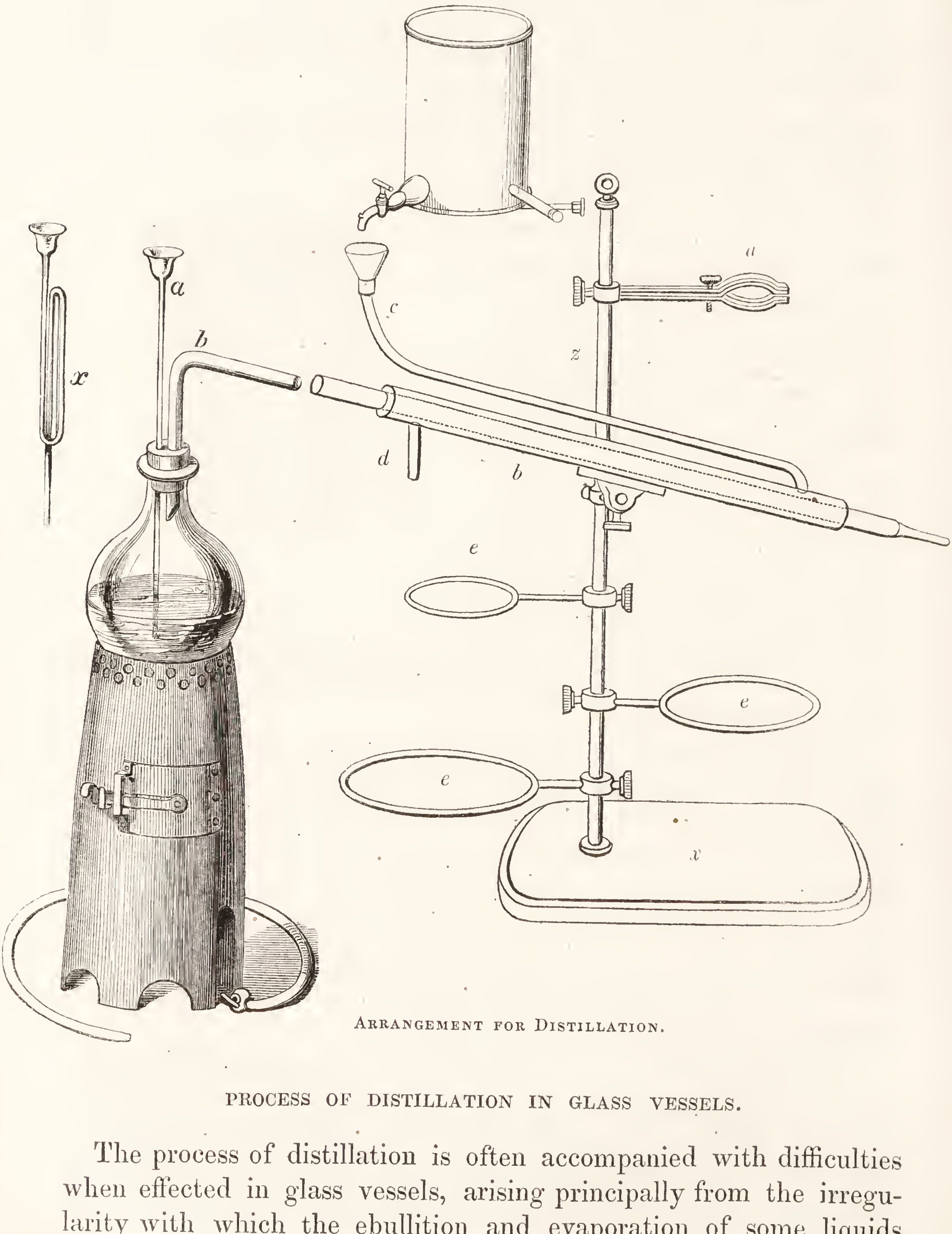


The flask, arranged as represented in fig. 152, presents a convenient form of apparatus for effecting distillation. Powders and other solid or liquid ingredients, are easily introduced through the open mouth of the flask without soiling the tube through which the vapours are conveyed, so that the distilled products are less likely to be contaminated with any non-volatile substances than is the case when a retort is used, through the long neck of which it is difficult to introduce the ingredients without some portion of them adhering to this part.

The contamination of the distilled products, occasioned by spirting, may also be easily obviated with the flask, by increasing the length of the lower limb of the tube (*b*), or by using the flask with the longer neck. The method represented in fig. 137 for obviating the effects of spirting when a retort is used, is neither elegant nor convenient.

There are some cases, however, in which the flask cannot be used, as, for instance, in the distillation of nitric acid or oil of vitriol. In fact, whenever the substance to be distilled acts chemically upon the cork, this form of apparatus must be considered objectionable, and should be replaced by the retort.

*Fig.* 152.




ARRANGEMENT FOR DISTILLATION.

## PROCESS OF DISTILLATION IN GLASS VESSELS.

The process of distillation is often accompanied with difficulties when effected in glass vessels, arising principally from the irregularity with which the ebullition and evaporation of some liquids takes place under these circumstances. The boiling point of some liquids is several degrees higher in a glass vessel than it is, under the same atmospheric conditions, in a metallic vessel. There is also a difference in the manner in which these liquids boil in glass and in metallic vessels. In the latter, the ebullition takes place uniformly and without interruption; the bubbles of steam which rise through the liquid are small, and they are generated equally from all parts of the vessel equally exposed to the heat. In the former, the ebullition takes place less uniformly; the bubbles of steam are much larger, and they are generated only from a few points on the surface of the vessel, and there often by fits and starts.

This irregularity in the boiling of liquids in glass vessels is a frequent source of annoyance and perplexity to the operator in the chemical or pharmaceutical laboratory, constituting at its maximum degree, what is commonly called the "bumping" of the liquid.

Among the liquids which present this irregularity of ebullition to the greatest extent, may be mentioned *oil of vitriol;* the mixture for yielding *hydrocyanic acid,* according to the process of the Pharmacopœia; and aqueous, alcoholic, or etherial liquids generally, which contain *resins* or *oleo-resins*, in solution or in suspension. It is impossible to effect the distillation of some of the last-named class of liquids in glass vessels. Thus, for instance, if a piece of common resin or of shellac be introduced into a flask (fig. 153) filled nearly up to the commencement of the neck with distilled water, and if the water be then boiled over the gas-furnace (fig. 141,) the ebullition will at first take place pretty uniformly, but after some time it will be observed that the bubbles of steam which are formed at the bottom of the flask in contact with the most heated part of the glass, will be larger than they were in the first instance; and instead of their passing continuously through the liquid, there will be frequent intermissions, during which ebullition will entirely cease. After each of these intermissions the disengagement of steam will take place with increased violence, and, as the process is continued, the length of the intermissions will become greater. If a thermometer be introduced into the flask, it will be found that this irregularity of ebullition is accompanied by great variations of temperature. While the bubbles of steam are passing freely through the liquid, the temperature will be from 212° to 214° Fahr., but when a cessation of ebullition takes place, the temperature will rise, and will sometimes reach 220°. This will be followed

*Fig.* 153.

FLASK.

by a sudden and violent evolution of steam, constituting the phenomenon of *bumping*, by which the accumulated heat is disengaged, and the temperature of the liquid reduced again to its usual boiling-point. The violence of these explosions will, after some time, become so great as to cause the projection of a great part of the liquid at once out of the flask, endangering in no slight degree the safety of the operator.

This may be taken as a forcible illustration of the phenomena which accompany the bumping of certain liquids when boiled in glass vessels. It is rarely, however, that the effects are so decided as they are in the above case; nor am I aware that the phenomena, as here described, have been previously noticed.

Several explanations have been given by different writers with the view of explaining the cause of the bumping of liquids. It has been ascribed to the imperfect conduction of heat from the vessel in which the liquid is contained, the accumulation of heat on the surface of such vessel, and then its sudden transmission to the liquid; it has also been ascribed to a kind of *vis inertia* in the liquid, and to the absence of solid points at which the vapour might be generated.

These explanations, however, are very imperfect and unsatisfactory.

More recently an explanation has been proposed, which ascribes the effects alluded to, to a modification of the forces of *cohesion* and *adhesion* in the liquid, caused by the expulsion of atmospheric air during the process of ebullition.

It may, indeed, be readily admitted that the immediate cause of the bumping of liquids is some modification of the forces of *cohesion* and *adhesion;* but that this condition is induced simply by the expulsion of air, is a position that will not be so readily assented to.

The three conditions which matter is capable of assuming, namely, the *solid,* the *liquid*, and the *aëriform* or *gaseous*, are sometimes described as depending on two forces existing in different degrees, the one tending to attract or hold together the particles, the other tending to repel them or separate them assunder. In *solids*, the force of attraction is predominant; in *gases*, the force of repulsion prevails; while in *liquids*, it is stated, these forces are so equally balanced that the particles have perfect freedom of motion among each other.

It must not be supposed, however, that these forces are in a state of perfect equilibrium in liquids, or that the particles are not held together by a certain amount of *cohesive force.* It is easy to prove that this force of *cohesion* exists in all cases between the particles of a liquid. A good illustration of it is afforded in the familiar experiment of blowing a soap-bubble. This force may be roughly estimated by suspending a plate of glass to one end of the beam of a balance, adjusting the balance so that the glass shall be exactly equipoised, then placing a vessel of water under the glass with the two surfaces parallel to each other, and allowing contact to take place. It will be found that some force will be required to break the contact, which may be estimated by the weights put into the opposite pan of the balance.

An exemplification of the force of *adhesion* existing between a liquid and a solid body with which it is in contact, is afforded in the instances of capillarity, which are familiar to every one.

It cannot be denied, then, that the forces of *cohesion* and *adhesion* exist; the former, between the particles of a liquid; and the latter, between the liquid and the vessel containing it. It will be evident, too, on considering what occurs in the boiling of a liquid, that these forces, in addition to the pressure of the atmosphere, have to be overcome by the repulsive influence of the heat. In the boiling of water, bubbles of steam are formed at the bottom of the vessel containing it; and as the particles of the liquid are separated from the surface of the vessel, as well as from each other, on the formation of each bubble of steam, it is evident that the tension of the steam thus generated, must be equal to the pressure of the atmosphere, *plus* the force of *cohesion* between the particles of liquid, or of *adhesion* between the liquid and the surface of the vessel containing it.

Now, when water is boiled in a metallic vessel, it has been found by Marcet, from some very carefully performed experiments, that the temperature of the steam after quitting the water, is about a third of a degree lower than that of the boiling water. This difference of a third of a degree, then, may be considered to represent a measure of the force of cohesion or adhesion in the water.

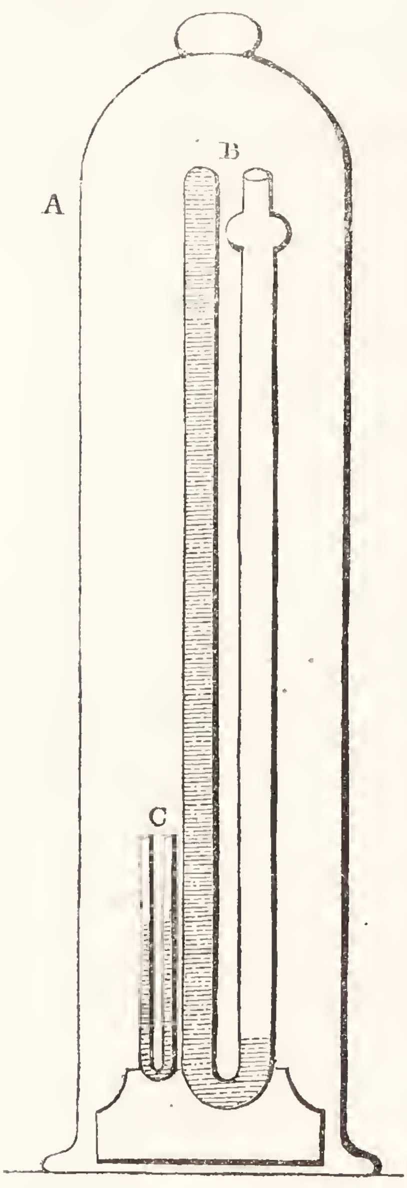
In glass vessels, the difference between the temperature of the steam after quitting the water, and that of the boiling water, amounts to more than the third of a degree, and this increased difference accords with the higher boiling point of water in glass than in metallic vessels. It is inferred, therefore, that the forces of cohesion and adhesion are greater when water is boiled in glass than in metallic vessels.

But the results of these experiments afford a very inadequate indication of the extent to which the forces of *cohesion* and *adhesion* are capable of existing in water and other liquids. It appears, from the investigations of Mr. Henry, of Prince Town, in America, and of M. Donné, a Belgian Chemist, that these forces frequently exist in liquids to a much greater extent than had previously been supposed.

Donné found that *oil of vitriol*, completely freed from air, introduced into the closed limb on an inverted syphon tube, and placed under the receiver of an air-pump, is retained there in opposition to the force of gravity, through the power of cohesion and adhesion in the liquid.

The apparatus represented in fig. 154, will illustrate this experiment. The closed limb of the tube (B) is filled with oil of vitriol, and the corresponding limb of the smaller tube (C) is filled with mercury. The tubes being fixed to a stand, are placed under the receiver (A), over an air-pump, and the air is then pumped out. The tube (C) containing the mercury, will indicate the degree to which the receiver is exhausted. A great number of air-bubbles will be extricated from the oil of vitriol as the exhaustion proceeds, and it will be necessary to re-admit the air into the receiver, and remove the portion of air which will be found to have collected in the top of the closed limb of B, as long as any air continues to be disengaged from the oil of vitriol, on exhausting the receiver. This will not be completely effected in less than six or eight days.

*Fig.* 154.



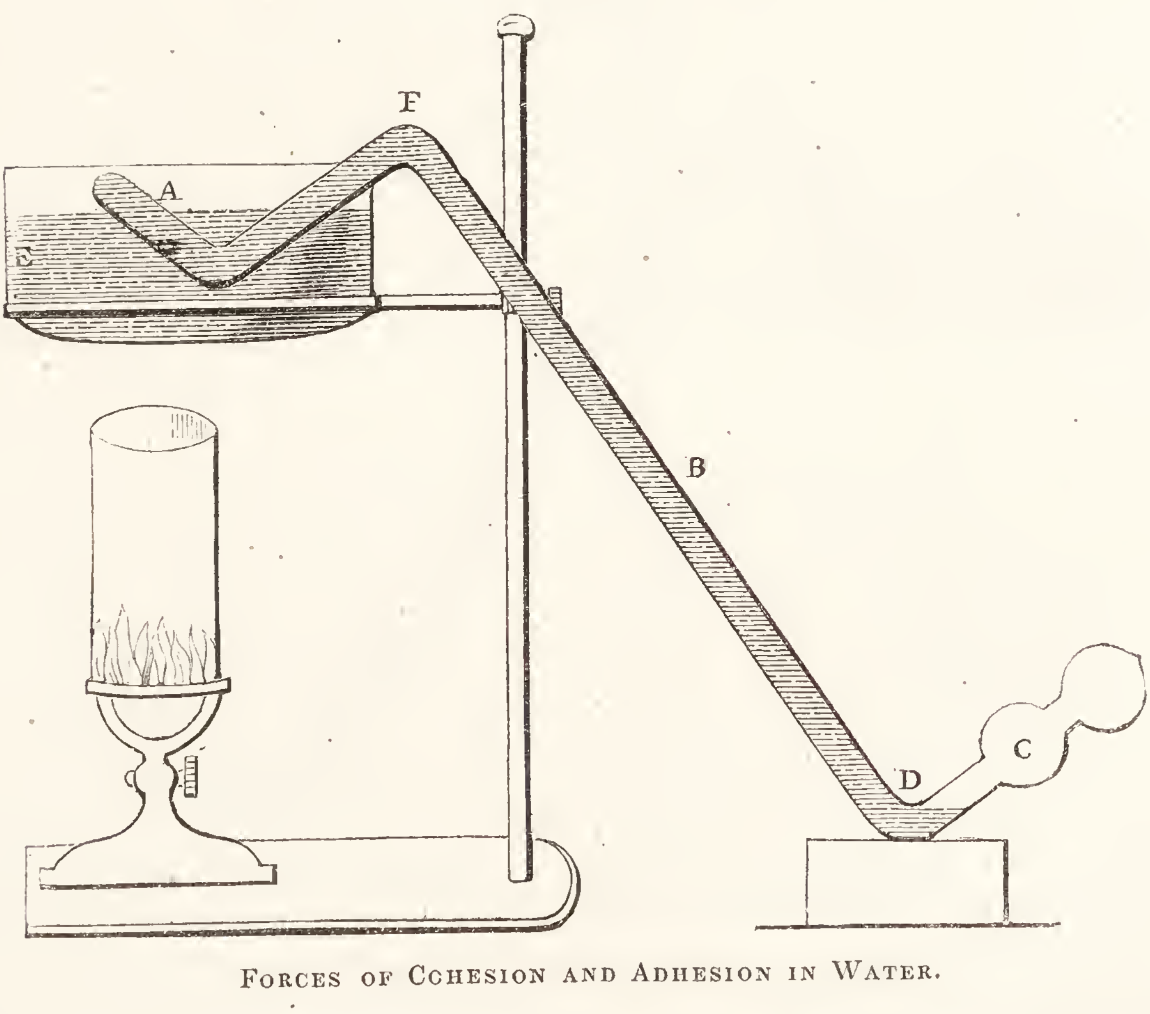

Forces of Cohesion and Adhesion in Oil of Vitriol.

On commencing this operation, it will be observed that the height of the columns of oil of vitriol and of mercury supported in the sealed limbs of the tubes by the pressure of the atmosphere in the receiver, will be in the same proportion as the specific gravities of the liquids; that is to say, that mercury being 7·3 times heavier than oil of vitriol, the column of oil of vitriol will be 7·3 times longer than that of mercury. Thus, when the column of mercury is half an inch, that of the oil of vitriol will be rather more than three and a half inches. When, however, the greater part of the air has been extracted from the oil of vitriol, the respective heights of the columns will no longer maintain this relation with any certainty. The oil of vitriol will frequently not fall in the tube (B) until long after the time at which such a result has been indicated by the column of mercury in C, and when it does fall, it will be observed that a little bubble of air is formed in some part of the column at the same moment. When the oil of vitriol has been deprived of air, so that air-bubbles are no longer formed in it, the receiver may be exhausted to the greatest extent practicable, without effecting any reduction in the column of oil of vitriol. The tube I have used, is thirty-five inches long, and half-an-inch internal diameter, and a column of oil of vitriol of this length, has been supported in the sealed limb of the tube, as shewn in the figure, while the column of mercury was less than half-an-inch.

Now, in this case, the pressure of the atmosphere in the receiver was equivalent only to a column of about three and a half inches of oil of vitriol, so that a column of this liquid, thirty-one and a half inches high, and half-an-inch in diameter, was supported by the forces of cohesion and adhesion.

Having thus ascertained that the cohesive and adhesive power of a liquid are greatly increased when the air is entirely removed from it, Donné devised the following experiment, with the view of determining what the boiling-point of the liquid would be under such circumstances.

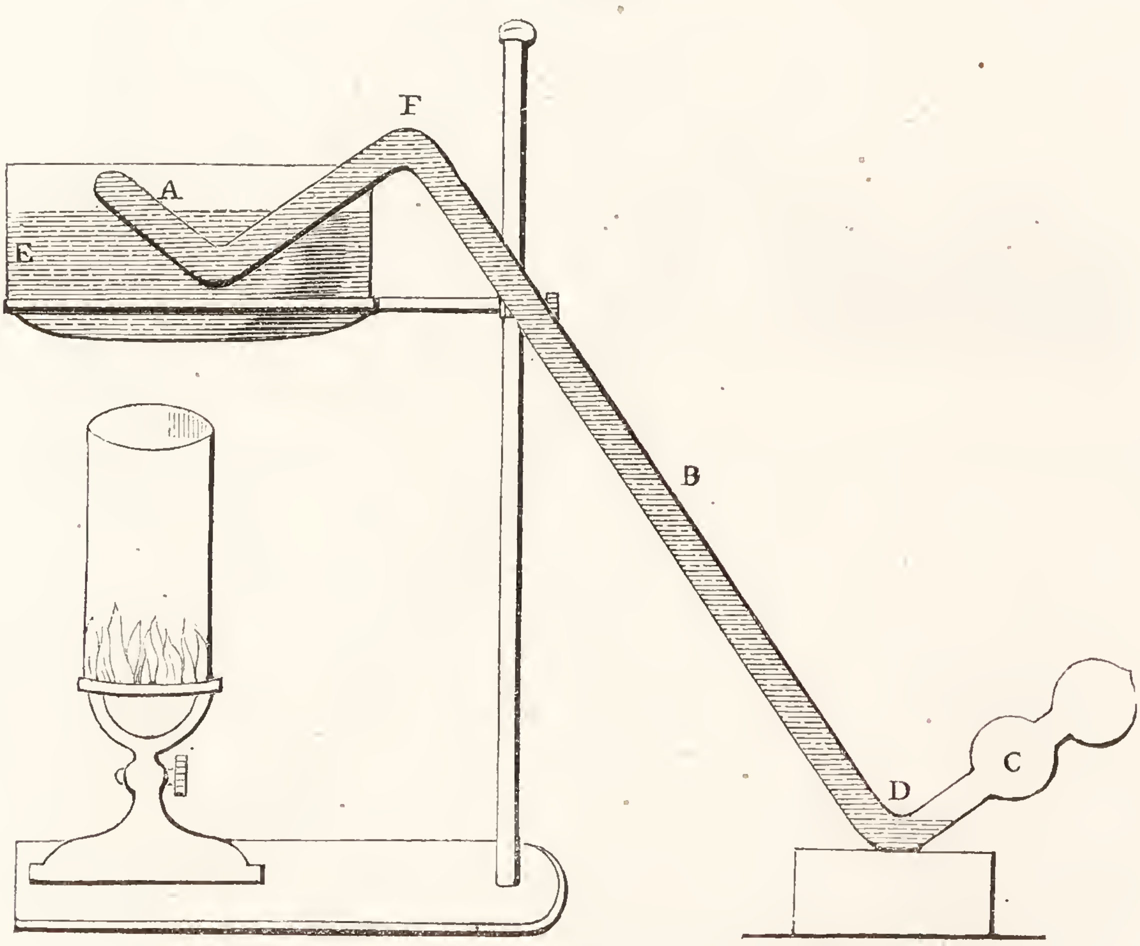
*Fig.* 155.




FORCES OF COHESION AND ADHESION IN WATER.

A tube (A, B, C,) containing as much water as will fill the limbs (A B) to the point (D) is deprived of air, and sealed in the way usually adopted in making a cryophorus. If the water be made to run into the end of the tube (A, B) and perfect contact between the water and the glass be ensured by gently striking the end (A) on a table, it will be found that the tube may be placed as shewn in the figure, without any of the water running out of B into C. The water is retained in the limb (B) by the forces of cohesion and of adhesion; and this will continue to be the case if the tube be placed so that B shall be perfectly vertical. If, now, a vessel (E) containing hot oil be placed as represented, so that the end (A) of the tube shall be immersed in the oil, the water in the tube from A to F will be heated, without any heat being communicated to the water in the limb (B), or to the vacuous part of the tube (C). Donné applied a bath heated to 212° to the tube arranged as described, but no ebullition took place, nor was any vapour formed. He then increased the temperature of the bath to 234°, to 251°, and to 264°, but still there was no appearance of ebullition, or of the formation of vapour. On increasing the temperature to 275°, the water in the end (A) of the tube was suddenly converted into vapour, and the contents of the limb (B) were sent with great violence into the bulbs (C).

*Fig.* 156.




Forces of Cohesion and Adhesion in Water.

Now, if the water at A was really heated in this experiment to 275° before it entered into ebullition, the particles must have been held together by a cohesive force equivalent to the pressure of three atmospheres, or forty-two pounds to the inch; for water boils under this pressure at 275° Fahr.

From these experiments Donné infers that water boils at 212° under the mean pressure of the atmosphere, only when it contains a certain portion of air in solution, the action of the air being to destroy or to lessen the force of cohesion and of adhesion in the liquid; and he ascribes the irregularity and the bumping which occur in the boiling of liquids, to increased cohesive and adhesive power caused by the disengagement of air in the process of boiling. He has proposed, as a remedy in these cases, that air should be passed through the liquid from a tube.

Interesting as are the experiments of Donné, it cannot be admitted that they are sufficient to justify the conclusion he has drawn from them. I have repeatedly tried his proposed remedy in cases of irregular ebullition, but have not found it successful. Moreover, the proposed theory does not offer a rational explanation of some of the phenomena in question. It was found by Marcet that if pure water be put into a glass flask which has previously had *oil of vitriol* heated in it, the boiling-point of the water will sometimes rise as high as 220°; while, on the other hand, if the inner surface of the flask be coated with a thin film of *shellac*, the boiling-point of pure water heated in it will be sensibly below 212°. In a metallic vessel the same liquid would boil precisely at 212°, and in a glass vessel in its usual condition, without any previous preparation, the boiling-point would be a little above 212°. In these cases the boiling-point of the liquid appears to have some relation to the condition of the surface of the containing vessel, and to be unconnected with the presence or absence of air in the liquid.

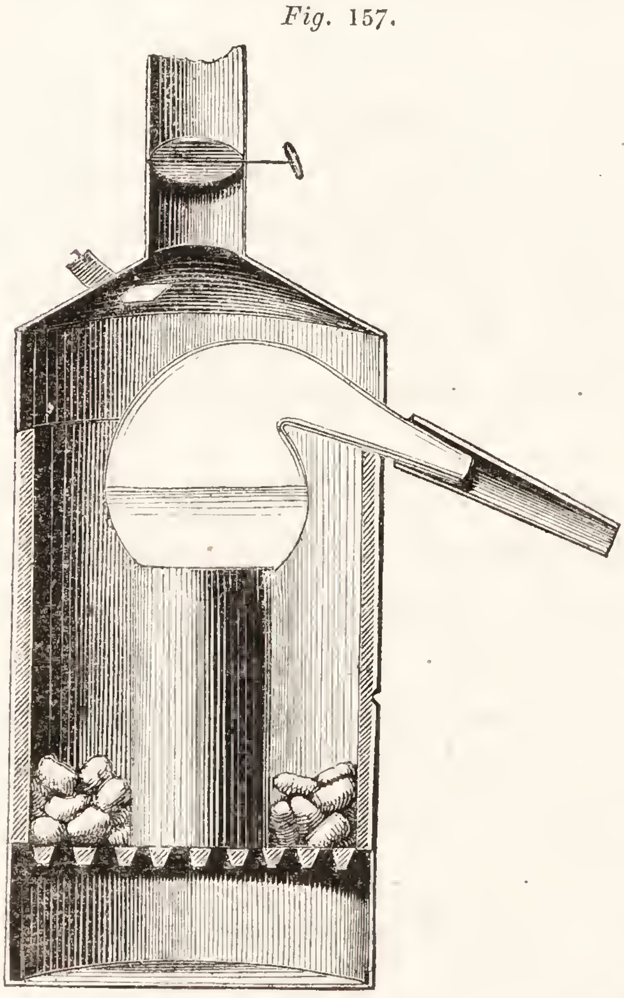
There are other cases in which certain substances, dissolved or suspended in the liquid, occasion variations in the boiling-point as great as those above noticed. Some salts, and especially resins and oils, belong to this class; and it is worthy of remark that the same substance, shellac for instance, when spread over the surface of the glass, produces an effect the opposite of that which occurs when the same substance is suspended in the liquid. In the one case the boiling-point is reduced, while in the other it is raised to the extent of seven or eight degress. But these variations, caused by the presence of substances dissolved or suspended in the liquid, do not occur in metallic vessels. The water containing shellac, which boils at 220° in a glass flask, if put into a metallic vessel will boil steadily at 212°, without the slightest tendency to bumping. Indeed, I have invariably found that liquids, the ebullition of which in glass vessels is accompanied by even the most violent bumping, present no such phenomenon when boiled in metallic vessels.

It appears, therefore, that the effects under consideration do not depend wholly on the state of the liquid, nor on that of the vessel containing it, but partly on each.

The *distillation of oil of vitriol*, which is sometimes effected with a view to the purification of the acid, presents an instance in which there is both difficulty and danger, from the irregularity of the ebullition of this liquid in glass vessels. The introduction of pieces of platinum wire or clippings into the retort, has been proposed as a method of obviating this difficulty, but this is not found to be a complete remedy for the evil. Dr. Mohr suggests the following method of conducting the distillation.]

A glass retort, of about two pounds capacity, is placed on a cylinder of sheet-iron in the centre of a small iron furnace (fig. 157), while its short neck protrudes through an opening in the side of the furnace. Ignited charcoal is placed around the cylinder, without being allowed to come in contact with the glass, and a current of hot air is thus made to play on all parts of the retort excepting the bottom, which is protected by its support. There is a valve in the flue of the furnace for regulating the draught, and three small doors in the cupola or head for supplying fresh fuel on every side, and for observing the progress of the distillation.

*Fig.* 157.



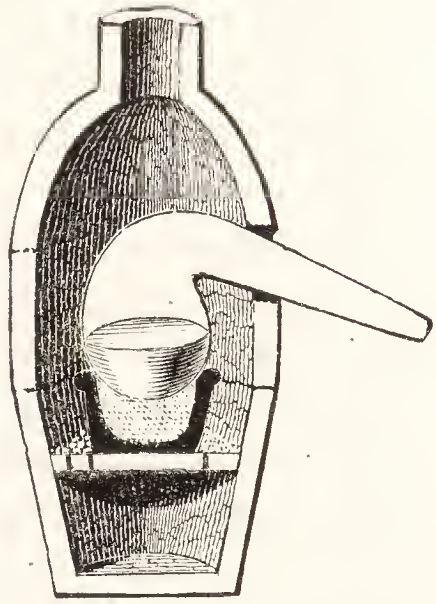
DISTILLATION OF OIL OF VITRIOL.

The process should be conducted cautiously, and without the application of an unnecessary degree of heat. The means of condensation which I am accustomed to adopt, consists simply in the application of a thin glass tube, about four or five feet in length, to the projecting neck of the retort. These are made to fit to each other without the use of luting, which would be inadmissible, and the lower end of the tube is somewhat contracted to prevent currents of air from ascending through it.

With this arrangement the distillation takes place without much danger or difficulty.

Instead of the sheet-iron cylinder, a Hessean crucible might perhaps be employed, and this, if requisite, might be elevated by placing it on a brick. An arrangement of this kind is shewn in fig. 158.

*Fig.* 158.



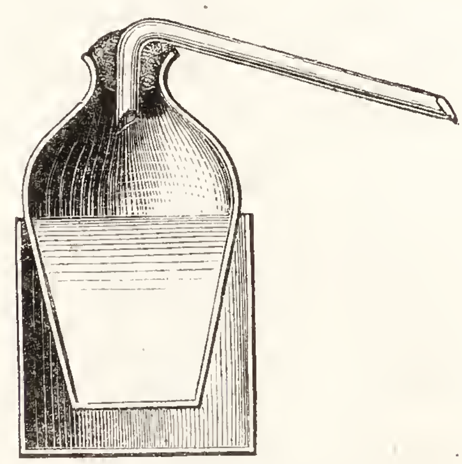
DISTILLATION OF OIL OF VITRIOL

I have sometimes used a stoneware bottle, such as is frequently met with in commerce. A bent glass tube is fixed in the neck of the bottle by means of plaster of Paris, the acid being previously introduced. This arrangement is shewn in fig. 159. The tube should be three or four feet in length, so as to act as a condenser.

Retorts of porcelain, or of good stoneware, offer great facilities in conducting this process, but these are not always to be obtained.

[In the manufacture of oil of vitriol, the process of distillation, by which the acid is concentrated, is now always conducted in platinum stills, which have superseded the glass retorts originally used. This substitution has rendered the process, which was formerly a hazardous and difficult one, perfectly safe and easy. The result confirms the statement already made with regard to the influence of a metallic vessel. But platinum stills are too expensive for laboratory use, and other means have therefore been sought for facilitating the distillation of oil of vitriol.

*Fig.* 159.



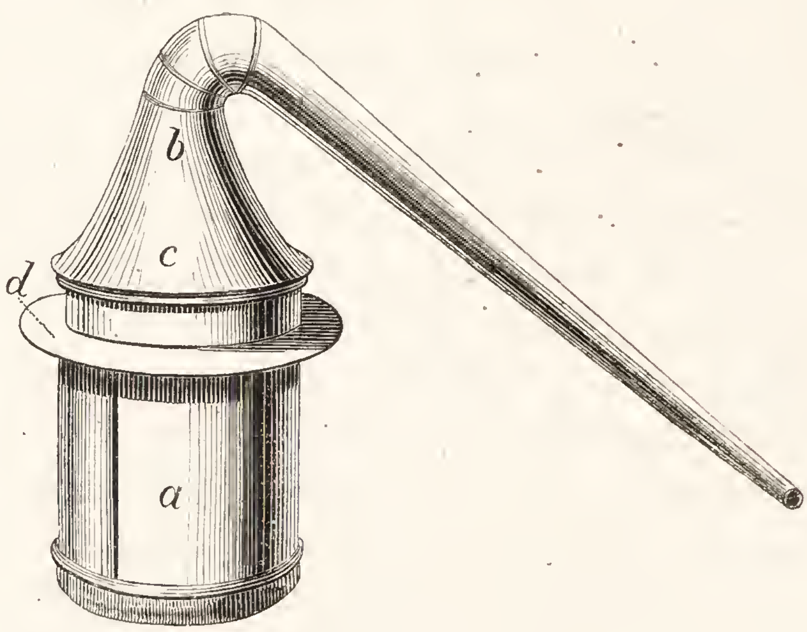
DISTILLATION OF OIL OF VITRIOL.

A French chemist, M. Lambert, has proposed the use of fragments of a species of quartz (*quarzite*), which are introduced into the glass retort. These fragments should be angular and not very small. About a dozen pieces, each from a quarter of an inch to half an inch in length, will render the distillation of several pounds of the acid quite manageable. I have used fragments of *rock crystal* in the distillation of *balsam of copaiba*, essential oils, and other similar substances, in glass vessels, and have found that by this means the inconvenience otherwise experienced in conducting the process has been entirely obviated. Pieces of rock crystal suitable for this purpose, consisting of the chippings formed in making spectacle glasses, may be obtained at a lapidary's or optician's. These pieces, which contain only pure silica, may be used in processes of this kind without the fear of contaminating the resulting products.

It might be supposed that broken fragments of glass, or sand, would answer the same purpose as quartz or rock-crystal, but such is not the case.

The presence of small fragments of rock-crystal in the flask or retort, appears, in all cases, as far as I have observed, to prevent the occurrence of bumping; but when the object of the process is to obtain and preserve the residue from which the more volatile parts have been separated by distillation or vaporisation, it may be found inconvenient to have any foreign matter mixed with it. In cases of this kind a small metallic still may be sometimes used with advantage. Such an apparatus is represented in fig. 160. It is made of copper thickly plated on the inside with silver, and is used with the gas-furnace (fig. 141), on the top of which it is supported by the collar *d*. The head (*b*) fits on to the body (*a*) at *c*, so that when the former is removed, any resinous or other solid matter can be easily taken out, and the apparatus completely cleaned. It may be used either with or without the head, for concentrating caustic solutions of potash or soda.

*Fig.* 160.




SMALL PLATED STILL.

In some processes glass vessels, partly coated on the inside with silver, may be conveniently used. Fig. 161 represents an arrangement of apparatus for distillation, in which a flask (*a*) is employed, the bottom of which is thus coated. It has the advantage of presenting a metallic surface to the liquid, in the part most exposed to the heat, while the contents of the vessel are unobscured from view. The silver is deposited on the glass by the process of Mr. Drayton, in which the two following solutions are used.

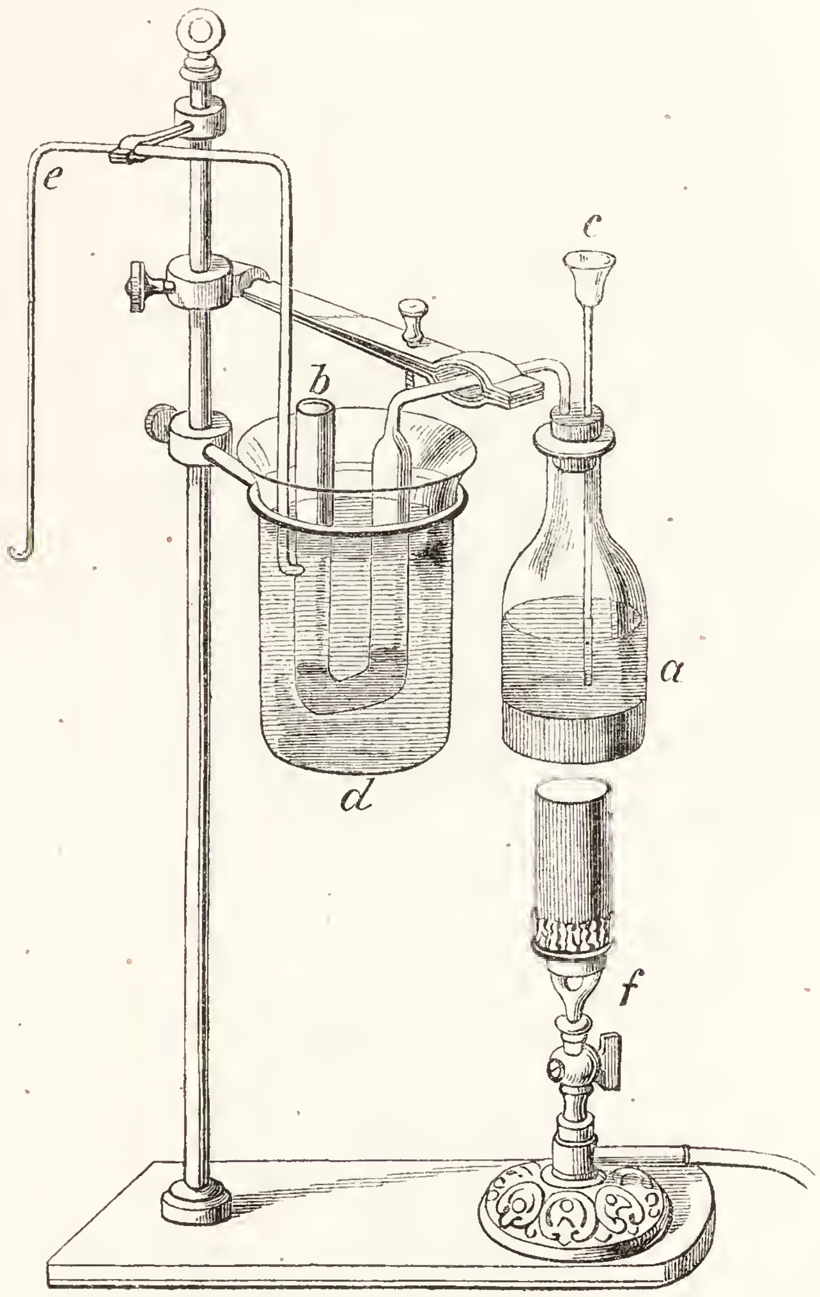
1. *Solution of silver.*—Dissolve twenty-five grains of nitrate of silver in about an ounce of distilled water, and add to it some pure caustic ammonia, drop by drop, until the precipitated oxide of

silver is redissolved, carefully avoiding the use of more ammonia than is necessary; then add sufficient distilled water to make twenty ounces of clear solution.

2. *Solution of essential oils.*—Dissolve half a fluid drachm of oil of cloves, and the same quantity of oil of cassia, in three fluid ounces of rectified spirit of wine.

In silvering glass vessels by this process *the solution of silver* is introduced into the vessel so as to cover the part intended to be silvered, and *the solution of essential oils* is then added in the proportion of one drachm of the latter to every ounce of the former. The mixture first becomes milky, and subsequently assumes a dark or blackish appearance, while at the same time metallic silver is deposited on the surface of the glass. It will be several hours before this deposition is completed, during which time the solution should be left undisturbed. The liquid may then be poured out, and the vessel cleaned from adhering oil by means of spirit of wine, several successive quantities of which should be boiled in it, until the surface of the deposited silver becomes perfectly clean and bright, and no smell of the oil remains.

*Fig.* 161.




Apparatus for Distillation.

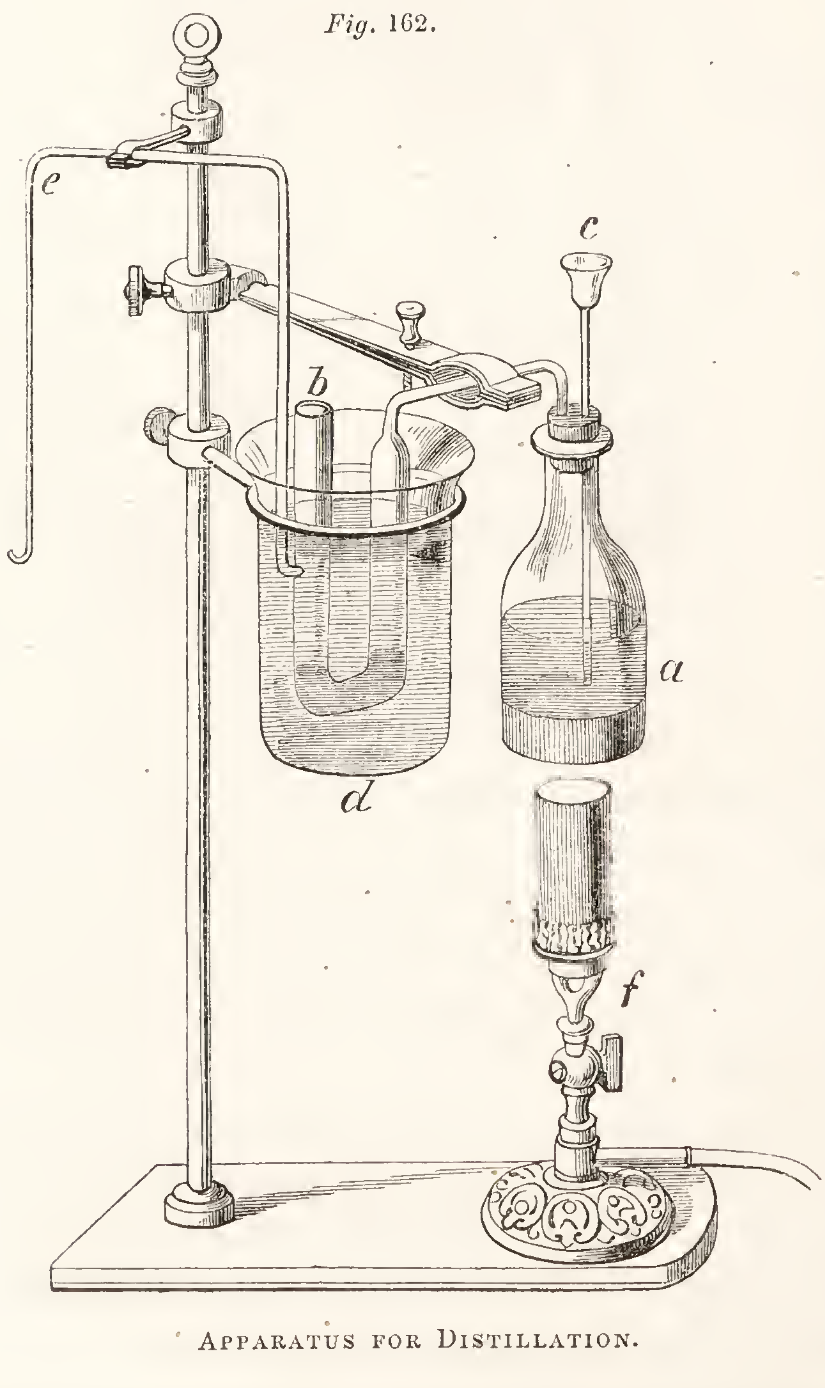
It is important that the essential oils used in this process should not be old or resinified, as in this case the silver would be deposited not in a bright metallic state, but in the form of a dirty blackish brown powder, a result which would also ensue if the oils be added in undue quantity. It may be sometimes necessary to vary the quantity to a slight extent, according to the quality of the oils used.

When the process has been successfully performed, and every trace of oil removed with spirit in the manner described, the coating of silver may be rendered thicker by depositing a fresh portion of metal, from a solution of oxide of silver in cyanide of potassium by electricity.

Glass vessels may also be covered with platinum, by putting into them a solution of the chloride of that metal, adding thereto some formic acid, and then boiling the mixture. The coating of metallic platinum thus obtained, will not, generally, be so perfect and uniform, as that of the silver deposited by the preceding process, but I have frequently succeeded in getting a deposit of perfectly bright platinum in this way, which has adhered very strongly to the glass, and has not been separated by the action of strong acids and other substances repeatedly boiled in the vessel.

The arrangement of apparatus shewn in fig. 162, is convenient for distilling small quantities of liquid. It consists of a flask (*a*), through the cork of which a tube-funnel (*c*) passes for the supply of fresh liquid, if required; a bent tube (*b*), which forms the receiver; and a beaker (*d*), nearly filled with cold water, by which the condensation is effected. The tube (*b*) being inserted through the cork of the flask, is supported by the *Gay-Lussac holder*, and immersed in the contents of the beaker, which is placed in one of the rings of the retort-stand. The syphon (*e*) is used for removing the water, heated in the process of condensation from the upper part of the beaker, when cold water is from time to time poured in through a tube-funnel reaching to the

*Fig.* 162.

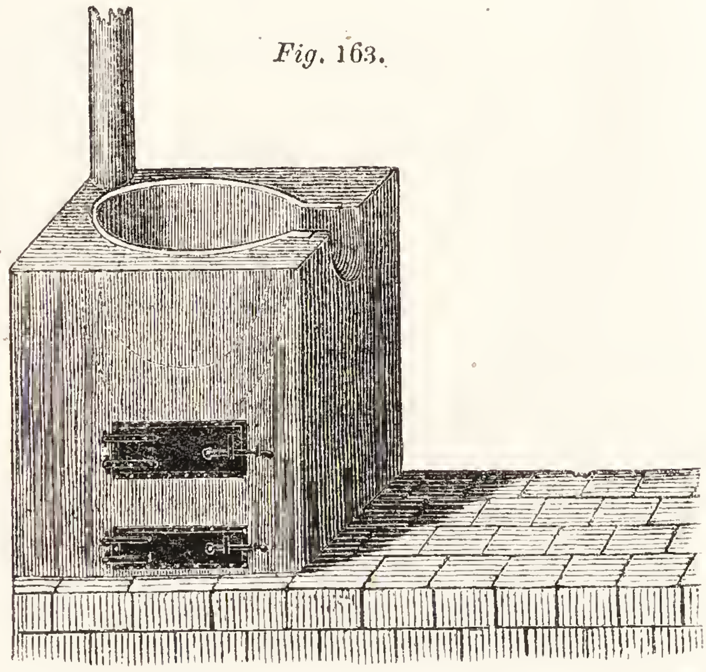



APPARATUS FOR DISTILLATION.

bottom. This syphon may also be employed for withdrawing the condensed liquor from the tube (*b*). The manner of using it in cases such as these will be described hereafter in treating of syphons. Heat is applied to the flask by the gas-lamp (*f*).]

When retorts of a large size are employed in the process of distillation, it becomes necessary to have a furnace and sand-pot expressly adapted for their reception, as represented in fig. 163. The sand-pot should be of cast-iron, and of such a size that, when the retort is put in, there shall be a stratum of sand of about an inch in thickness between them. The intervening sand should never exceed this thickness, for in such case there would be unnecessary consumption of fuel, and, moreover, it would be much more difficult to regulate the heat. When there is a great thickness of sand between the retort and the iron pot, the heat, if accidentally raised too high, is retained for some time by the sand, and cannot be speedily reduced by removing the fire, or checking combustion.

*Fig.* 163.



Furnace and Sand-pot for Distillation with a Retort.

The construction of the fire-place, and position of the fire in relation to the sand-pot, are also of some importance. The grate should not be immediately underneath the sand-pot, but a little in front of it, as shewn in fig. 164. This drawing represents a section of fig. 165, in the direction of the lines A, B, C, D.

The combustion and intensity of the heat are regulated by means of the valve (*e*) in the chimney, the sliding door of the ash-chamber (*c*), and the door (*b*) of the fire-place. When a strong fire is required, the valve (*e*) and the door of the ash-chamber are kept open, and the door of the fire-place closed. As soon as the apparatus has been brought into full operation the valve may be partially closed, by which means a saving of fuel is effected without diminishing the available heat. If the fire should become too strong, the combustion may be checked by partially closing the door of the ash-chamber and contracting still further the valve in the chimney, or by opening the latter to the fullest extent, and at the same time closing entirely the door of the ash-chamber. Should even this be insufficeint, the door of the fire-place must be opened so as to admit a current of cold air to pass in contact with the bottom of the sand-pot.

*Fig.* 164.

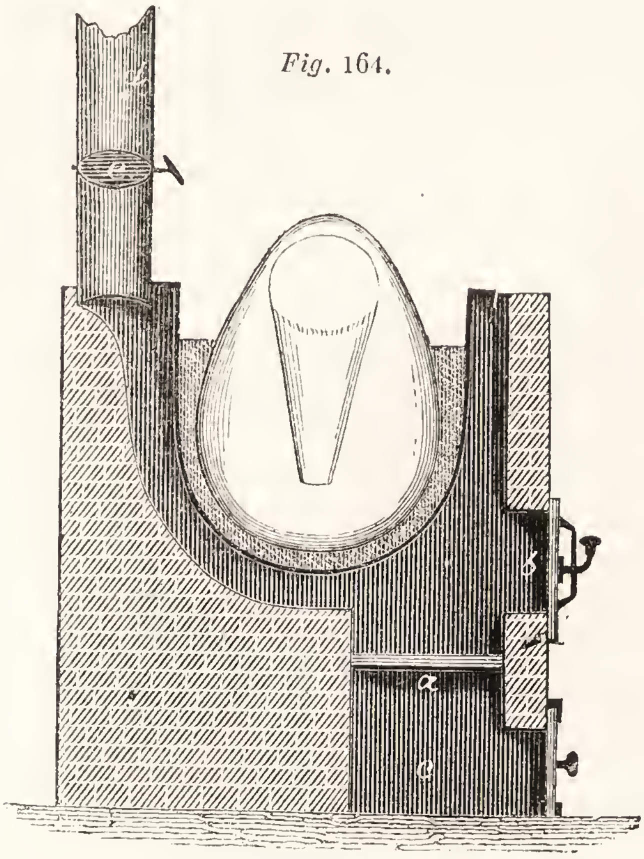
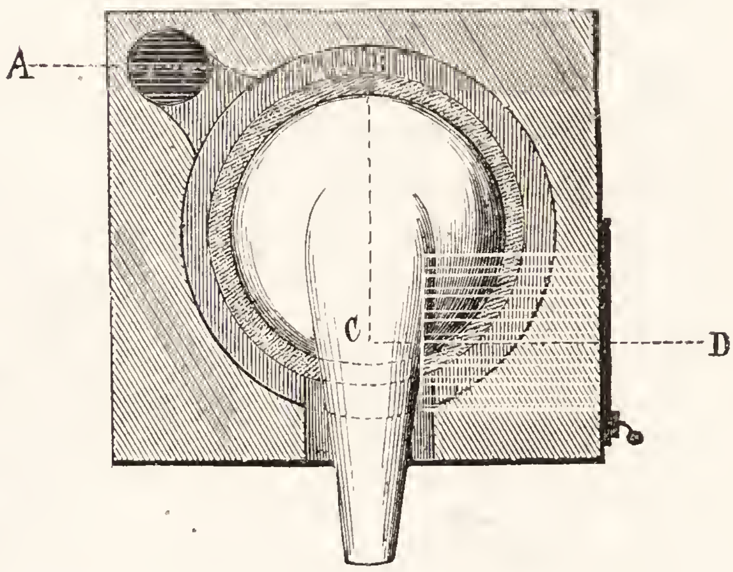



*Fig.* 165.




RETORT IN SAND-POT.

In fig. 165, the position of the fire-place is shewn, as indicated by the white lines in the part between C and D.

*Fig.* 166.

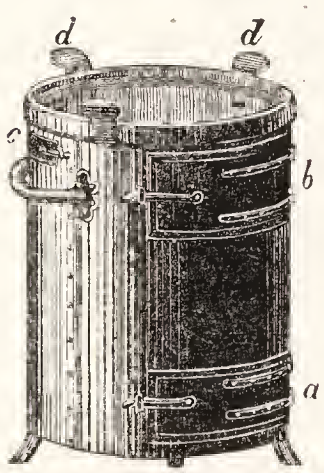



*Fig.* 167.

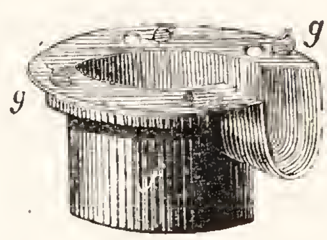
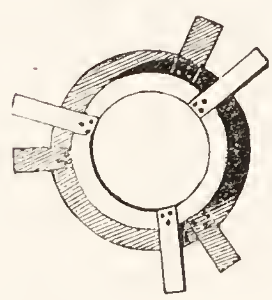



*Fig.* 168.

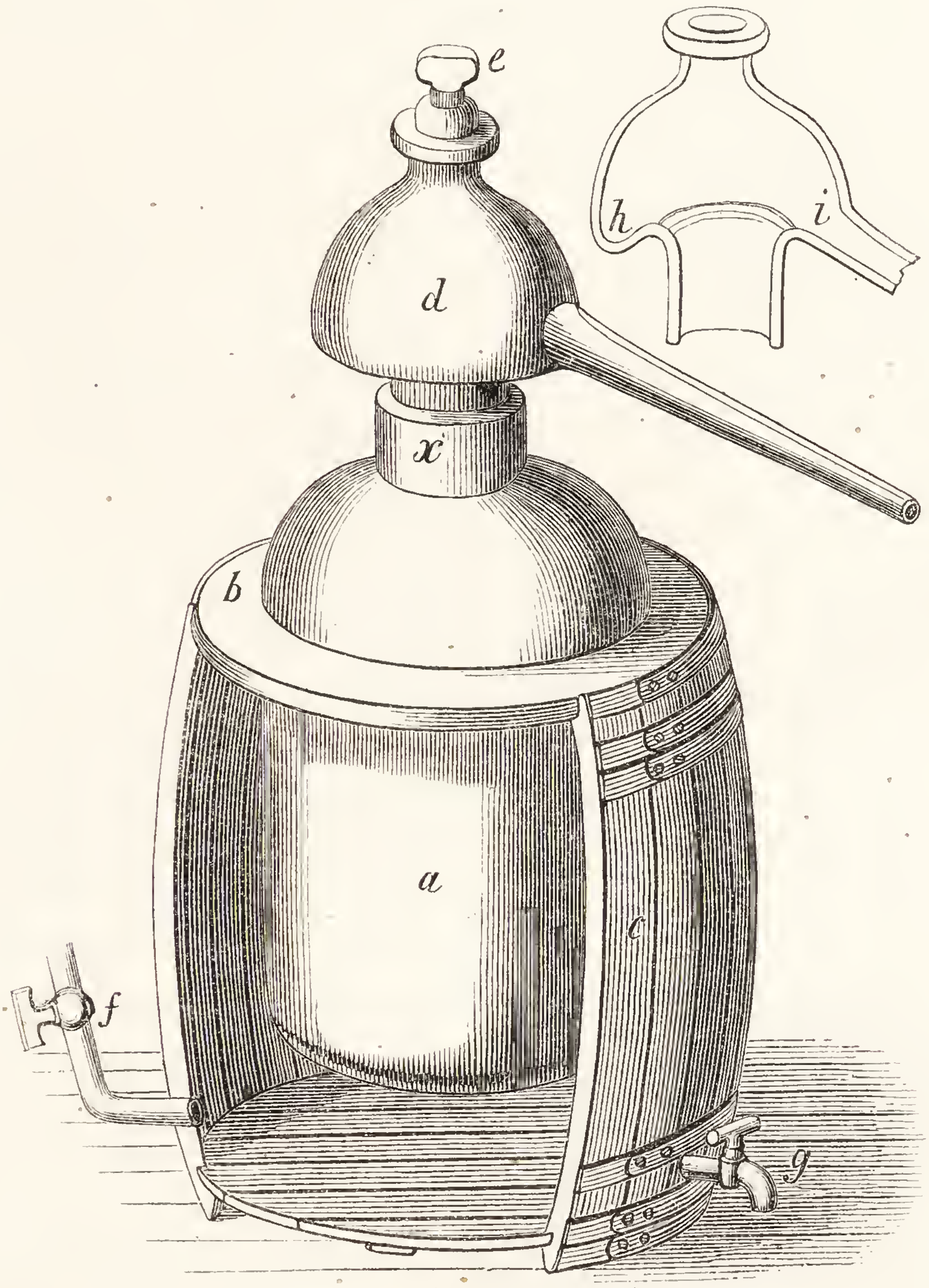


PORTABLE FURNACE AND APPENDAGES FOR DISTILLATION.

Fig. 166 represents a portable furnace, which would sometimes be found useful in processes of distillation. It is designed only for a charcoal fire, and the fuel is supplied during the continuance of the process, through the door (*b*). The supports (*d*, *d*, *d*) are intended for the reception of any large vessel which may be placed over the fire. The sand-pot (fig. 167), or the rings (fig. 168), are used for supporting retorts.

[*The stone-ware still* (fig. 169) is a convenient form of apparatus for some processes in the pharmaceutical laboratory, as for instance, in the distillation of *vinegar*, *sweet spirit of nitre*, *spirit of sal*

*Fig.* 169. *Fig.* 170.

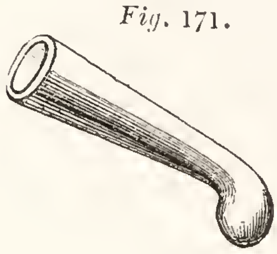



STONE-WARE STILL.

*volatile*, &c. The quantities of ingredients operated upon in these processes, which are necessarily conducted with glass or earthenware vessels, are such, that, if a retort be used, there is much danger of breaking it in consequence of its size. The charging of a large retort capable of holding several gallons, its introduction into the sand-bath, and its subsequent removal when the process is finished, are attended with much hazard, and the occasional fracture of the vessel, and loss of its contents, are almost inevitable results. These sources of loss and annoyance are entirely avoided by substituting the apparatus (fig. 169) for the retort. The body (*a*) of the still is made of brown earthenware, commonly called stone-ware. It has a projecting rim (*b*), by means of which it may be easily fixed in a jacket or case when heat is applied through the medium of steam. The head (*d*) may be made of the same material as the body, or it may be made of glass. It should have the form represented in the drawing, and which is more clearly indicated by the section (fig. 170). The object in adopting this form is to prevent any liquid, condensed in the head from running back into the body. Such liquid, being collected in the groove (*h*) runs off through the tube (*i*) in the direction of the receiver. There is a stopper (*e*) at the top of the head which admits of the introduction of fresh ingredients during the continuance of the process, if desired.

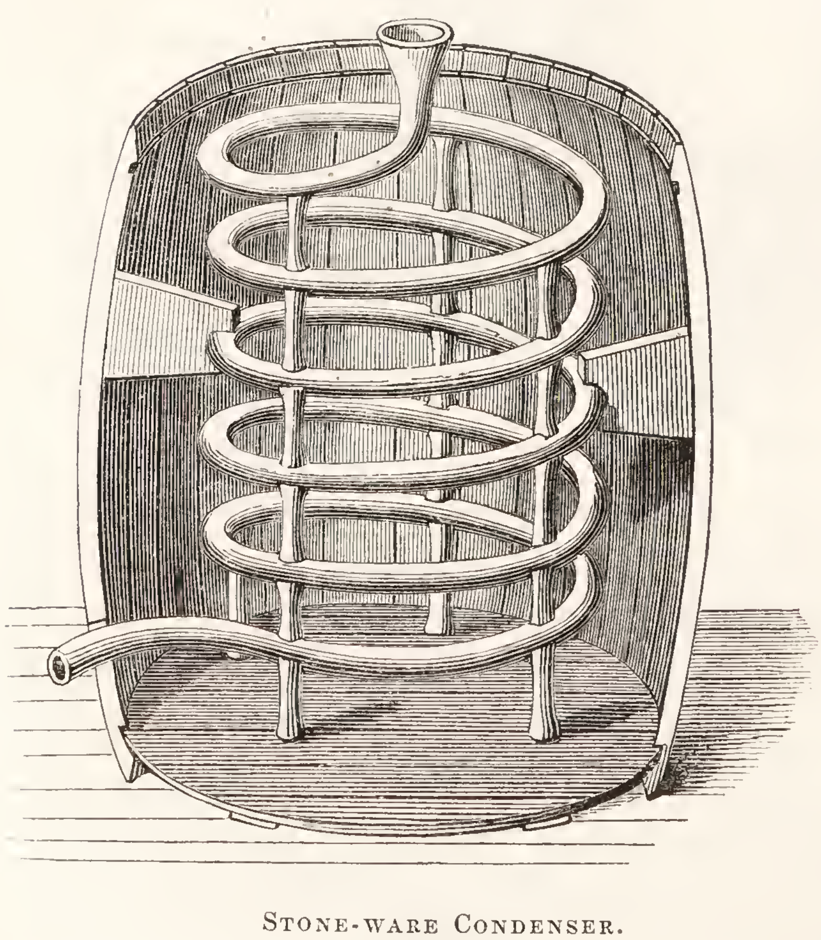
This still may be heated by means of the furnace and sand-pot (fig. 163) in the same way as a retort, but the drawing represents the arrangement adopted when steam is used as the source of heat. The still is fixed in a cask (*c*) of suitable size, to which steam is supplied through the pipe (*f*). On first turning on the steam the air is allowed to escape at the stop-cock (*g*), from whence also the condensed water runs off.

*Fig.* 171.



*The Stone-ware condenser*, (fig. 172,) and the *adapter*, (fig. 171,) are used with the still. These are all made by the manufacturers of stone-ware apparatus for chemical purposes, of whom there are several in the vicinity of Vauxhall Bridge, London. The stone-ware worm may be fixed in a cask, similar to that used as the jacket of the still.

*Fig.* 172.



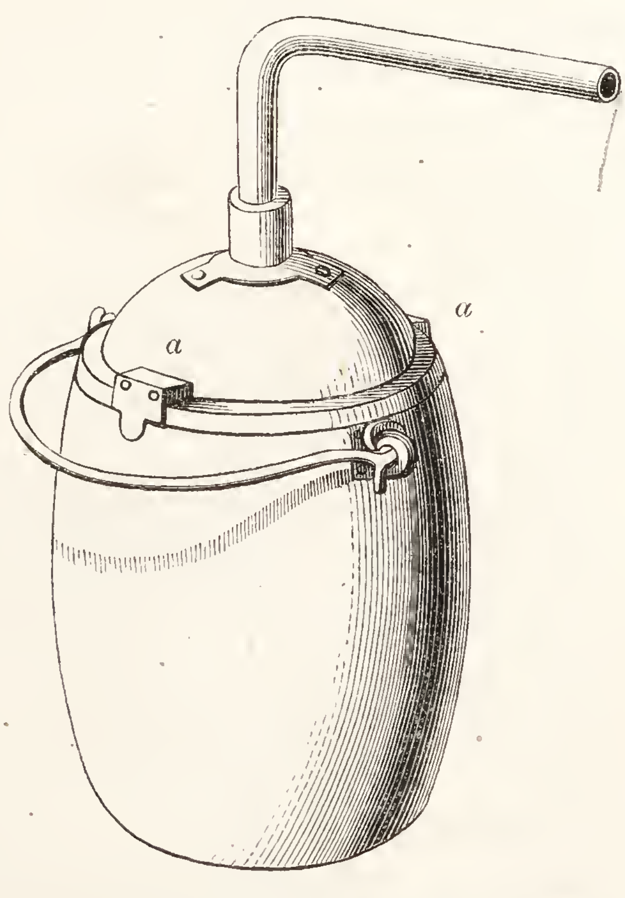
Stone-ware Condenser.

This kind of condenser answers very well, and is the most suitable for the distillation of *sweet spirit of nitre*, or *vinegar*, but it would be inapplicable in the process for the preparation of *spirit of sal-volatile*. In distilling this last-named spirit, the carbonate of ammonia, which it contains, is frequently deposited in considerable quantity in the condenser, and would soon block up a worm such as that represented in fig. 172. The best kind of condenser for the distillation of this spirit, is that represented at page 38, figs. 50 and 51, but the tube should be of much larger diameter than that mentioned in the description there given.

## DRY, OR DESTRUCTIVE DISTILLATION.

The process of *dry*, or *destructive distillation* is but seldom performed in the pharmaceutical laboratory, for although several substances in the preparation of which this process is applied, such as *acetic acid*, *oil of amber*, *succinic acid*, and *acetone* or *pyroacetic spirit*, are used in medicine, yet these are usually made exclusively by the wholesale manufacturer. The pharmaceutist, however, is sometimes required to perform processes of this kind, and on such occasions may experience difficulty in determining the best method of effecting the desired object. The substances operated upon in these processes are generally solid; the heat applied to them is much greater than that employed in ordinary cases of distillation; and the residuums left in the distillatory vessels, being usually in a fused, compact state, firmly adhering to the vessel, and insoluble in water, can only be removed by mechanical means. It is, therefore, necessary to employ apparatus of a peculiar description applicable to these conditions. *Glass* vessels are not generally suitable; they do not bear the required heat without cracking, or fusing, at least, when made of common English glass, and the residuums cannot be removed without breaking the apparatus. *Earthen-ware* or *porcelain* vessels are sometimes used, but these do not answer well, unless made of the best porcelain, which is expensive. *Cast-iron* is the material of which the apparatus used in these processes, or at least, that part of it

*Fig.* 173.




Apparatus for Dry or Destructive Distillation.

which is exposed to the fire, is usually made, and this is in every respect well adapted for the purpose, being economical, and sufficiently infusible when carefully used.

These processes are not of sufficiently frequent occurrence to require the provision of apparatus in anticipation of them; and, when they do occur, they are generally not of sufficient importance to justify the expense of having a suitable vessel cast expressly for the purpose. I have found a small cast-iron boiler, commonly called a *Pappin's digester*, easily convertible into an apparatus suitable for dry distillation. These *digesters* are sold by all ironmongers, and the only alteration required to adapt them for the use here contemplated, consists in removing the safety-valve from the top of the cover and fixing in its place a bent iron tube, as shewn in fig. 173. The cover fits on to the boiler with a steam-tight joint, and is kept securely in its place, when in use, by the clamps (*a a*).

## THE DISTILLATION OF ESSENTIAL OILS.

The method of proceeding in the distillation of essential oils is very similar to that adopted in making the medicinal distilled waters. The object contemplated in both cases is, to effect the volatilization of the essential oils contained or formed in the substances operated upon, together with water, and thus to separate these from the fixed or less volatile parts with which they were associated.

In making *distilled waters*, a sufficient quantity of water is used in the process to dissolve the whole, or nearly the whole, of the oil afforded by the other ingredients, so as to form a saturated solution.

In conducting the process with the view of obtaining the *essential oil* alone, the smallest possible quantity of water is employed, so as to avoid unnecessary loss of the required product by its solution in the water.

The quantity of water added to the other ingredients constitutes, therefore, the principal difference between the two processes.

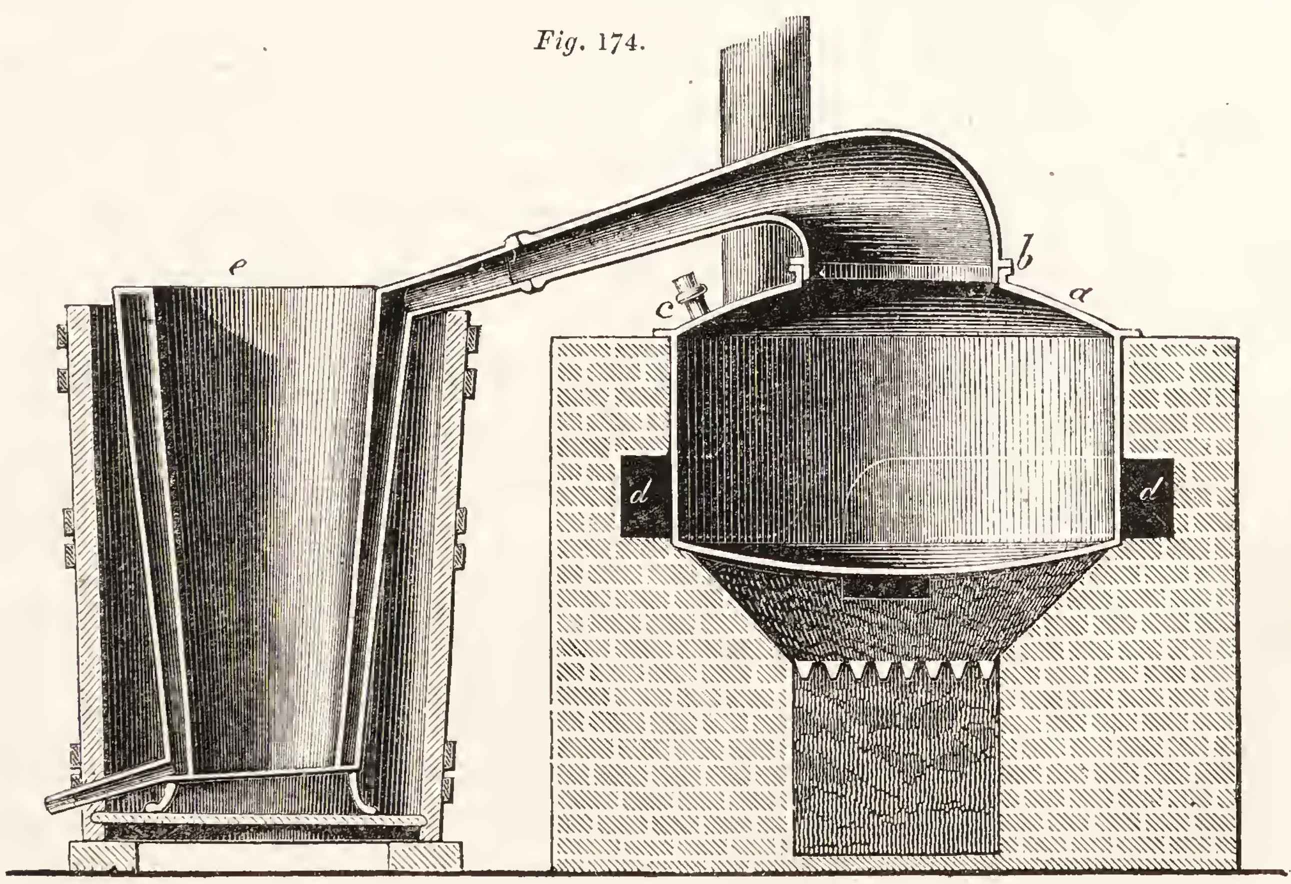
The essential oils employed in pharmacy are obtained from different parts of vegetables, in which they are generally contained in cells, and sometimes associated with other constituents of the plant, such as fixed oil, resin, or wax. It is important that these oils should be separated and collected without exposing them to a high temperature, and their distillation is therefore effected at temperatures below their boiling points by distilling them together with water. The boiling points of these oils are much higher than that of water. Thus, the boiling point

| | | | |
|---|---|---|---|
| Of oil of mustard | is | 290° | Fahr. |
| „ turpentine | „ | 314° | „ |
| „ mint | „ | 320° | „ |
| „ cajuput | „ | 343° | „ |
| „ thyme | „ | 354° | „ |
| „ bitter almonds | „ | 356° | „ |
| „ peppermint | „ | 365° | „ |
| „ rosemary | „ | 365° | „ |
| „ meadow-sweet | „ | 380° | „ |
| „ pennyroyal | „ | 395° | „ |
| „ gaultheria | „ | 412° | „ |

But although any one of these oils, if submitted to distillation without the admixture of any other more easily volatilized substance, would require to be heated to the temperature above represented as its boiling point; yet, when mixed with water, it will readily distil at 212°, that is, at the boiling point of the water. This occurs through the tendency to diffusion of the less volatile liquid into the vapour of the more volatile, in accordance with the principles explained at pages 76 and 77.

It is thus that the distillation of essential oils is always effected. The vegetable substance, from which the oil is to be obtained, if it consist of root, wood, bark, fruit, or seed, is generally cut or

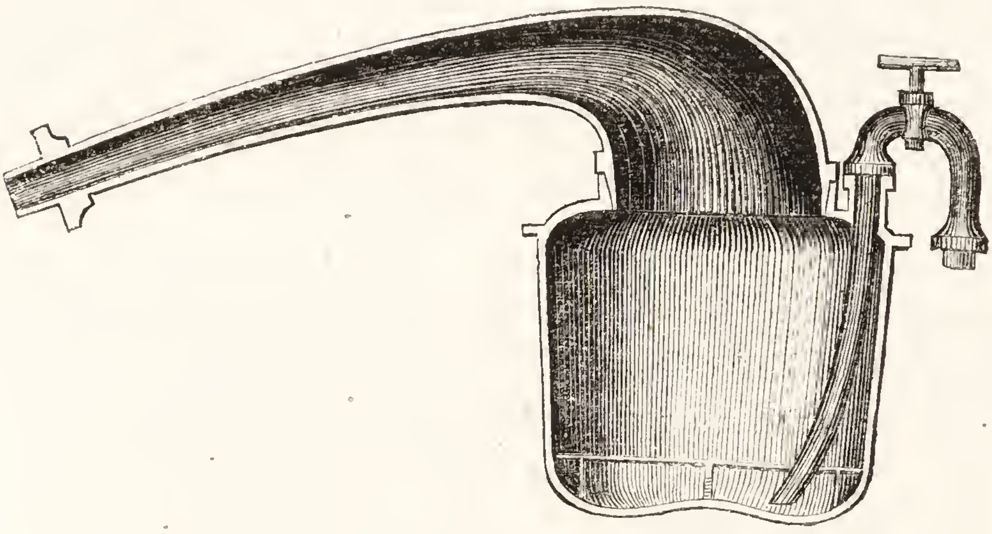
*Fig.* 174.




Still and Condenser.

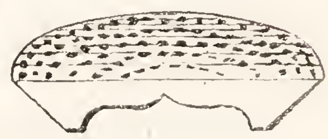
bruised, so as to facilitate the extraction of the oil. It is then either introduced into the body of the still (fig. 174), together with a suitable quantity of water, and, after being allowed to macerate for some time, is submitted to distillation in the usual way; or it is put into a vessel such as the cucurbit (fig. 175), and steam being allowed to issue from a pipe beneath the perforated false-bottom (fig. 176), is made to pass through it into the condenser.

*Fig.* 175.



CUCURBIT AND FALSE-BOTTOM.

*Fig.* 176.



PERFORATED FALSE-BOTTOM.

Some difference of opinion exists as to which of these two methods of operating is the best. The former, when conducted in a still set over the fire, as represented in the drawing, is subject to objection in consequence of the danger there is of applying too much heat, and thus injuring the quality of the oil by contaminating it with the products of the decomposition of vegetable matter. In the latter method of operating, the above objection does not apply; but it is difficult, if not impossible, to draw over the whole of the oil in this way, without using so much steam that the product in undissolved oil will be very small, as compared with that obtained by the other process.

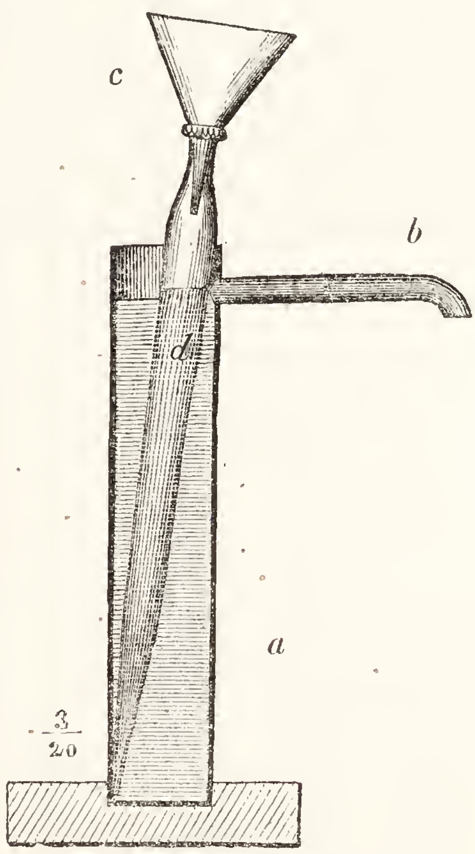
At Mitcham, where large quantities of essential oils are distilled for the London market, the process is conducted with common stills, set as represented in fig. 174. These stills are generally of great magnitude, having, sometimes, a capacity of two or three thousand gallons. The bottom of the still is covered with wicker-work, or with perforated boards, over which the vegetable substance to be operated upon is placed, and the body of the still being thus nearly filled, water is introduced so as just to cover the solid ingredients. It is customary to allow some hours to elapse, after charging the still, before commencing the process of distillation; the fire is then lighted, and water saturated with essential oil passes over, together with a portion of oil beyond that which the water is capable of holding in solution. The distilled products, if the oil be lighter than water, are received into a vessel (fig. 177) called the *Florentine receiver.* The oil collects here in the neck of the vessel at *a*, while the water flows off into another vessel through the spout *b*. The small bottle (*c*) represented as attached to the neck of the receiver is not used in this part of the process, but in a subsequent operation, which will be described hereafter.

*Fig.* 177.


THE FLORENTINE RECEIVER.

If the oil be heavier than water, the form of apparatus (fig. 178) may be conveniently adopted for collecting it. This consists of a vessel (*a*), near the top of which there is a spout (*b*) through which the water flows into a suitable receiver, as fresh portions are supplied through the long funnel (*c*, *d*). The oil, being heavier than the water, collects at the bottom of *a*.

*Fig.* 178.




OIL-SEPARATER.

This apparatus may also be used for collecting and separating oils that are lighter than water, which application of it will be described hereafter.

When the object of the process is merely the collection of essential oil, the distilled water which comes over with it, and from which the oil has been separated as above, is used, on re-charging the still, instead of common water, by which means a larger product of oil is obtained, to the extent of the portion held in solution by the water.

Some oils pass over more slowly than others, being either less volatile, or more tenaciously held by the vegetable matter. In these cases it is sometimes necessary to return the distilled water two or three times on to the solid ingredients before the whole of the oil is extracted.

The utmost care should be taken, in this process, to prevent the distilled product from acquiring any empyreumatic impregnation, which might be acquired by the incautious application of heat, or the continuance of the process until carbonization of some of the vegetable matter has commenced. In operating with the common still (fig. 174) it is very difficult to avoid these results, and hence the reason that other methods of conducting the process have been resorted to. The substitution of steam apparatus for the still set over the fire, affords the best means of remedying the evil alluded to. If a still such as that represented in fig. 60, page 51, be employed the process may be conducted without any fear of injuring the product by excessive heat. The only objection to this arrangement is, that there is much loss of heat by radiation from the steam pipes, and the outer surface of the steam-chamber of the still, which occasions an undue consumption of fuel. The loss of heat by radiation is diminished when the steam is conveyed directly into the interior of the distillatory vessel, as represented at S T, fig. 60, and the process then conducted in the manner represented in fig. 175; but although this method answers very well for preparing most of the distilled waters, it is not, as already stated, completely efficient in the distillation of essential oils, especially of those which are the least volatile.

There is another method of applying steam for distillation or vaporization, in which the objections which apply to the two foregoing methods are obviated. It consists in heating the liquid by means of a coil of steam-pipe fixed within the still or boiler. This pipe, through which steam at a suitable temperature is passed, being surrounded by the liquid, parts with no heat that is not rendered available. It is found to be the most economical and efficient method of applying the steam, and may be beneficially adopted for processes in which the presence of the steam-pipe within the boiler is not objectionable. In operating in this way, a strong cask may be readily converted into a still by fixing a coil of steam-pipe within it, somewhat in the manner represented in fig. 172; but the pipe should be more nearly in contact with the sides of the cask than is there represented, if much solid matter is to be put in, and the head of the cask should, of course, be retained, with a suitable opening for introducing and removing solid ingredients, and a pipe for conveying the vapour to a condenser.

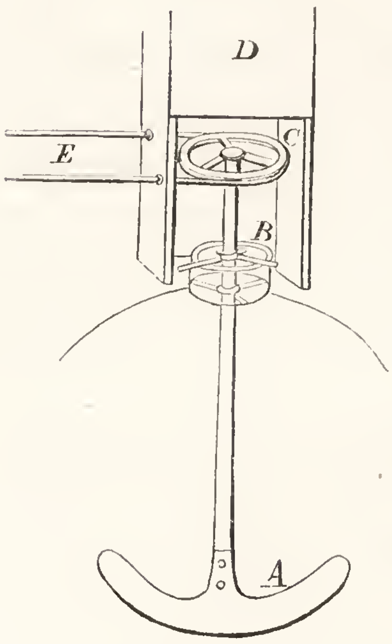
So important has the avoidance of the application of a high temperature been considered with reference to the preparation of essential oils that it has been proposed to effect their distillation *in vacuo*, with apparatus similar in principle and general arrangement to that represented in fig. 71. Oils that have been thus prepared are said to be superior to those obtained in the ordinary way, and the chief obstacle to the adoption of this process is, probably, the expense of the apparatus.

The quality of essential oils, and distilled waters, however, does not depend solely on the process by which they are distilled. When obtained from fresh plants, leaves, or flowers, it is important that these should be collected at suitable periods with reference to the growth of the plant. Labiate plants are said to yield the best oils when they are just beginning to flower, although the quantity yielded is greater at a later period of their growth. In the distillation of roses, the petals only should be used, and not the entire flower including the calyx. In like manner, elder flowers should be stripped from the stalks. When seeds, fruits, or other parts, are bruised or otherwise disintegrated, previously to submitting them to distillation, the one process should immediately precede the other, for if they be much exposed to the air after being so prepared there will be both diminution of product and deterioration of its quality.

There are a few substances in obtaining essential oil from which it is necessary to conduct the process of distillation in a particular manner. *Bitter almonds*, *mustard seeds*, and *horseradish*, are of this class. These substances do not contain essential oil ready formed, but the oil is produced in the process to which they are submitted. *Bitter almond cake*, for instance, from which essential oil and distilled water are obtained, contains two bodies, *amygdaline* and *emulsine*, by the mutual reaction of which, together with water, the oil is produced. Black mustard-seed, also, contains two analogous bodies, *myronic acid* and *myrocyne*, which in like manner produce the essential oil of mustard. Bodies of analogous nature exist in *horseradish*, and in *laurel leaves*. The *emulsine* and the *myrocyne* of the almond and the mustard-seed, and the corresponding substances in the other plants mentioned, undergo a change, similar to the coagulation of albumen, when heated to a temperature approaching that of boiling water, and when thus coagulated they are no longer capable of producing essential oil with the other vegetable principles. It is necessary, therefore, in obtaining essential oil from this class of substances, to macerate them with cold or luke-warm water for some time previously to the application of heat. If boiling water were added at once to these substances, it would coagulate and render inoperative one of the constituents from which, under other circumstances, the oil would be formed.

In distilling *bitter almonds*, the cake, which has been previously freed from fixed oil by expression, is powdered and mixed with about twenty parts of cold water. The mixture is allowed to stand for twenty-four hours before the application of heat, during which time the essential oil is produced; it is then submitted to distillation. The mixture, after being boiled, and especially when part of the water has been distilled off, becomes thick, and is apt to adhere in a hard cake to the inner surface of the still; and if this be allowed to remain there, it will greatly retard the progress of the distillation by obstructing the free conduction of heat to the more liquid part; while, at the same time, the product may be contaminated with an empyreumatic flavour from the action of the heated metal on the caked vegetable matter. To obviate these results, it is customary to have an apparatus, technically called a *rouser*, attached to the still, by which constant agitation of the ingredients may be effected.

*Fig.* 179.

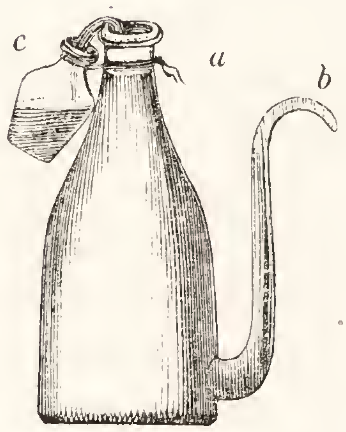



THE ROUSER.

Fig. 179 represents an arrangement of this kind, but in addition to the projecting arms (A), chains are sometimes attached, which are dragged along the bottom of the still as the agitator is turned.]

After obtaining the oil by distillation, and collecting it in the Florentine receiver, it has to be separated from the water, on the surface of which it floats. If the quantity of oil be small, and there be no better arrangement at hand for the purpose, the separation may be effected as follows:—the spout (*b*) of the *Florentine receiver* (fig. 177), in which the oil has been collected, is stopped with a cork, and water is poured in until the oil rises to the top of the neck at *a*; a small bottle (*c*) is then tied to the neck of the receiver, and a few threads of lamp-cotton placed as represented, so as to form a syphon through which the oil will be conveyed into the bottle by capillary attraction.

*Fig.* 180.




OIL-SEPARATER.

If the quantity of oil be such as to render this method of proceeding tedious or inapplicable, one of the *oil separaters*, figs. 181 and 182, may be used. The apparatus, fig. 181, consists of a funnel, terminating in a small tube at the bottom, and contracted at the top so as to admit of its being closed by the thumb of the operator, or by a cork or glass stopper. The opening at the bottom is closed by the finger, or by inserting a small cork, when the liquid is poured into the funnel; and when the oil has collected on the surface of the water, the latter is allowed to run off either by opening the lower tube, or, the latter being left open, by allowing air to enter at the top. This apparatus is sometimes made with a stop-cock, as represented in fig. 182, and it is then much more efficient and convenient for use. If it be made of the form of fig. 182, the top of the funnel should have a rim ground to a flat smooth surface, over which a plate of glass may be placed to prevent evaporation.

In the apparatus (fig. 183), the separation of a light oil is thus

*Fig.* 181.

*Fig.* 182.

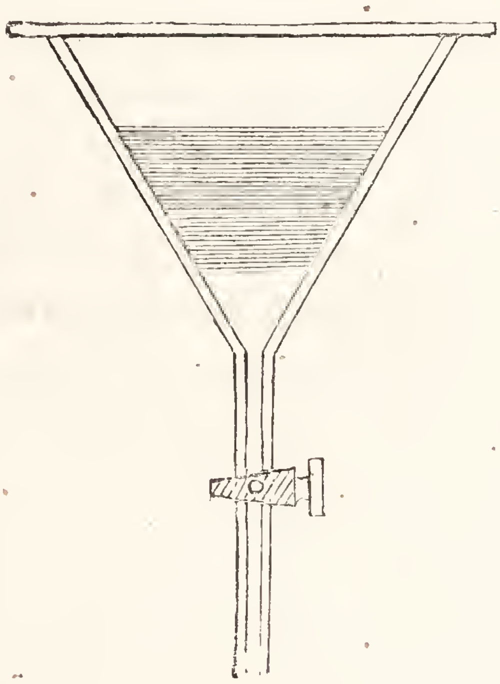
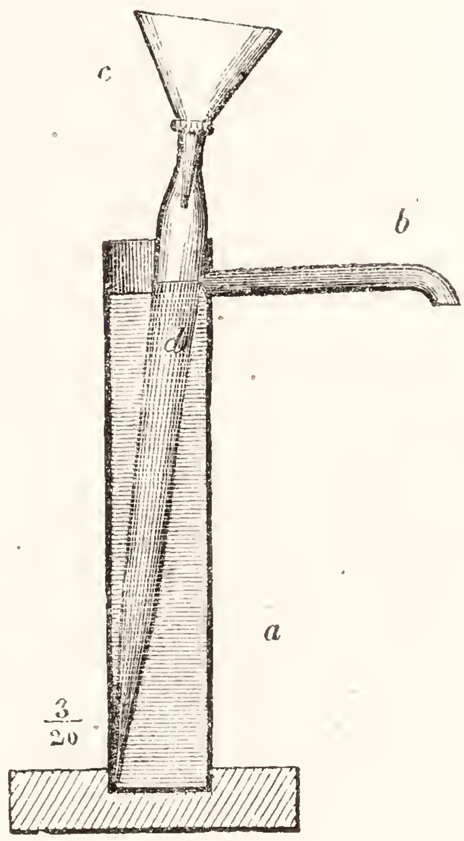


*Fig.* 183.




OIL SEPARATERS.

effected: the oil is collected in a tube (*d*) through which the water passes into the vessel (*a*); and when the distillation is concluded, the funnel (*c*) is removed, the mouth of the tube (*d*) is closed with the finger; the tube is then raised out of the vessel (*a*), and, by partially removing the finger so as slowly to admit air, the water is allowed to run out through the contracted opening at the bottom of the tube, the oil being retained by again closing the orifice at the top when the last drop of water has escaped.

## PRESERVATION AND RECTIFICATION OF ESSENTIAL OILS.

Essential oils are very liable to undergo deterioration if long kept, and especially if they be kept in a warm place, and the vessels containing them be imperfectly closed. This deterioration arises from the absorption of oxygen, which takes place at first but slowly, but when oxidation has proceeded to a certain extent the absorption becomes more rapid. During this change they assume a yellowish or brown colour; they become less limpid; acquire a tenacious consistence, and resinous character; and, finally, are either covered over with a tough pellicle, or are entirely dried up to a substance of that kind. Meanwhile the smell undergoes a change; it becomes less characteristic of the substance from which the oil was originally obtained, and more like that of oil of turpentine. The products of this oxidation are less volatile than the oil itself, and therefore essential oils that have become partially oxidized or resinified, may be freed from the products of oxidation by submitting them to distillation or rectification.

The rectification of essential oils is best effected by putting them, together with about twenty times their volume of water, into a retort or still, and using the distilled water which passes over with the oil for recharging the still, until the whole of the oil, excepting that retained by the water, has been drawn over.

This method of operating is found to answer better than the passing of a jet of steam through the oil. If, instead of thus distilling it with water, the oil were to be submitted to distillation alone, the quality of the product would be injured, and its character, in some cases, completely altered.

The conditions most favourable to the preservation of essential oils, are, that they should be kept in a cool place, in bottles completely filled, well stopped, and excluded from the light.

## THE RECTIFICATION OF ETHER.

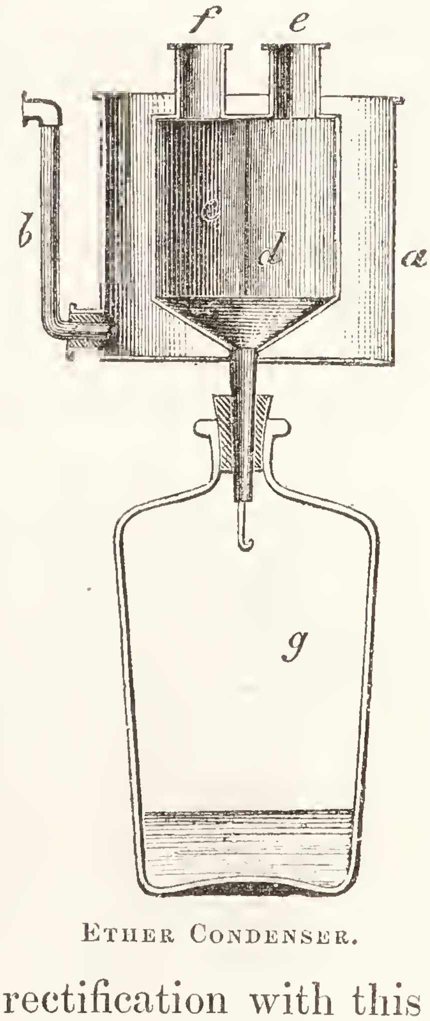
In rectifying commercial ether in the usual way, distilling it by the heat of a water-bath, with a retort and common condenser, it is impossible to effect the complete separation of the spirit, much of which passes over towards the latter part of the process. It is only by frequently ascertaining the specific gravity of the distilled product that the right time for stopping the process can be determined, and even then the ether distilled over will contain some alcohol, while the alcohol which remains undistilled will retain some ether. It is true that by washing the ether with water the whole of the alcohol may be removed from it, but this is an expensive method of effecting its purification, as the water thus used dissolves ether as well as alcohol, and thus renders another process of rectification necessary, unless it be thought less expensive to sacrifice the ether contained in the washings than to incur the trouble of recovering it.

This subject occupied my attention some time ago, and I contrived an apparatus by the use of which the ether may be obtained in a state of purity from the unrectified liquor in one operation, while the spirit is, at the same time, left tolerably free from ether.

The principle on which the apparatus is constructed, I have designated by a term, which may, perhaps, appear somewhat paradoxical, namely, *warm-cooling.* The vapours arising from the impure ether are conducted through a condenser which is kept constantly at a temperature of 118° Fahr., by the application of warm water. In this vessel, the temperature being some degrees higher than the boiling point of ether, yet much lower than that of alcohol, the latter substance is condensed, while the former passes in the state of vapour into a second condenser which is kept surrounded with cold water, and, when these can be obtained, with ice or snow.

Fig. 184 represents the *ether condenser*, which may be made of sheet tin, or, preferably, of copper. The cylindrical vessel (*a*) contains the warm water. It is open at the top, and has a tube (*b*) inserted through a cork near the bottom, by turning which the water may be drawn off as mentioned in the description of the apparatus, fig. 76, page 84. A stop-cock might be substituted for this tube, but would be more expensive. The exit pipe of the interior vessel (*c*) passes through the bottom of the vessel (*a*). It has two openings at the top to receive the glass or tin tubes, through which the vapours are conveyed to and from this apparatus. The vessel (*c*) is divided into two compartments by the partition (*d*), so that the vapours pass down one side and up the other, and are thus more completely exposed to the influence of the warm water.

*Fig.* 184.

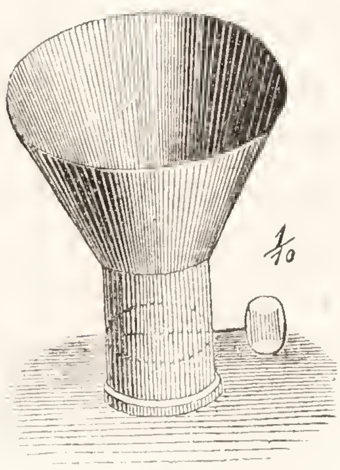



ETHER CONDENSER.

The method of conducting the process of rectification with this apparatus will be readily understood.

The crude ether, previously mixed with carbonate of potash so as to neutralize any free acid it may contain, is put into a retort, placed in the *steam-funnel*, fig. 185, or in any other suitable apparatus for applying the heat of boiling water. The beak of the retort is connected by a glass or tin tube with the opening (*e*) of the condenser. The delivering tube of the condenser is fixed loosely in the mouth of a bottle (*g*) which is intended for the reception of the condensed spirit, and at the end of this tube there is a smaller bent tube, inserted by means of a cork, which serves to prevent the ether vapour from passing into the bottle (*g*), the drop of spirit which is always retained in the end of this tube keeping it closed. To the second opening (*f*) of the vessel (*c*), a tube is attached by which the ether vapour is conveyed to an efficient condenser, well supplied with cold water.

*Fig.* 185.

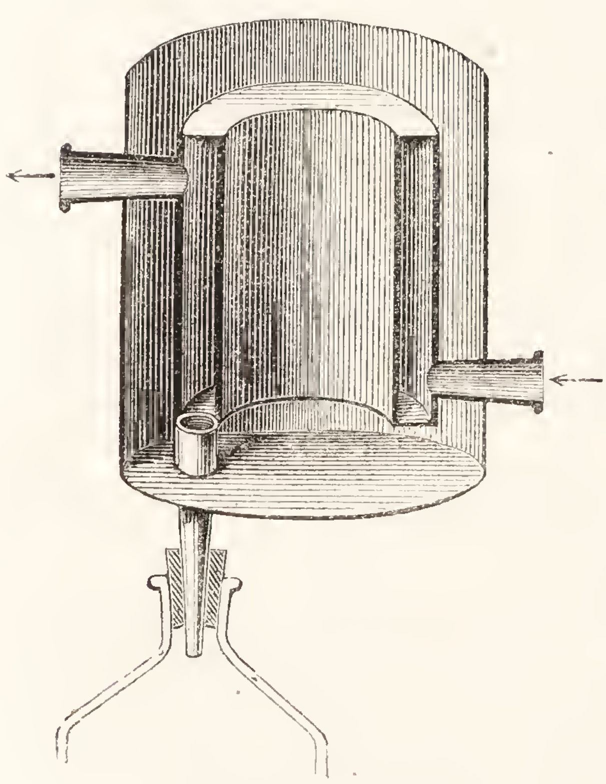


STEAM-FUNNEL.

The apparatus being thus arranged the valve of the steam-funnel, the use of which is described at pages 30 and 38, is opened so as to admit the steam to the bottom of the retort. At the same time the vessel (*a*) of the condenser is filled with warm water at a temperature of 118° Fahr., and this temperature is maintained by the addition from time to time of fresh water.

When the distillation commences, ether alone will at first pass over, none of which will be condensed in the first condenser; but when the process has continued for some time spirit will begin to collect in (*g*), while the quantity of ether passing into the next condenser will be diminished; and, lastly, the distillation of ether will entirely cease, and spirit alone will distil, being condensed in the first condenser, and collected in *g*.

*Fig.* 186.



ETHER CONDENSER.

The ether obtained by this process has the specific gravity of pure ether. The spirit has a faint smell of aldehyde and ether. It is readily converted into strong spirit or alcohol by distilling it from carbonate of potash or from lime.

Fig. 186 represents another form of *ether condenser*, the construction of which is similar in principle to that of *Gadda's condenser* described at page 35. In this the vapours enter at the lower, and escape at the upper opening, as indicated by the arrows. The method of using this apparatus and its effects are similar to those of the preceding.

## THE GENERATION AND ABSORPTION OF GASES.

The processes for generating and absorbing gases are of frequent occurrence in the pharmaceutical laboratory. Among the gases thus operated upon, the most important are, carbonic acid, sulphuretted hydrogen, chlorine, ammonia, and muriatic acid. Of these, the three first-named, are more difficultly, and the two last-named, more easily, absorbed. The first two are evolved without the application of heat, but those which follow, require some heat to ensure their complete evolution.

It will be necessary to describe the practical details connected with the generation and absorption of these gases separately.

*Carbonic acid gas* is produced by the action of sulphuric or muriatic acid on chalk, marble, or lime-stone.

When *sulphuric acid* is used, the insoluble sulphate of lime which is formed, tends to retard the reaction of the ingredients, by enveloping the undecomposed carbonate and protecting it from free contact with the acid. [In operations on the large scale, it is customary to guard against this inconvenience, by having a stirrer attached to the generating vessel, by which the mixture is, from time to time, agitated, so as to remove the enveloping sulphate and bring fresh portions of chalk and acid into contact.] *Muriatic acid*, on the other hand, forms a soluble salt with lime, which offers no material obstruction to the continuance of the decomposition: this acid is, therefore, better suited than the other for generating the gas for pharmaceutical purposes, as, in such cases, glass apparatus is generally employed, which is unprovided with means for stirring the ingredients.

The gas thus evolved, whichever process be adopted, is usually contaminated to a greater or less extent with the mineral acid, or with some volatile substance resulting from bituminous matter contained in the carbonate of lime. Before using it, it should be freed from these impurities, and this is especially necessary when muriatic acid has been employed, as an appreciable quantity of this volatile acid is generally carried over with the gas. The best method of effecting its purification, is to make it pass through a semi-fluid mixture of bicarbonate of soda and water, or through a tube filled with fragments of the dry salt.

Fig. 187, represents the arrangement of the apparatus for generating, purifying, and absorbing, carbonic acid. The vessel (*a*) contains the chalk, broken into pieces of a suitable size for being introduced through the mouth of the bottle. Crude muriatic acid, diluted with an equal volume of water, is poured in through the funnel-tube (*b*). The small bottle (*c*) contains bicarbonate of soda mixed with a little water; and the bottle (*d*), or some other suitable vessel, is intended to contain the liquid into which the gas is to be passed.

Fig. 188, represents another modification of the apparatus, in

*Fig.* 187.

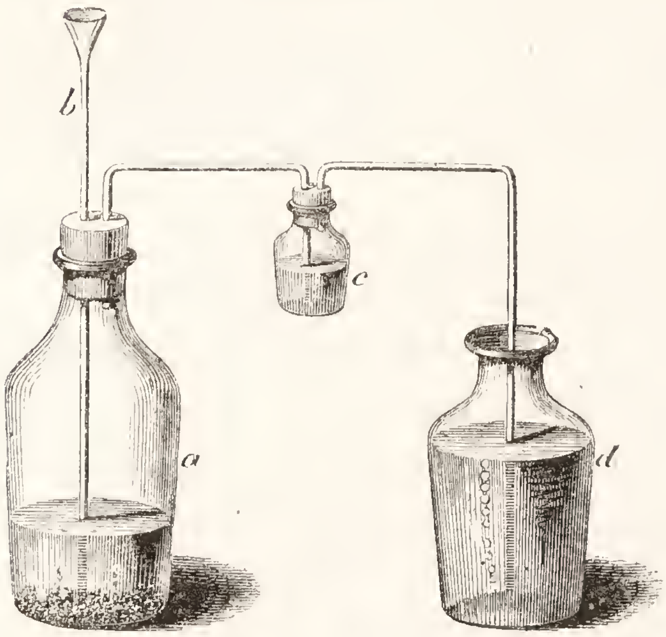
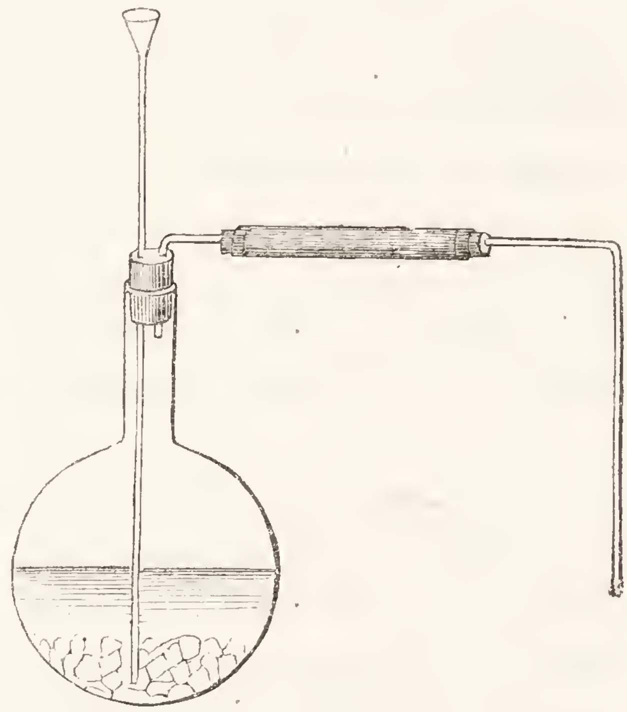



*Fig.* 188.



CARBONIC ACID APPARATUS.

which a flask is substituted for a bottle as the generating vessel, and a tube filled with dry bicarbonate of soda is used for purifying the gas.

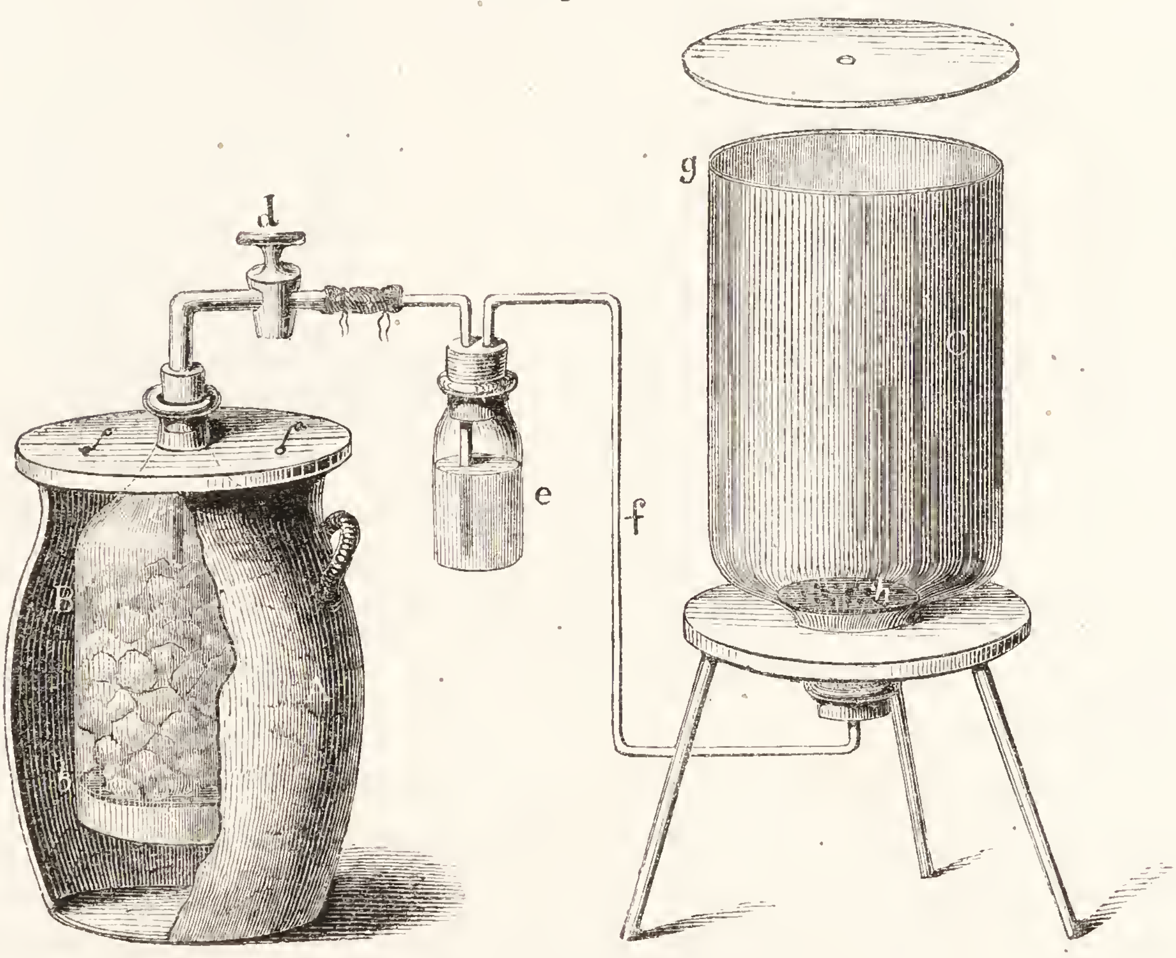
Towards the close of the operation, the further disengagement of gas may be aided by the application of heat, which is best effected by putting the generating vessel into warm water.

When the solution of chloride of calcium becomes somewhat concentrated, this prevents the further action of the acid on the carbonate, so that after the disengagement of gas has ceased, there may still be free acid and undecomposed carbonate of lime present. In this case, the addition of some warm water, poured in through the funnel-tube, will occasion a renewal of the reaction, which may be thus maintained until complete decomposition has been effected.

[When broken pieces of marble can be obtained, these will be found greatly preferable to chalk as a source of carbonic acid gas. Not only will the gas be more pure and free from smell, but its disengagement will not be attended by so much frothing as occurs when chalk is used, and which, in the latter case, sometimes causes the contents of the generating vessel to pass over into other parts of the apparatus.]

The arrangement represented in fig. 187 is that frequently adopted for effecting the absorption as well as the generation of carbonic acid; but when the gas is merely made to pass in bubbles through the liquid, as there indicated, the absorption often takes place but slowly and imperfectly, and it generally happens that the quantity of gas absorbed is not more than one fourth or one fifth of that which has been used. This loss of gas is sometimes of little importance, but there are cases in which it becomes a consideration to economize the expenditure of materials to the greatest extent practicable. With the view of accomplishing this object I have constructed an apparatus, in the use of which the disengagement of gas is dependent upon, and proportionate to, the extent of absorption which, at the same time, takes place. This apparatus is represented in fig. 189. It consists of the following parts:—first,

*Fig.* 189.




CARBONIC ACID APPARATUS.

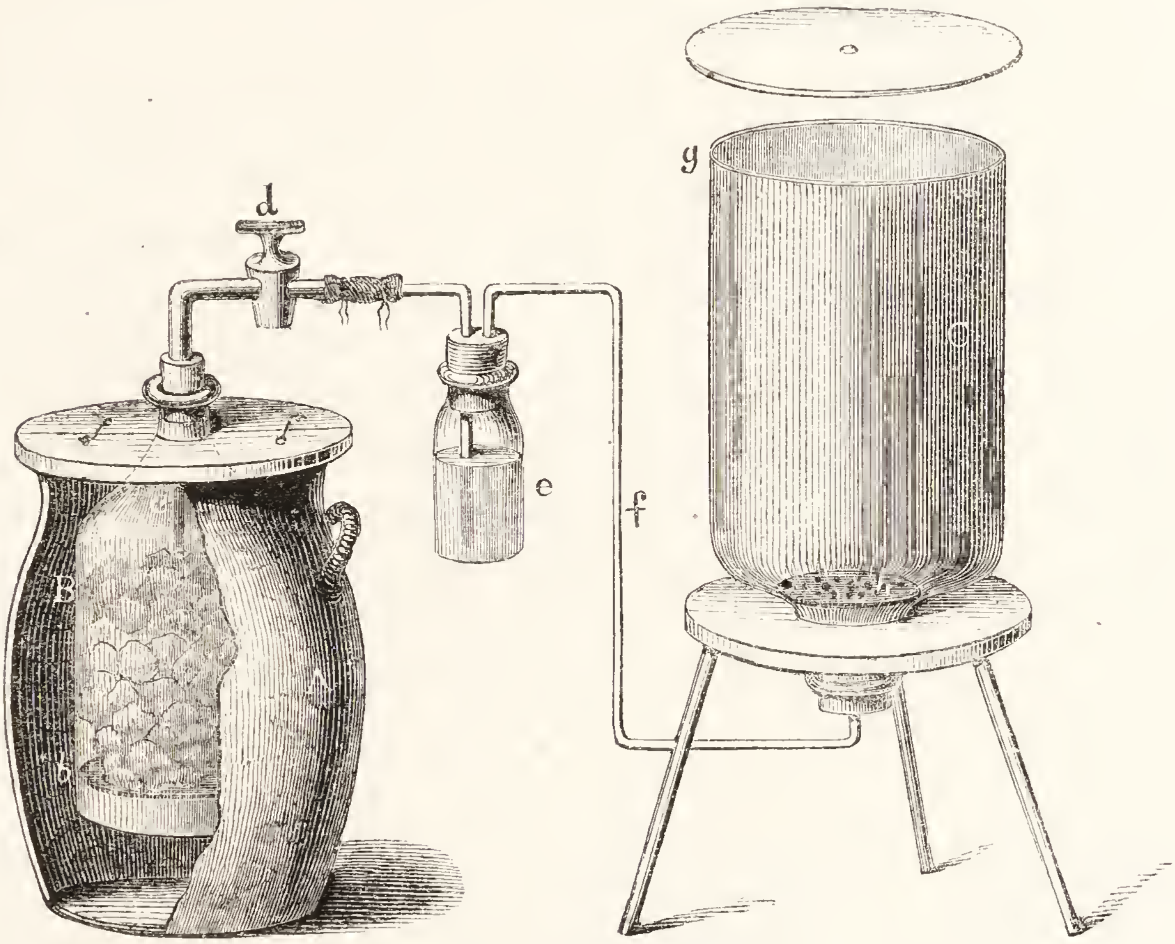
a glazed earthenware jar (A), such as is commonly used for domestic purposes. The top of this is closed with a wooden cover, in the centre of which there is a round hole through which passes the neck of the bottle (B), which is used for generating the gas. The wooden cover is in two pieces, being cut through its diameter, and these, when placed around the neck of the bottle, are kept together by two pair of hooks and eyes. The generating vessel (B) is a large green glass bottle, the bottom of which has been cut off. A brass tube and stop-cock (*d*) are fitted to the mouth of this bottle by means of a cork, and at the end of the tube which is inserted through the cork there is a hook, from which a circular plate of brass or lead is suspended by a wire for supporting the fragments of marble or chalk. This part of the apparatus resembles the gas-generator of the well known Döbereiners lamp, which was originally invented by Gay Lussac.

The generator (B) fig. 190 is filled in the following manner:—the circular plate being removed, the bottle is turned with its bottom upwards, and held by the wire attached to the end of the brass tube, while the pieces of chalk or marble are packed in so as nearly to fill it. The plate of brass or lead is then placed over the carbonate of lime, and the wire is passed through a hole in the centre of the plate, and secured by means of a nut, which screws on to the end of the wire. Crude muriatic acid, diluted with a little water, having been poured into the jar (A), the bottle (B) is fixed in its place, as shewn in the drawing. So long as the stop-cock (*d*) remains closed, the acid will be prevented from entering the bottle (B) by the elasticity of the air contained in it, but on turning (*d*) the air will escape through the tube, and the acid coming in contact with the carbonate of lime, carbonic acid will be disengaged. If now the stop-cock be again closed, or there be any obstruction to the escape of the gas, the carbonic acid accumulating in the generator will displace the muriatic acid from the bottle B, and the further evolution of gas will cease. In proportion as the gas escapes from B, in consequence of its finding an exit at the other end of the apparatus, or being absorbed there, the muriatic acid will re-enter and decompose a further portion of carbonate, thus keeping up a uniform supply of carbonic acid equivalent to the consumption of it.

The other parts of the apparatus, as represented in the drawing, are intended for the preparation of *bicarbonate of soda*. The gas, after passing through the stop-cock (*d*), is purified in the manner already described, in the bottle (*e*), and is then conveyed through the tube (*f*) into the vessel (C.) This vessel consists of a large bottle, the bottom of which has been cut off, and the edge (*g*) ground to a perfectly smooth, flat surface, over which a circular disk of ground plate-glass, having a small hole in the centre, fits closely. There is also at the bottom of this vessel a perforated wooden disk (*h*), upon which the salt intended to absorb the gas is placed.

As bicarbonate of soda contains but one atom of water, while the carbonate contains ten atoms, it is found advantageous to use a mixture of three parts by weight of anhydrous, and one part of crystallized carbonate of soda. This mixture is put loosely into the vessel (C), so as nearly to fill it. The rim of the vessel is then covered with tallow, or other hard grease, and the glass-plate fitted on so as to be air-tight. The stop-cock (*d*) is now opened, and carbonic acid, being rapidly disengaged, soon displaces the atmospheric air from the apparatus, this gas escaping through the small

*Fig.* 190.




CARBONIC ACID APPARATUS.

hole in the glass-plate which is not yet closed. When the air has been thus chased out, and it is found that carbonic acid begins to escape, the hole is to be closed with some wax, and the glass-plate loaded with weights to prevent any further escape of gas. Absorption of carbonic acid by the carbonate of soda will now commence. At first this will take place slowly, but after a little while the salt will become warm, and the action much more energetic. Indeed, the absorption, sometimes, proceeds so rapidly, that the solution is drawn over from the generator into the absorbing vessel. It is principally with the view of preventing this result that the stopcock (*d*) is attached to the apparatus, as by this means the communication between the vessels (B) and (C) can be instantly cut off when the liquid is seen to rise unduly in the former. Hence it is necessary carefully to watch the process, at least until the action has ceased to be energetic.

*Sulphuretted hydrogen* is produced by the action of diluted sulphuric or muriatic acid on sulphuret of iron. As sulphuric acid forms a soluble salt with oxide of iron, and is less volatile than muriatic acid it is used in preference to the other in this process. The gas may be generated in an apparatus similar to that represented in fig. 187. If a long continued and slow evolution be desired, large pieces of the sulphuret, and very dilute acid should be employed; or if, on the other hand, it be wished to have a more rapid evolution, the sulphuret should be broken into small pieces, and a stronger acid used.

*In saturating water with this gas* it is desirable to have a brisk evolution of the gas. Distilled water should be employed, and this should be kept at a low temperature. The following is the best method of conducting the process. Into two stoppered bottles introduce the cold distilled water, so that they shall be one-third full. Pass the gas into one of these bottles until it is completely filled with it, the atmospheric air being displaced; then transfer the gas-delivering tube to the second bottle, and immediately close the mouth of the first and shake it for some time so as to bring the gas completely into contact with the water and promote its absorption. Meanwhile the second bottle will be filled with the gas, and the tube conveying it being again transferred to the other, this bottle with its contents is agitated until absorption is completed. In this way the process is repeated first with one bottle and then with the other, until it is found that no more gas is absorbed by the water. The saturated water is then put into small bottles which should be completely filled, well stopped, and kept, with the mouths inverted, in a vessel containing cold water.

*Sulphuret of ammonium* may be prepared and preserved in the same manner.

When sulphuretted hydrogen is used for precipitating a metal from a considerable quantity of liquid, the latter should be put into a large vessel, a carboy for instance, the capacity of which is three or four times greater than the volume of the liquid, and the gas having been rapidly passed into the vessel until atmospheric air is entirely displaced, the vessel is to be shaken so as to promote absorption. A further quantity of gas is then, again, to be introduced, and the agitation repeated, continuing this process until no further precipitation takes place.

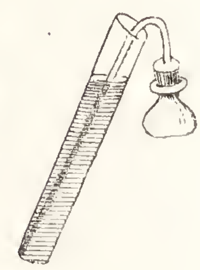
By operating in this way the decomposition is effected at a much smaller cost of time and materials than occurs when the gas is merely made to pass in bubbles through the liquid, for in this latter case much of the gas escapes without effect, while the liquid, in parts through which the bubbles do not pass, remains unacted upon unless it be brought into contact with the gas by agitation.

These remarks apply also to the process for preparing *hydriodic acid* by the action of sulphuretted hydrogen on iodine, and to that for the preparation of *hydrocyanic acid* from bicyanide of mercury according to Vauquelin's process.

When sulphuretted hydrogen is used as *a test*, a very small vial may be employed for generating the gas. A few fragments of sulphuret of iron being put into the vial, together with some diluted sulphuric acid, and a bent tube inserted through the cork, this little apparatus may be applied to the glass or tube containing the liquid to be tested, as shewn in figs. 191 and 192.

*Fig.* 191.

*Fig.* 192.



*Chlorine gas*, when prepared in small quantities, is usually obtained from a mixture of peroxide of manganese and muriatic acid. When prepared on the large scale, the mixture of peroxide of manganese, common salt, and oil of vitriol, is more frequently employed. The ingredients are put either into a flask (fig. 193), or a retort (fig. 194), to which heat can be applied by a lamp or charcoal fire. The gas ought to be purified, before using it, by passing it through water in a small wash-bottle, such as that shewn in fig. 187.

*Fig.* 193.

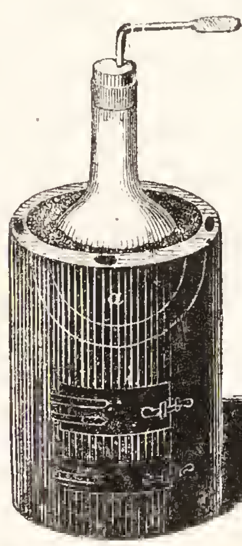
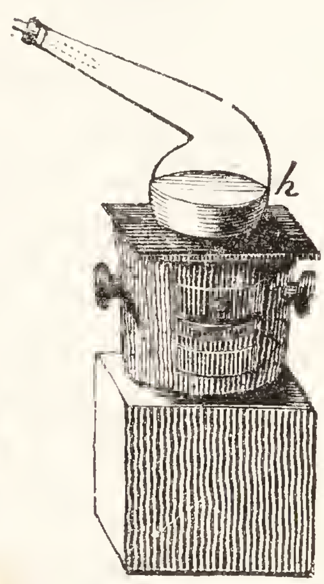


*Fig.* 194.




Apparatus for generating Chlorine.

The corks by which the tubes are fitted to the apparatus are generally much acted upon in this process, and there is, therefore, an advantage in making the connexions by means of caoutchouc, whenever this is practicable.

In making a saturated solution of chlorine in water, the best method of operating is that recommended in treating of sulphuretted hydrogen. Two bottles, each one third filled with water and the remaining space occupied with the gas, well shaken to promote absorption, and fresh gas added four or five times to supply the place of that which is absorbed, while the agitation is each time renewed, will afford a perfectly saturated solution of a greenish yellow colour. In no other way, even with the best Woulf's apparatus, can so strong a solution be obtained, although by the latter process more time and material are expended. Whoever has once prepared chlorine water in this way with two bottles, in less than a quarter of an hour, can but smile at the instructions given in some chemical works for using the complicated and expensive apparatus of Woulf, with its four bottles, twelve necks, and as many pierced corks and connecting and safety tubes. This philosophical toy is already going out of use. For gases which are easily absorbed, such as *ammonia* and *muriatic acid*, it is not required, and for gases which are not so readily absorbed, such as *chlorine*, *sulphuretted hydrogen*, and *carbonic acid*, it is inefficient, or, at least, is less efficient than the method above described. The last-named gases pass rapidly through the water in bubbles, the volumes of which are but little diminished in their passage, especially if the gases be mixed with any quantity of atmospheric air. It is only by extending and renewing the contact of the gas with the liquid, by shaking them well together, that complete absorption can be effected. A temperature of from 48° to 50° Fahr. is that at which water is capable of dissolving the largest quantity of chlorine.

Notwithstanding what has been stated above with reference to Woulf's apparatus, it may sometimes be found convenient to use one or more of the bottles of which it is composed, in operating on gases. When a gas has to be passed through more than one vessel, there is an advantage in using bottles which have separate openings for each tube. The corks which are fitted into these openings are common bottle corks, of which there is no difficulty in finding those of suitable size, and each cork has but one perforation. After using the apparatus, if it be dismounted, the corks should always be taken out and kept in a drawer until wanted again, for if left inserted in the bottles they lose much of their elasticity, and cease to form air-tight connexions.

Wide mouthed bottles, the corks of which admit of two or three tubes being passed through them, are sometimes substituted for the Woulf's bottles; but not only are the corks used in this arrangement more expensive in the first instance, but, if they be put away for subsequent use, they are not so easily refitted, on again mounting the apparatus, as would be the case with the smaller corks of the Woulf's arrangement. If the apparatus be not taken to pieces after using it, the corks should, at least, be taken out and left partially inserted or merely resting on the mouths of the bottles, so that they may remain in a fit state for being tightly inserted when subsequently required for use.

Fig. 195 represents a convenient method of mounting a Woulf's bottle. Into the widest mouth of the bottle a glass tube, the diameter of which is as large as the opening for its insertion will admit, is cemented by means of sealing-wax, so that its lower extremity shall reach nearly to the bottom of the vessel. This tube is intended to form a permanent fixture in the bottle. The gas-delivering tube (*a*), the end (*b*) of which is slightly bent, passes freely through the wider tube, and when placed as shewn in the

*a* *Fig.* 195.

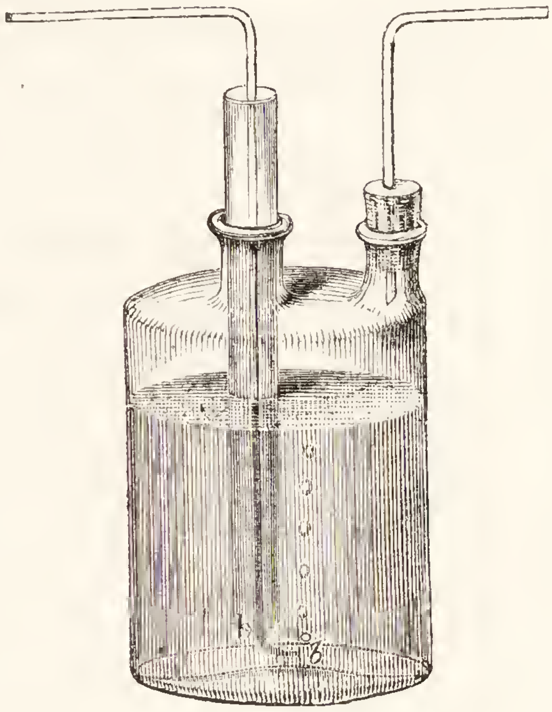
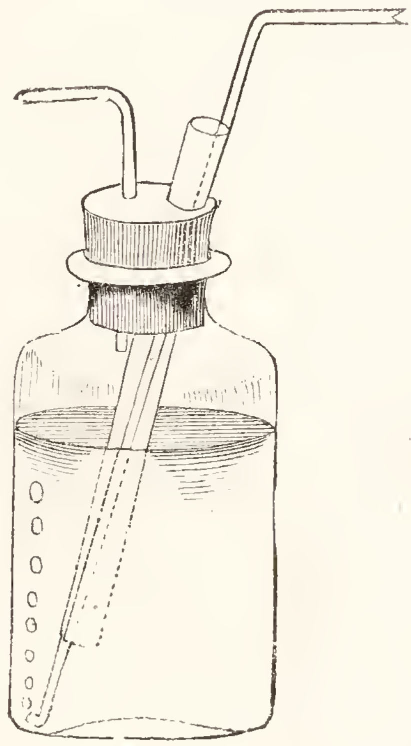



*Fig.* 196.



drawing, the bubbles of gas as they issue at *b* rise into the upper part of the bottle without any portion escaping. [The gas-delivering tube (*a*) may be larger in proportion to that through which it is inserted than the drawing represents, and it will then be unnecessary for it to be bent at the lower end, the impetus with which the gas is conveyed being sufficient to cause the bubbles to pass beyond the mouth of the outer tube.]

When a wide-mouthed bottle is used, the large tube may be fixed obliquely, as shewn in fig. 196, in which case the gas, under any circumstances, would rise into the bottle without escaping through the space between the two tubes.

In using apparatus such as figs. 195 and 196 for the condensation of gases, it is always desirable to have a safety-tube attached to some part of the arrangement. If this provision be not made there will be danger at the conclusion of the process, when the heat is withdrawn from the generating vessel, or from this or other cause, the evolution of gas has ceased or partly subsided, while at the same time the absorption proceeds, or contraction of the volume of the gas takes place in consequence of reduction of temperature, that the pressure of the atmosphere acting on the surface of the liquid in the absorption bottle, will force a portion of this liquid into the generating vessel.

The most simple arrangement of the *safety-tube* consists in the use of a straight tube passing through the cork and dipping into the liquid contained in the bottle. If there be but one absorption bottle, the safety-tube is attached to the generating vessel, as shewn in fig. 197, and it can then be used for supplying fresh liquid to promote further evolution of gas. When the pressure of the gas within the apparatus is greater than that of the atmospheric air, the liquid will be forced up this tube, and the length of the column thus sustained will indicate the amount of pressure within. On the other hand, should the pressure outside exceed that within, the liquid in the tube will be depressed below the level of that contained in the bottle, and on this depression reaching the bottom of the tube, atmospheric air will gain admission to the interior of the apparatus, and thus equalize the pressure.

*Fig.* 197.

*Fig.* 198.

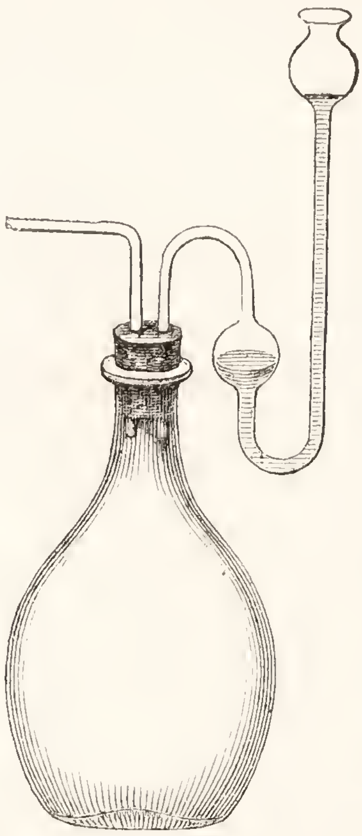


Fig. 198 represents a different arrangement, in which the tube is not made to dip into the liquid, but being bent in the manner represented, and furnished with a bulb in one of its short limbs, the liquid contained in this, when forced into the long limb, offers resistance to the escape of gas from within in proportion to the length of the sustained column, while, under different circumstances, air can gain admission from without, on its overcoming a pressure equal to the weight of a column the length of the short limb.

If there be any difficulty experienced in getting a bulb blown in the safety-tube, this may be obviated by substituting two tubes and a small bottle, arranged as shewn in fig. 199, which will answer the same purpose as the safety-tube (fig. 198).

Sometimes, instead of fixing the safety-tube to the generating or absorption bottle, it is attached to the gas-delivering tube, as shewn in fig. 200. This is called *Welter's safety-tube*. This arrangement is objectionable, inasmuch as there is some difficulty in uniting these tubes, and much danger of breaking them when used.

[When two or more bottles, such as fig. 195 or fig. 196, are united to form a condensing apparatus, with a separate vessel for generating the gas, the arrangement constitutes a *Woulf's apparatus*. It is customary to use three-necked bottles in this arrangement, each bottle, as well as the generating vessel, being furnished with a

*Fig.* 199.

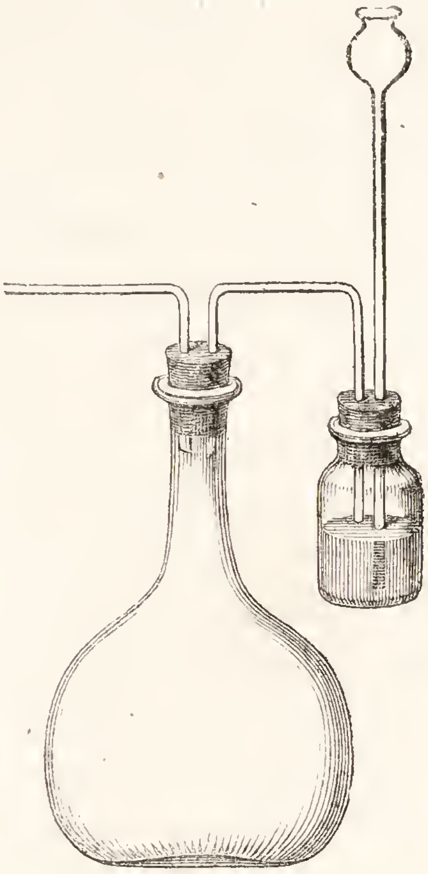
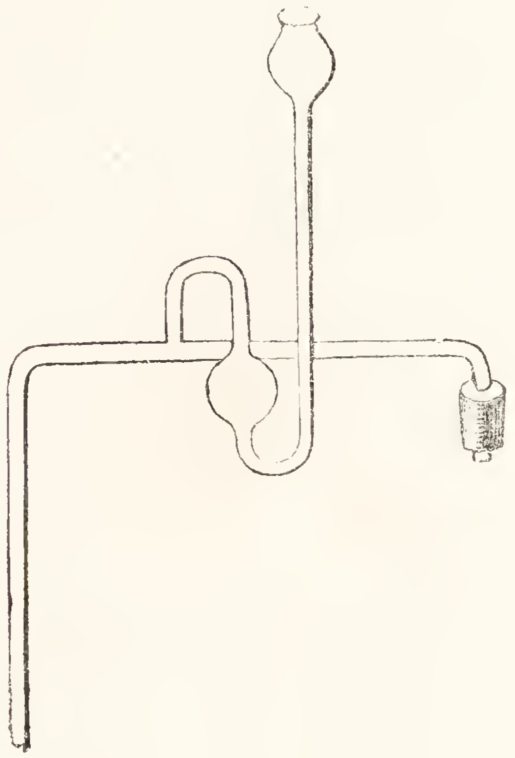
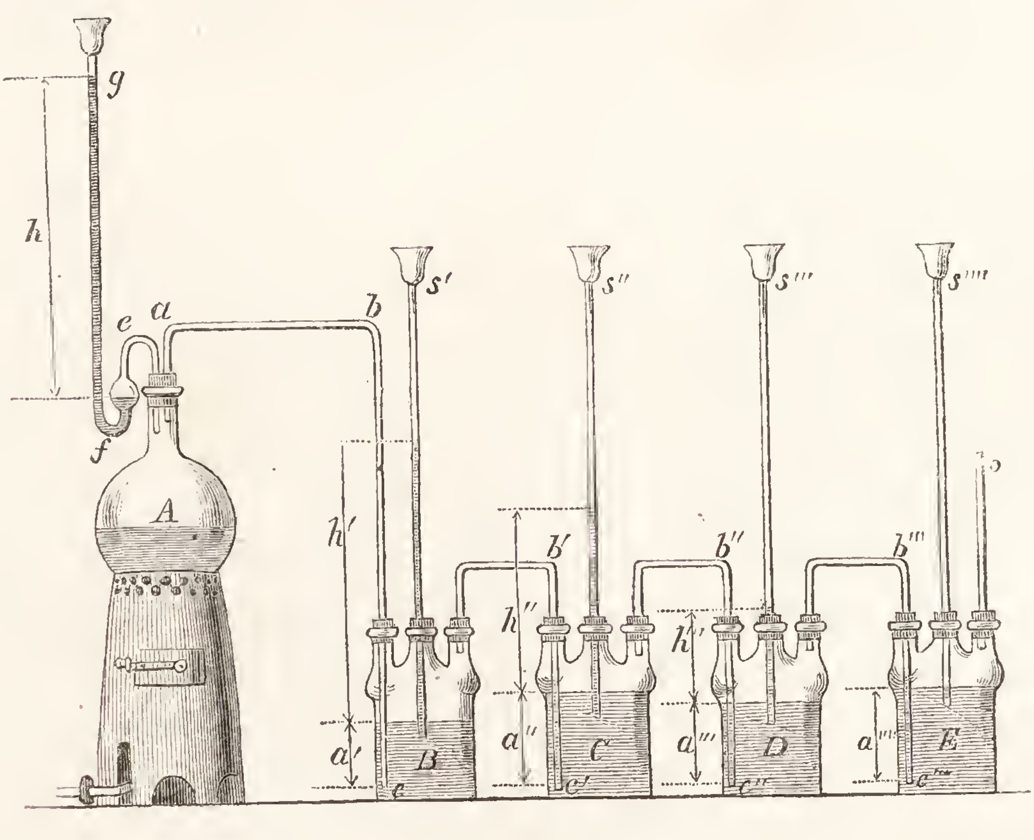


*Fig.* 200.



safety-tube, as shewn in figs. 201 and 202. A is the flask in which the gas is evolved, and B, C, D, E, the bottles for effecting the condensation of the gas.

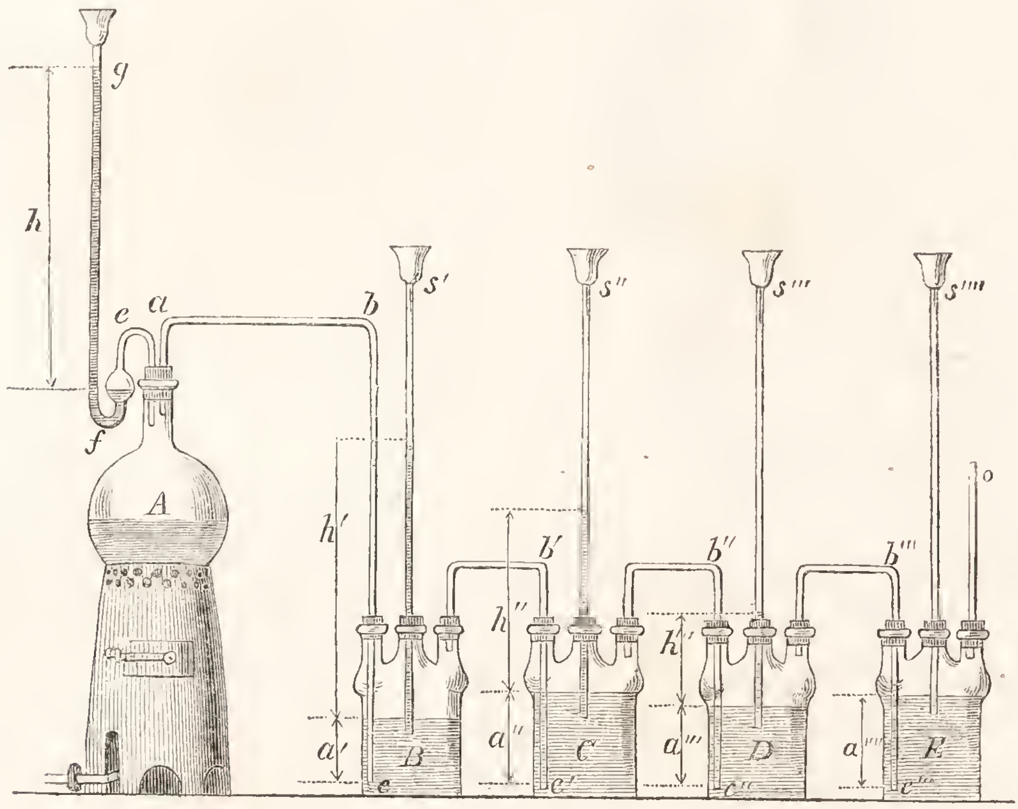
*Fig.* 201.




WOULF'S APPARATUS.

With the view of explaining the method of using the *Woulf's apparatus*, and the principle of its action, it will be well to describe what occurs in applying it for a specific purpose. This may be the preparation of bleaching liquor by passing chlorine gas through solution of potash or soda. A quantity of peroxide of manganese is put into the flask (A), which is fixed over the lamp furnace, and the alkaline solution is introduced into the bottles (B, C, D, E). The connexions being made tight, muriatic acid is poured into the tube (*g*), until it reaches to the top of the short limb (*f e*). It will now be observed that the acid stands at the same height in this tube in the limbs (*f e*, and *f g*). It will also be observed that

*Fig.* 202.




WOULF'S APPARATUS.

the liquid in the bottles (B, C, D, E), is at the same height within and without the tubes (S′, S″, S‴, S⁗). These conditions indicate that the air within the apparatus and the atmosphere on the outside have the same degree of tension. On pouring more acid into the tube (*g*), it will flow over the bend at *e* into the flask, and, coming into contact with the oxide of manganese, chlorine gas will be evolved, which, adding its elastic force to that of the air previously present, causes an increase of tension here, and this acting simultaneously on the acid in the tube (*g*), and on the liquid in the lower end of the tube (*b*), the former is forced partly out of the short limb (*f e*), into the long limb (*f g*), and the latter is depressed until the gas, reaching the open end (*c*) of the tube, escapes into the bottle (B). The gas, as it passes through the liquid in B, will be partly dissolved, and the remainder accumulating in the upper part of the bottle, will add its elastic force to that of the air previously present there. This increased tension will be exerted upon the surface of the liquid in the bottle (B), and within the tube ($b'$) in the bottle (C), while the surface of the liquid within the tube ($S'$) will bear only the pressure of the external air to which it is exposed; a portion of the liquid from B will, therefore, be forced up into the tube ($S'$), and the weight of the column thus supported will be equivalent to the increased tension of the gas in the upper part of B beyond that of the external air. There will also be a like difference between the tension of the gas in contact with the surface of the liquid in the tube ($b'$), and that of the air in the upper part of the bottle (C) into which none of the gas has yet entered, so that the liquid in the lower part of $b'$ will be depressed to a degree proportionate to this difference, and if the density of the liquids in B and C be equal, the depression of the liquid in $b'$ will be to the same extent as the elevation of the liquid in $S'$. The gas, accumulating in B will soon force the liquid out of $b'$, and escaping at $c'$, it will enter the bottle (C), where the same effect will be produced as in the previous bottle (B). From C the gas will pass into D; from thence into E, and any residue that may accumulate here will escape through the open tube into the atmosphere. When the gas has commenced issuing from the tube ($c'''$) into the bottle (E), it will be found that there will be a column of liquid supported in each of the tubes ($S'$, $S''$, and $S'''$), by the tension of the gas contained in the upper part of the bottles (B, C, and D). These columns of liquid will be of unequal lengths, the tension of the gas being different in each bottle. The liquid will not be elevated in the tube ($S''''$), because the gas in the bottle (E), having free means of escape into the atmosphere, will have the same tension only as the external air. The column of liquid $h'''$ in the tube $S'''$ will be equal to the column $a''''$; the column $h''$ in the tube $S''$, will be equal to $h''' + a'''$; the column $h'$ in the tube $S'$, will be equal to $h'' + a''$; and the column $h$ in the tube $g$, will be equal to $h' + a'$. Thus the columns of liquid in the safety-tubes indicate the degrees of tension of the gas in the bottles to which they are attached. The increased tension of the gas will tend to promote its solution, and this being greatest in the first bottle (B), the liquid in this bottle will become most saturated.

The objects contemplated in the adoption of this form of apparatus are, the application of pressure to promote the absorption of the gas, and the extension of contact by making the gas pass through several successive quantities of the liquid.

If, in conducting the process under notice, the evolution of chlorine in the flask (A) should become suspended before the alkaline solution has been fully saturated, the absorption of the gas in the bottles still proceeding, or contraction of volume in the gas contained in the flask being caused by a reduction of temperature, the tension of the gaseous contents of the bottles and flask may become less than that of the external air. In this case the columns of liquid in the safety-tubes will entirely subside, and atmospheric air will enter the bottles through these tubes as soon as the tension of the external air exceeds that of the gas within to an extent equivalent to the weight of a column of the liquid the length of the immersed ends of the tubes. It is thus that these tubes act as safety-tubes, for without this provision the pressure of the external air on the surface of the liquid in the bottle (E) would force the liquid through the tubes $b'''$, $b''$, $b'$, and finally through $b$, into the flask, thus causing a loss of part of the product of the process.

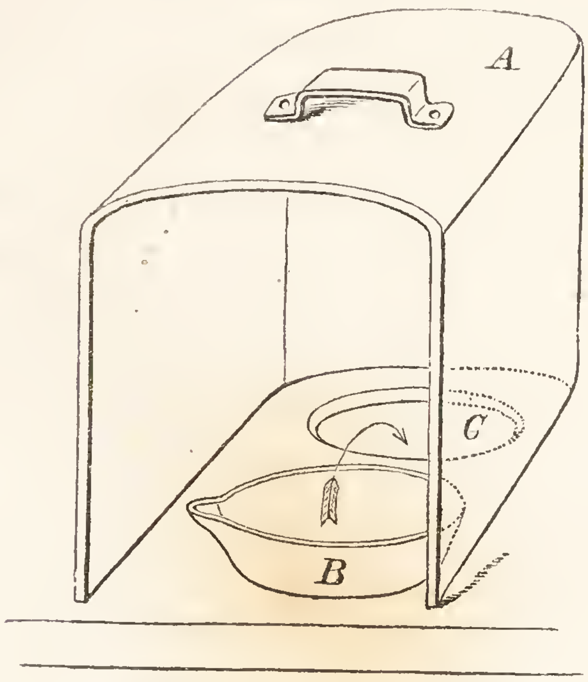
In conducting operations with gases of a noxious character, such as chlorine and sulphuretted hydrogen, it is desirable to avoid as much as possible the escape of the gas into the apartment in which the process is performed. This may be readily done with a Woulf's apparatus by lengthening the tube ($o$), and conveying the excess of gas beyond that which is dissolved or decomposed into a chimney or other means of escape.

I have found the most effectual method of getting rid of chlorine and sulphuretted hydrogen, both of which are much heavier than atmospheric air, to consist in conveying them into the drain. This method is adopted in the laboratory of the Pharmaceutical Society, and it has been found most effectual. All analytical processes involving the use of sulphuretted hydrogen are conducted in an air-tight closet with glass doors, from which the surplus gas is conveyed through a pipe, four inches in diameter, into the drain.

There are some processes in which gases are evolved without any view to their subsequent condensation, and when these gases are of a noxious character it is important to prevent their contaminating the atmosphere of the laboratory. Gases of this description are disengaged during the solution of metals in nitric acid, and also in the action of oil of vitriol on some metals, such as copper and mercury. The application of heat is frequently required in these processes, and the means adopted for getting rid of the gases should, therefore, be reconcileable with this condition.

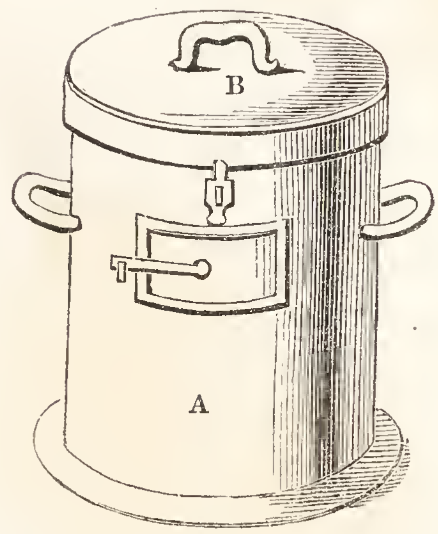
*The furnace hood*, the use of which has been already alluded to, affords convenient and efficient means for accomplishing the object contemplated. Figs. 203 and 204, represent two different kinds of *furnace hood*, which are used in the laboratory of the Pharmaceutical Society, Fig. 203, has been already described at page 8. Fig. 204 is a more complicated and expensive apparatus, but it is more efficient than the other, especially if there be not a good draught to the furnace. A, fig. 204, is a cylinder fourteen inches

*Fig.* 203.




FURNACE HOOD.

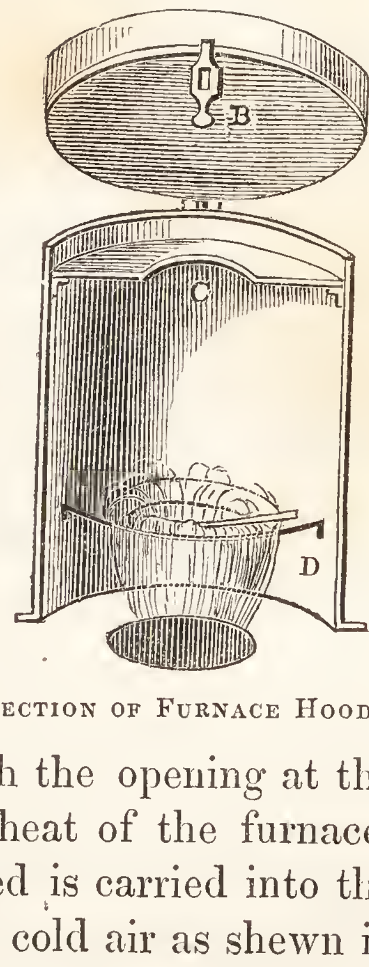
*Fig.* 204.




FURNACE HOOD.

in diameter, and eighteen inches high, made of galvanized iron, painted; it is open at the bottom, furnished with two handles attached to the sides, and one to the centre of the lid, and a door as shewn in the drawing. Fig. 205, shews a section of the apparatus, with the lid partly raised. Immediately under the lid there is a moveable plate (C), which rests on a ledge, and has a circular hole, six inches in diameter, in the centre. About four inches from the bottom there is a ring six inches in diameter, attached by three supports to the sides of the cylinder, as seen at D. The section (fig. 205) represents the apparatus in use, placed over the open mouth of a ring-topped furnace. The lid being opened, and the plate (C) removed, a Wedgewood's dish, or other similar vessel, is introduced at the top, and placed on the ring (D); the plate (C) is now returned to its place, and the ingredients to be operated upon put into the dish through the door, or through the opening at the top. The dish is, of course, exposed to the heat of the furnace, and any gas or vapour which may be disengaged is carried into the furnace by the pressure of the superincumbent cold air as shewn in the drawing.]

*Fig.* 205.




SECTION OF FURNACE HOOD.

## SUBLIMATION.

The process of sublimation resembles that of distillation, in being generally adopted with a view to the separation of unequally volatile substances, the more volatile of which is first converted into vapour by the application of heat, and then condensed in a part of the apparatus in which it can be conveniently collected. The two processes, however, differ essentially in this, that distillation is applied to the elimination of products which are liquid, and sublimation to that of those which are solid.

Most medicinal substances which are prepared by sublimation, are invariably made on the large scale, by wholesale manufacturers. Of this class, are salammoniac, carbonate of ammonia, corrosive sublimate, cinnabar, and flowers of sulphur, which are never prepared in the pharmaceutical laboratory. Cases do occur, however, in which the pharmaceutist has occasion to resort to the process of sublimation, and some explanation must, therefore, be given of the apparatus to be used, and the arrangements generally adopted.

Benzoic acid and calomel are selected, as substances, the preparation of which by sublimation, will comprise those details which will be most practically useful to the pharmaceutist.

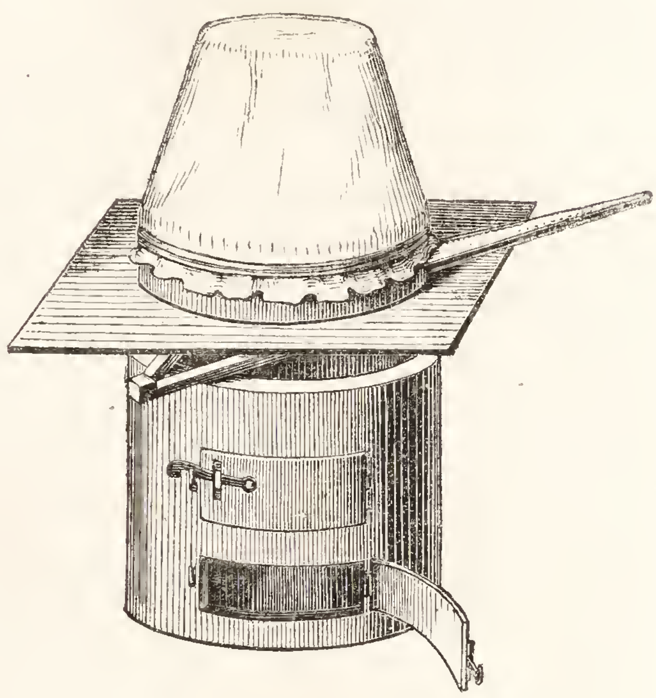
*Sublimed benzoic acid* is prepared from the resinous substance commonly called *gum benzoin*. The method formerly adopted for subliming the acid, was to put the benzoin, in powder, into a Hessian crucible, and to invert a paper bag over the mouth of the crucible, while heat was applied in any suitable manner. In operating in this way, much of the acid was lost in consequence of the vapours passing through the paper and escaping; there was also considerable loss from decomposition of the acid by the strong heat which was required to drive the vapours through the thick cake of resin at the bottom of the crucible. The product in benzoic acid was, therefore, less than it ought to be, while an increased quantity of empyreumatic oil, resulting from decomposition by heat, was at the same time formed, which tended to contaminate the sublimed acid.

Many years ago I introduced, and published an account of, a subliming apparatus, in the use of which the evils above alluded to are avoided. This apparatus has been extensively employed, and experience has established it in the estimation of practical men.

The subliming vessel consists of a shallow cast-iron pot or pan, about eight inches in diameter and two inches deep. The bottom is perfectly flat and the sides perpendicular. The benzoin, in coarse powder, is spread over the bottom of this pot to the thickness of about half an inch or rather more, and a sheet of filtering paper is then stretched over the top, and secured there by pasting it to the sides of the vessel. Over this is fitted a paper cap made of thick packing paper, joined together with paste, and standing about as high as a man's hat. The cap is secured on by tying it with strong cord.

The apparatus, thus prepared, is placed on a sheet of iron, with a layer of sand intervening, over a slow fire. The whole arrangement is represented in fig. 206. The fire should be kept up at as uniform a temperature as possible, for three or four hours, during which time the paper cap must not be allowed to become very hot, nor the vapours to escape at the junctures. Should such occur, it would be necessary to lower the fire. Finally, the fire is to be allowed to go out, and the apparatus to cool before removing it from the stove. On untying the string and carefully raising the cap, the benzoic acid will be found in the upper part of it in large shining crystals, the groups of which are sometimes so beautiful that it causes some regret to remove them. After taking off the bibulous paper from the top of the iron pot, the fused resin is to be cut out, coarsely powdered in a mortar, then replaced, and the apparatus fitted up as before, and submitted again to the heating process. A second crop of crystals of inferior quality will be thus obtained. Even after this, a still further product may be got by boiling the residue with lime and water, according to Scheele's method, but the properties of the precipitated acid render it unfit for use in medicine.

*Fig. 206.*

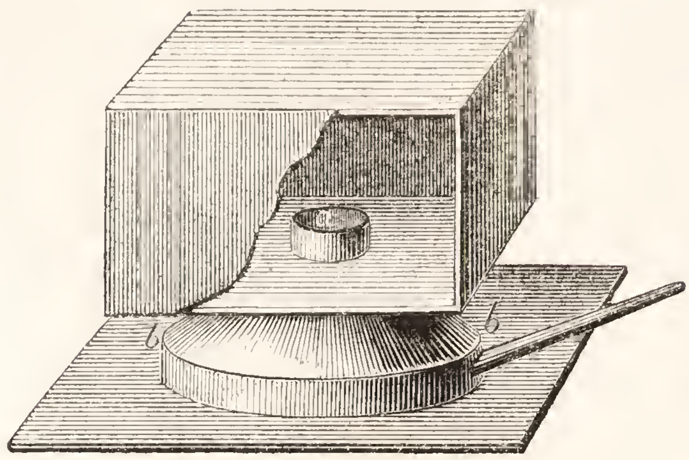


APPARATUS FOR SUBLIMING BENZOIC ACID.

Fig. 207 represents a slight modification of the apparatus above described, the object here being, more completely to ensure the condensation of the vapours.

In the first place, a funnel-shaped cover, made of sheet iron, is placed over the top of the pot, and fastened on with linseed-meal luting. This inverted funnel has a cylindrical top ($a$), about three inches in diameter, which fits into a square box of pasteboard or wood. A piece of fine muslin is stretched over the mouth of the cylinder, and the process, in other respects, is conducted as already described. The box, in this form of the apparatus, is better protected from the heat than the paper cap in that previously noticed, the air in the space (*b b*) being constantly renewed as it becomes heated. If the box be made of wood, it may be provided with a sliding cover at the top, which will readily admit of the removal of the sublimed product.

*Fig.* 207.




Apparatus for Subliming Benzoic Acid.

About $12\frac{1}{2}$ per cent. of benzoic acid may be obtained from the best benzoin by this process. The product, obtained by precipitation, is greater, but is not suitable for medicinal use.

*The sublimation of calomel* is a process which is frequently conducted (in Germany) in pharmaceutical laboratories. The process formerly adopted by most of those who made it for their own consumption, consisted in first rubbing together four parts of corrosive sublimate and three parts of mercury; the grey powder thus formed was then put into small glass phials in which the sublimation was effected. This method of conducting the process was, however, subject to many objections. The calomel being sublimed in a crust on to the upper part of the phials, it was necessary to break the bottles in order to remove the products. The process, therefore, involved much breakage of glass, and splinters of glass sometimes got mixed with the calomel. The product was also generally contaminated with a little uncombined mercury, and sometimes, from the cylindrical form of the subliming vessel the ingredients, instead of being volatilized, were forced up in a solid mass, to the top of the phial, by the tension of the vapour formed at the bottom. Hence it became necessary, if phials were used, that they should not be perfectly cylindrical, or of equal diameters throughout their whole length.

The mixture of four parts, by weight, of corrosive sublimate, and three parts of mercury, is very nearly in equivalent proportions, the former ingredient being slightly in excess; yet on submitting the mixture to sublimation, some globules of mercury will be found in the portion that first sublimes. This result arises from the difficulty of effecting so intimate a mixture of the ingredients as to ensure complete combination on the application of heat. It was customary to remedy this defect by submitting the product to repeated sublimations, until no globules of mercury could be detected.

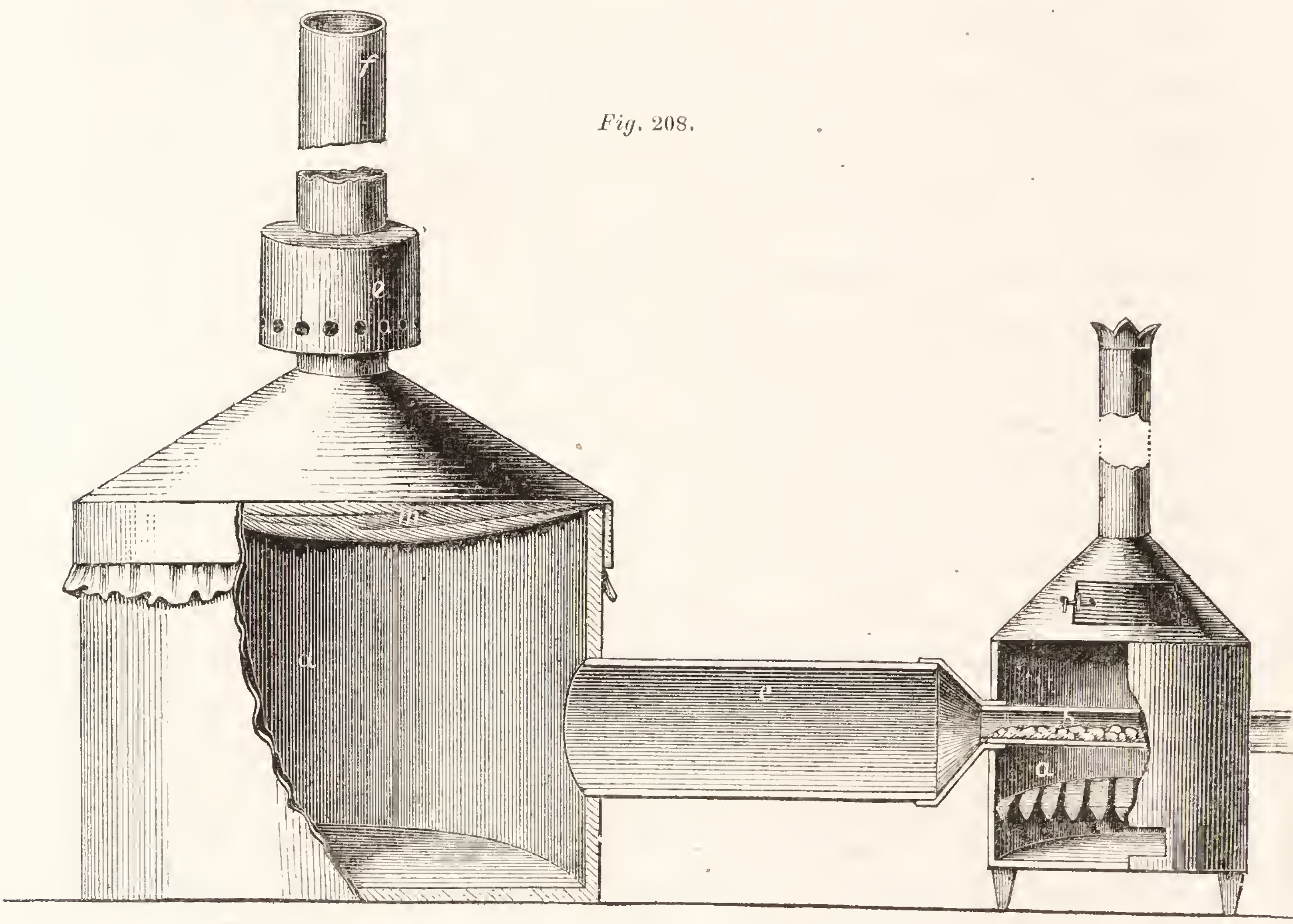
I have proposed a modification of the foregoing process, in which the formation of the calomel is completed, before the sublimation is commenced. I use rather more than three parts of mercury to every four parts of corrosive sublimate—say thirty-one parts of the former to forty parts of the latter; these are rubbed in a mortar, with the addition from time to time of a little rectified spirit, until an impalpable grey powder is produced. Water may be substituted for spirit in this part of the process, but does not answer so well, as it is necessary that the powder should be thoroughly dried, by exposure to the air, before submitting it to the next operation. The dry powder is put into a shallow vessel, of enamelled cast-iron, or Wedgewood's ware, covered with a heavy cast-iron lid, and exposed to the heat of a sand-bath. Under these circumstances the colour soon begins to change from grey to yellow as combination takes place, and this change gradually extends throughout the whole mass. At the same time any uncombined mercury will be sublimed and condensed on to the iron cover, the heat being so regulated that it shall be sufficient to volatilize the mercury, but not the calomel. When the combination is completed, which is known from the uniform yellowish colour of the powder, the globules of mercury adhering to the cover are carefully brushed off with a feather, and collected for subsequent use; and the powder is submitted to sublimation in any convenient apparatus. One sublimation will in this case be sufficient, the product being pure calomel. If the sublimation be effected in vessels of small capacity, the calomel will be obtained in a crystalline condition, and must be reduced to an impalpable powder, by careful trituration and elutriation before being used.

Calomel may be obtained at once in a state of minute division, by adopting the process of precipitation; but the product of this process is considered to differ in its medicinal action from that obtained by sublimation. Several methods have been tried for producing sublimed calomel in a state of division similar to that of the precipitated powder. A process for this purpose has been described by Mr. Henry, of Paris, which consists in condensing the vapour of the calomel in a vessel filled with steam, by which means an impalpable powder is produced.

[This process was invented by Mr. Joseph Jewell, of the firm of Howard and Company, manufacturing chemists, of Stratford, near London.] There are, however, some practical difficulties in the adoption of this process, and other means have been since discovered by which a similar result is more easily obtained.

The following process fulfils the desired object satisfactorily. The calomel is first prepared in the manner already described, by heating the mixture of corrosive sublimate and mercury until combination has been effected. It is then sublimed in the apparatus of which a representation is given in fig. 208. An earthen tube

*Fig.* 208.




Apparatus for subliming Calomel.

(*b*), about two inches and a quarter in diameter, and ten or twelve inches long, is fixed across a small iron furnace. This tube should be made of a mixture of fire-clay and sand, capable of bearing the action of a dull red heat, without cracking. To one end of it an earthen plug or stopper is fitted, through which passes a pipe connected with a bellows. To the other end, a tube (*c*), of much larger diameter, is attached, which communicates with a wooden box (*d*). The inside of this box is lined with glazed paper, and over the top of it a cloth (*m*) is stretched, which is secured in its place by a sheet iron funnel forming the top of the box. The funnel is terminated by a pipe (*f*), three or four inches in diameter, and about three feet long. Around this pipe there is a small iron corridor for the reception of ignited charcoal.

In conducting the process of sublimation with this apparatus, the calomel is introduced into the pipe (*b*), and fires are kindled in the furnace (*a*), and in the corridor (*e*). When the vapours of calomel begin to be formed a current of air is forced through the pipe by means of a double bellows, or centrifugal blower, which, mixing with the vapour, carries it into the box (*d*), while at the same time the vapour is condensed, and its further progress is arrested by the cloth (*m*). When the tube (*f*) gets well heated, there may be sufficient draught through the apparatus without using the bellows, in which case the plug must be removed from the mouth of the tube (*b*), and the process can then be maintained uninterruptedly for a great length of time, fresh portions of the powder being introduced into the tube as the sublimation proceeds.

[It is not necessary in this process to have a current of air passing through the apparatus, provided that the vessel or chamber into which the vapours are conducted be of ample size, so that by the admixture of a large quantity of cool air condensation may be speedily effected. In fact, the condition of the products obtained by sublimation are always influenced by the size and position of the receiver in which the vapours are condensed. If the receiver be small, and if it be immediately contiguous to the vessel from which the substance is sublimed, the product will assume a crystalline condition, the temperature being such as to admit of the slow and regular aggregation of the particles. If, on the other hand, the receiver be large, or if, from its position, the air within it be kept cool, the sublimed product will assume a more or less amorphous condition, the condensation being so rapid that no symmetrical arrangement of the particles can take place.]

## FILTRATION.

[*The process of filtration* consists in the separation of liquids from substances held by them in suspension, by causing the former to pass through the pores of media which are impervious to the latter. When the solid matter to be removed is a powder which subsides on standing, this is called a *precipitate*, and the liquid separated by filtration is called the *filtrate*. In some cases, filtration is adopted merely for the purpose of rendering turbid liquids clear and transparent, the substances collected on the filter being rejected; in other cases, the object of the process is to collect and preserve the substance which remains on the filter, while the liquid is thrown away; in other instances again, the preservation of both precipitate and filtrate is desired. The materials employed as filtering media, when prepared for use, are called *filters*. These materials are of different kinds, some being organic, such as cloths of linen, cotton, or wool, and paper made of these materials, while others are inorganic, such as sand, pounded glass, asbestos, rock crystal, and charcoal.

Filtering media may, therefore, be divided into two classes, the *organic* and the *inorganic*. The organic media may, again, be divided into those which are of *vegetable*, and those which are of *animal* origin. Besides these distinctions, there is another frequently made, although not always admitted, which is founded on the greater or lesser porousness of the filtering material. Thus, cloth filters are more porous, and offer less obstruction to the passage of any solid particles, than paper filters. Cloth filters, therefore, are generally used in those cases where the solid particles to be removed are not very finely divided, or where their complete separation is not an object of much importance, while, at the same time, rapid filtration is required. The process thus conducted is sometimes called *straining*, but it differs not essentially from those processes which, being conducted with less porous media, are, in such cases, distinguished as *filtering*.

The substances used as filtering media are :—

*Woollen cloth* or *flannel*, which may be of different degrees of thickness and of closeness of texture.

*Calico*, or other fabric of cotton. There is a material of this kind called *swans-down*, which is used in some cases where fine straining is required.

*Linen*, or other fabric of flax or hemp.

*Filtering paper*, of which there are a great many different kinds, but they may all be classed under two heads :—

1. Filtering paper made from cotton or linen rags. This constitutes the thinner and whiter kinds of filtering paper.

2. Filtering paper made from woollen materials. This constitutes the thicker and coarser kinds of filtering paper. It is more porous than the other, and is used for rapid filtration.

There is often some difficulty experienced in getting filtering paper of good quality. It should be easily permeated by the liquids to be filtered, without allowing any solid particles to pass through. It should present a tolerably smooth surface, so that any precipitate collected on it, might be easily removed, and not absorbed into the pores. It should also be strong enough to support the weight of the substance filtered, when placed in a funnel, without breaking. Moreover, it should contain nothing that is soluble in the liquids to be filtered.

*Sand.*—This should be rather large-grained, and perfectly free from organic matter. It should be purified by washing it with diluted hydrochloric acid, and subsequently with water.

*Powdered glass*, consisting of common wine-bottle glass, reduced to coarse powder in an iron mortar, sorted by the use of sieves of different degrees of fineness, and then washed with diluted acid and water.

*Powdered rock crystal*, prepared in the same way as the glass, from chippings formed in cutting spectacle glasses, or from other fragments of rock crystal. It is preferable to either sand or glass, being less readily acted on by the liquids in the filtration of which it is used. It should be prepared ready for use, reduced to different degrees of comminution, and each kind kept separately.

*Asbestos*, in the fibrous state, which has been purified by heating it to redness, and then washing it with diluted acid and water.

*Animal charcoal*, in rough grains, resembling very coarse gunpowder. This is made on the large scale by manufacturers who supply the sugar refiners.

These substances cannot be indiscriminately used in all processes of filtration. It is necessary to make a selection of a suitable material in each process, and some judgment is required in determining what kind of filter is best adapted for the substance under operation.

*Woollen cloth* is suitable for filtering a great number of substances employed in medicine. The filters used for syrups and for many aqueous decoctions, and expressed vegetable juices are made of this material. This is also the proper material to employ for straining plasters and ointments, or any substances of an oily nature.

Woollen material, whether in the form of cloth, such as flannel, or in that of paper, is inapplicable for the filtration of alkaline solutions, which exert a solvent action on the wool.

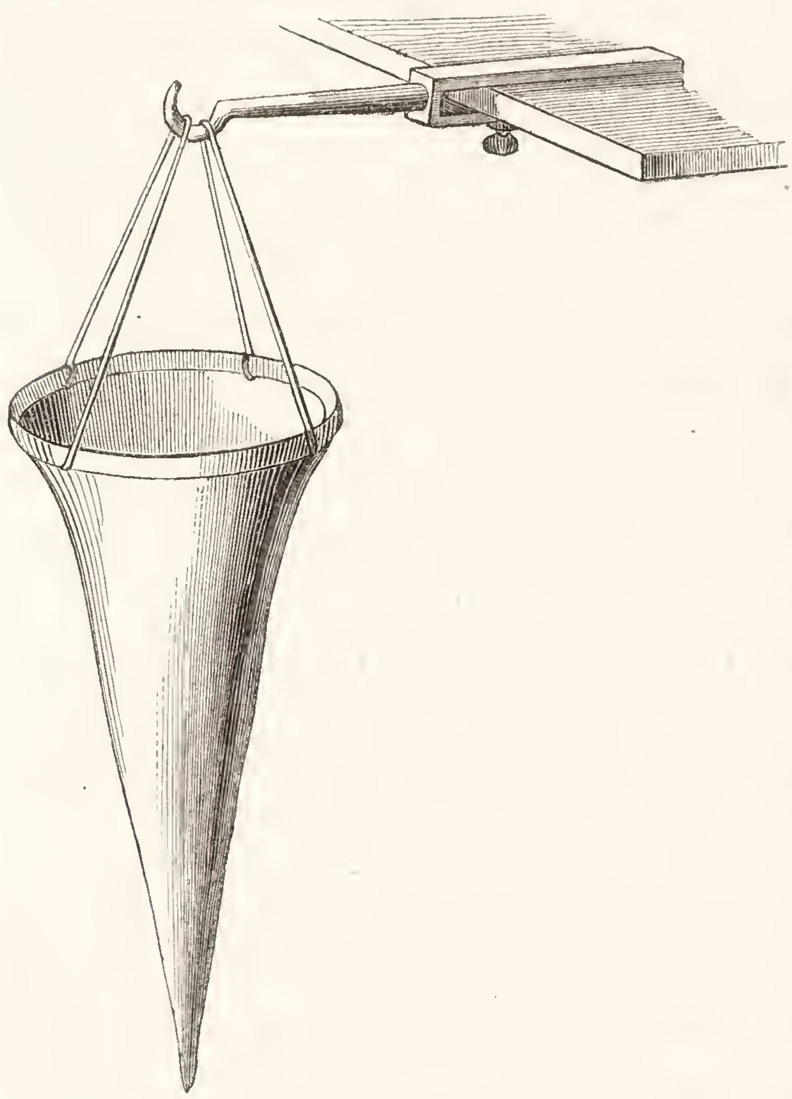
*Linen and cotton cloths*, and *paper made of these materials*, are used in a great variety of cases. They may be employed for the filtration of alkaline solutions, especially linen, which answers the purpose best. Linen or cotton cloths are also generally used for collecting and washing precipitates, where the quantities operated on are considerable. The paper of this kind is perhaps most suitable for the filtration of alcoholic and ethereal solutions. Tinctures, however, are frequently filtered through the coarse paper made from woollen materials.

*Sand*, *Powdered glass*, *Rock crystal*, and *Asbestos*, are employed in the filtration of strong alkaline or acid solutions, which would exercise a chemical action on organic filtering media.

*Animal charcoal*, is used in those cases only, where, in addition to the removal of solid particles, it is desired to deprive the liquid of certain constituents, held in solution, which give to it colour or smell.

The method of constructing a filter, and the arrangements adopted in using it, must depend on the nature of the filtering medium used, and on the particular object contemplated in the process to which it is applied.

*Fig.* 209.

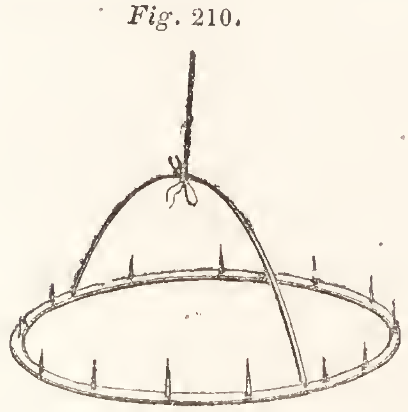


Conical Filter-bag.

*Cloth filters* are, in general, either made in the form of a conical bag, called the filter-bag, sometimes, also, called Hippocrates' sleeve, or they are constructed by loosely attaching the material to a square frame.

The *filter-bag*, or *Hippocrates' sleeve* (fig. 209), is the most useful kind of filter for pharmaceutical purposes. It may be made of flannel, cotton, or linen, which is formed into a conical bag with a wide hem around the top, into which a hoop of whalebone, wood, or wire, is put, to keep the mouth of the bag distended. When used, it is suspended by strings from any suitable support, as shewn in the drawing, a vessel being placed beneath it, to receive the filtered liquor.

*Fig.* 210.



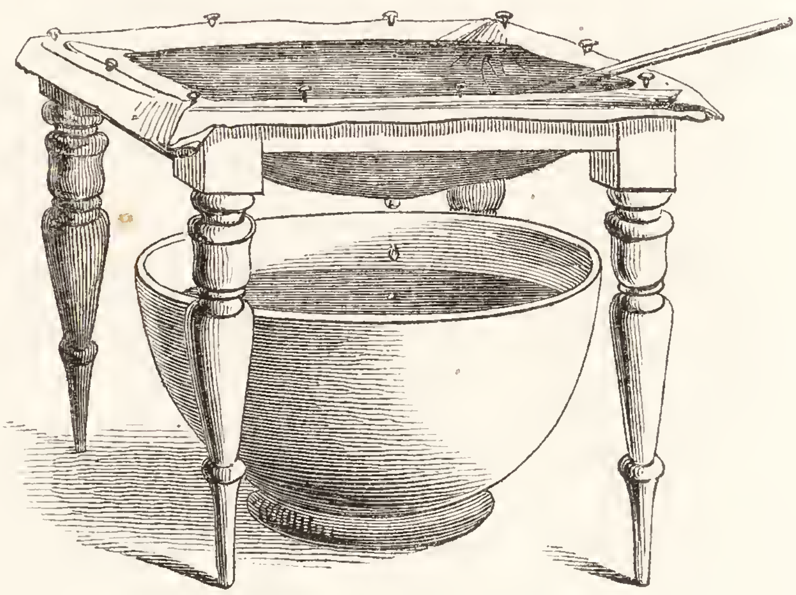
The principal inconvenience experienced with reference to this filter, consists in the difficulty of cleansing it by washing, while the hoop remains attached to it.

This inconvenience may be obviated, if the hoop be of wire, by having an opening in the hem to admit of its removal and reintroduction; or, instead of a hem, the bag may have strings by which to attach it to the hoop. In some cases a metallic ring (fig. 210) is used, which is furnished with a number of spikes over which the bag is temporarily fixed.

Liquids generally filter with great facility through this bag; indeed, there is no kind of filter that I am acquainted with, through which liquids, that are filtered with difficulty, pass more readily than they do through this, if a proper selection be made of the material of which the bag is made.

The other form of cloth filter usually adopted, is represented in fig. 211. The cloth is attached by means of nails to the top of the square frame, in such a manner that, on pouring the substance to be filtered on to it, the surface of the filter forms a concavity for the reception of the liquid.

*Fig.* 211.

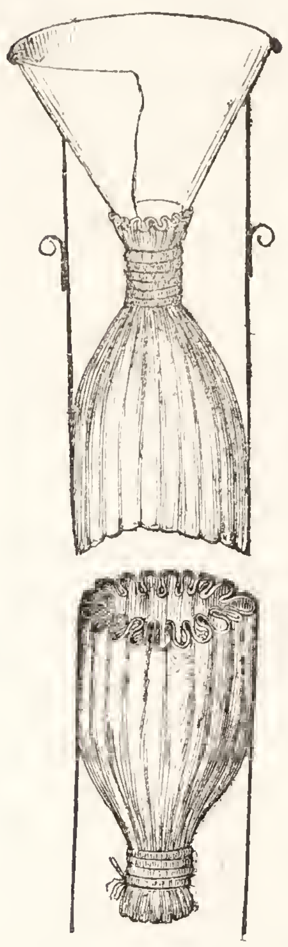


FRAME-FILTER.

This form of filter is convenient, and is generally adopted, where the object of the process is to collect and wash a precipitate. In such case a glass rod or stick is advantageously employed to stir the precipitate and break down any masses into which the particles may have aggregated, while the process of washing is continued. Liquids do not pass through this filter so readily as they do through the conical bag, nor is the filtered liquid obtained by it so clear. Its use, therefore, is principally confined to the washing of bulky precipitates. When the precipitate has been sufficiently washed, it is allowed to drain as long as any liquid continues to drop from it, and then, the nails by which the filter is secured to the frame being removed, the ends of the cloth are gathered together in the hand of the operator, so as to squeeze the precipitate into a globular mass, and press out a further portion of liquid from it. A string is now tied round the filter to retain it in the form which has been given to it, and it may be hung by this string in any suitable place to dry.

*Taylor's filter*, fig. 212, is sometimes used where large quantities of liquid are operated upon, as, for instance, in the filtration of oils, and of syrups in the process of sugar refining. It is not commonly employed in pharmaceutical laboratories, but there are some cases in which it might, perhaps, be used with advantage. The filter is usually made of twilled cotton, which is sewn so as to form a cylinder open at both ends, ten or twelve inches in diameter, and six or eight feet or more in length. It is gathered up into plaits and securely tied with a strong cord at the bottom, as represented in the drawing. The top is also gathered into plaits, and these are tied around the neck of a funnel, the lower end of which should have a rim to prevent the bag when heavily laden from slipping off. The filter, thus arranged, is covered with a case just large enough to receive it, which may be made of tin-plate, or of coarse canvas. If a tin-plate case be employed, the funnel will rest on its upper rim, which will thus form a support for the bag; and the whole apparatus may be suspended from the ceiling by cords attached to hooks on the outside of the case.

*Fig.* 212.



Taylor's Filter.

These filters, as used by sugar refiners, and other operators on the large scale, have a small funnel-shaped tube inserted in the mouth of the bag, which tube is screwed into the bottom of a large box or trough capable of thus receiving a great number of such filters, all of which are simultaneously supplied with liquid from the trough.

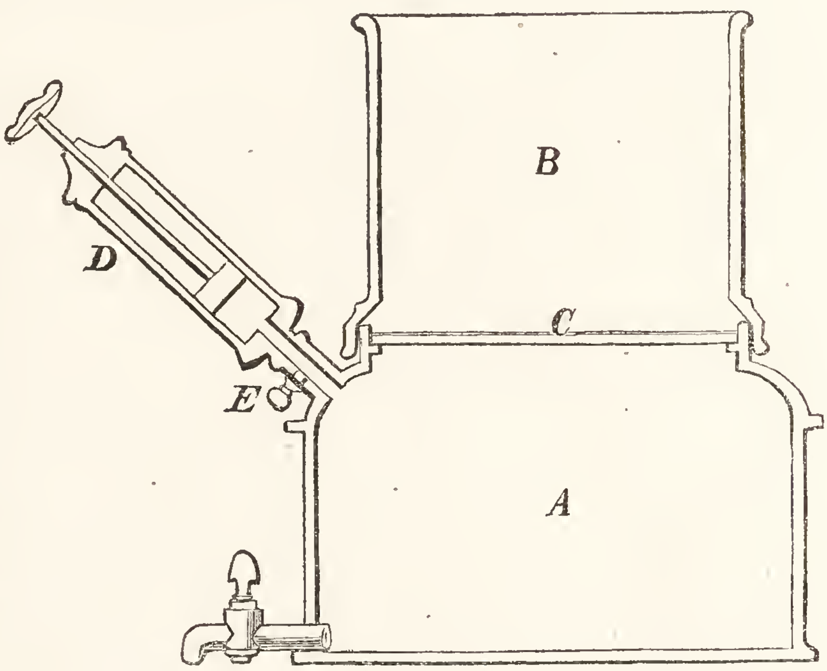
The advantages resulting from the use of these filters are ascribed to the following causes:—

In the first place, the metallic case prevents evaporation and loss of heat, consequently the liquid retains the fluidity imparted to it by heat for a long time; secondly, the outer case prevents the filter-bag from expanding to its full diameter, and therefore a given quantity of liquid forms a longer column than would otherwise be the case, so that the hydrostatic pressure is increased; finally, there is a large surface of filtering medium with which the liquid is in contact, and as any deposit from the liquid collects at the bottom of the bag, there is but little obstruction offered to the filtration from the accumulation of solid particles over the surface of the filter.

It not unfrequently happens, in pharmaceutical processes, that much difficulty is experienced in the filtration of liquids, some of which, especially if they be thick and mucilaginous, will not pass through the filter. Hence, it has been a desideratum to discover a method of facilitating filtration in such cases, and the *vacuum filter* was represented to be capable of fulfilling this object.

Fig. 213 represents the *vacuum filter.* The vessel A is furnished with a stop-cock, near the bottom, and an exhausting syringe (D) is attached to the upper part of it. A strong perforated disk rests on a ledge within the mouth of the vessel, and forms a mechanical support for the cloth or other filtering medium which is stretched over its surface, and, extending to the outside of the rim, is secured in its place by the cylinder (B), the bottom of which fits over it, and forms a water-tight joint. The apparatus, thus connected, consists of two compartments, A and B, with the filtering material forming a diaphragm (C) between them. The liquid to be filtered is poured into B, and air removed from A by means of the syringe. The liquid is thus made to bear the pressure of the external atmosphere, which forces it through the filter into the vessel below.

*Fig.* 213.



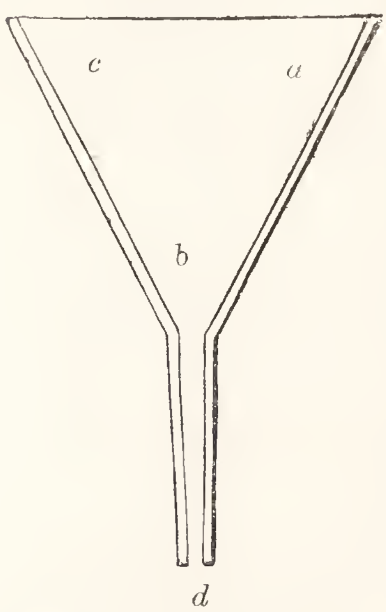

VACUUM FILTER.

The advantages that were anticipated from the use of this filter have not been fully realized, for although it expedites the filtration of substances which pass with tolerable facility, but not very rapidly, through a common filter, yet it has been found to afford little or no advantage in the filtration of liquids which will not pass through a common filter. When these latter are put into the vacuum filter, and the lower chamber is exhausted, the pressure of the atmosphere, instead of forcing the liquid through the filter, causes minute bubbles of air to pass through the liquid and thus enter the exhausted chamber.

*Paper filters* are employed for all the most delicate operations of filtering. They effect a more complete separation of solid particles from the liquids operated upon than is commonly effected by cloth filters, the pores of the paper being generally more minute than those of cloth. The paper used for filtering is made expressly for the purpose, and is called *filtering paper.* A filter made of this material is never used for more than one operation. It is too fragile to admit of its being purified by washing, after having been once used, and the small cost of the material renders its frequent renewal a matter of little consideration. The necessity for taking a new filter for every process, constitutes, indeed, one of the advantages resulting from the use of paper filters, as it ensures the absence of impurities from any previous process. It is important, however, to make a selection of paper suitable for the purpose to which it is applied.

The paper filter, when used, is generally placed in a funnel, which forms a convenient support for it. The funnels thus employed are made of glass or of earthenware; they should have the form represented in fig. 214, the sides (*a*, *b*, and *c*, *b*,) being straight, and the line (*a*, *b*, *d*,) forming an angle at *b*. In a section, as shewn in the drawing, the lines (*a*, *b*, *c*, and *a*, *c*, *b*,) should form angles of 60°, making an equilateral triangle. This form will be found best adapted for the reception of the filter as usually constructed.

*Fig.* 214.




WELL-FORMED FUNNEL.

The funnel may be supported by placing it with the tube inserted into the mouth of a bottle, on the lip of which the funnel rests, while the bottle receives the filtered liquor; or the funnel may rest on the ring of a retort-stand, or other support independent of the vessel into which the liquid is received. Sometimes a perforated shelf or stand is used, as shewn at page 21, fig. 25, such arrangement being made expressly for the reception of funnels of different sizes when employed in the process of filtration. If a bottle be made the support for the funnel, it will be necessary to ensure free means of escape for the air contained within it as the liquid enters. This is sometimes conveniently provided, when the tube of the funnel fits tightly into the mouth of the bottle, by putting a small piece of folded paper between them, on one side.

Several different methods are adopted of folding the paper for the construction of filters. The most simple kind of filter is that called the *plain filter*, which is represented in figs. 215, and 216. A square piece of paper (*a*, *b*, *c*, *d*,) is folded, first, in the direction (*b*, *c*), the point (*d*) being placed over *a*. Then the point (*c*) is placed over *b*, and a fold made in the direction (*a e*). The corners (*a* and *b*) are cut off with a pair of scissors, as marked by the dotted line, so as to give the proper form to the filter when opened for use. It may be otherwise made, with a similar result, by folding the paper twice in opposite directions, so as to bring the four corners together, and form a square, one fourth the original size of the paper. In either case, the paper, when folded as described, will consist of four layers, and in opening it for use, as shewn in fig.

*Fig.* 215.

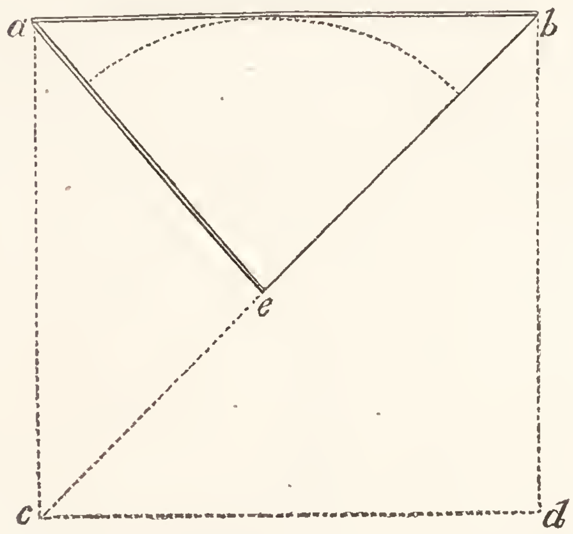
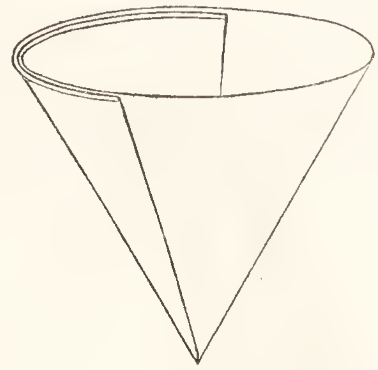



*Fig.* 216.

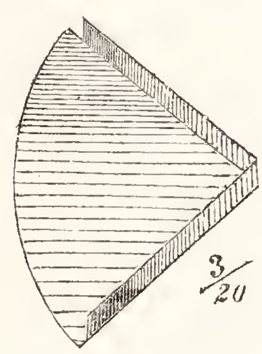


Plain Filter.

216, the filter, on one side, will have three layers of paper, and on the other side only one layer.

Dr. Mohr recommends the use of the instrument (fig. 217) for guiding the scissors in cutting off the corners of the paper. This instrument consists of a quadrant made of tin-plate, the straight sides of which have a rim turned up to the height of about a quarter of an inch. The folded papers are put into this, and a flat piece of tin-plate of the same form is placed over them; the outer edge of the paper is then cut to the figure of the quadrant.

*Fig.* 217.




Filter-Pattern.

The filter when placed in a funnel such as fig. 214, will fit closely to the sides of the latter, especially when a liquid is introduced into it, and the adhesion which thus takes place obstructs the passage of the liquid, and greatly retards the process. To obviate this effect several means have been recommended. The funnels which are made of Wedgewood's ware are generally grooved on the inner surface, with the view of providing channels through which the liquid may run; but these grooves are seldom of any use, not being deep enough to be efficient. With a similar object, and with better success, glass rods are sometimes placed between the filter and the funnel. There is also a method sometimes practised of slightly modifying the form of the filter so as to obviate, to a certain extent, the evil alluded to. This method consists in rolling one side of the filter as shewn in fig. 218, thus making a sort of paper tube which forms a channel for the liquid to run through. In making this alteration in the filter, its general figure might at the same time be changed to suit the angle of the funnel, if this should be more or less acute than 60.° Figs. 219 and 220 illustrate the way in which this is done by turning the edge of the paper over to a greater extent at one end than at the other.

*Fig.* 218.

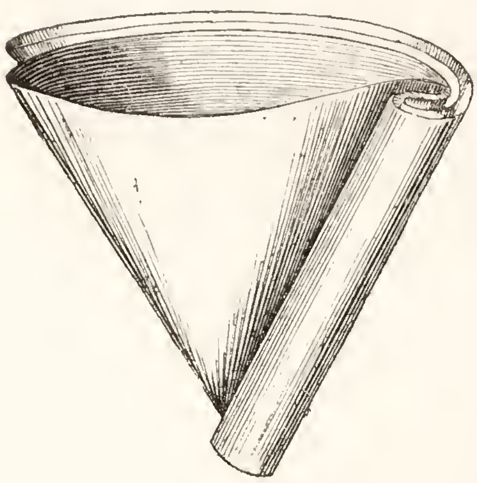


*Fig.* 219.

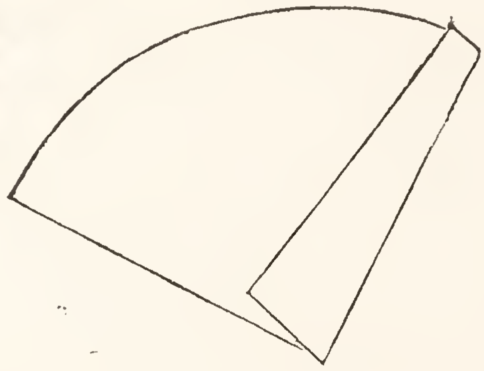
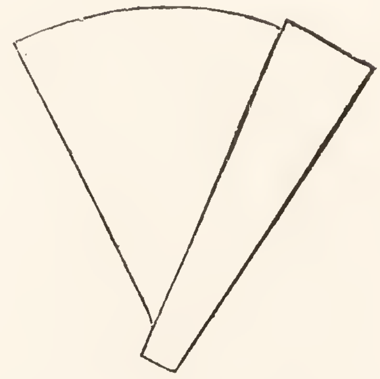


*Fig.* 220.



Modification of Plain Filter.

The most effectual method, however, of obviating the obstruction to the process of filtration resulting from the adhesion of the filter to the surface of the funnel, consists in the use of the *plaited filter*. This is made in the following manner:—A square piece of paper

*Fig.* 221.

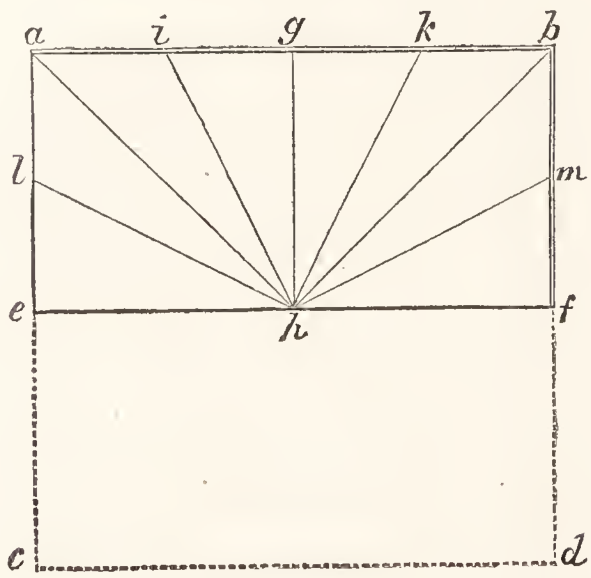
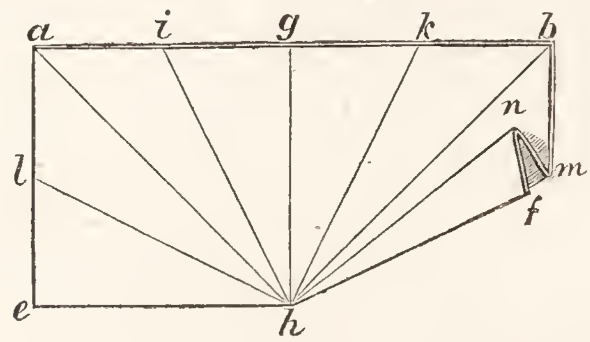



*Fig.* 222.




Plaited Filter.

(*a*, *b*, *c*, *d*, fig. 221), is folded in the line (*e*, *f*) the edge (*c*, *d*) being placed over (*a*, *b*). This doubled sheet is then creased as represented in the drawing. In the first place, the crease (*g*, *h*) is produced by laying *b f* over *a e* and pressing the thumb nail, or any hard surface, over the folded edge, so as to produce a sharp crease. Then placing *f* over *g* the crease (*b h*) is formed; in like manner the crease (*a h*) is formed by laying *e* over *g*, and by similar means the intermediate creases (*l*, *m*, *i*, *k*). These creases are all in one direction, forming seven receding angles, and in making them it is desirable not to bring the creases quite to the point (*h*), but to leave about half an inch or less through which they do not pass, otherwise the frequent foldings of the paper at this point would so weaken the texture as to cause it to break with the weight of the liquid introduced into the filter. In the next place an equal number of creases are to be made in the opposite direction, dividing each of the eight sections, represented in the upper part of fig. 221, in half. In doing this the edge (*f h*) is laid on the crease (*b h*) and then turned back as shewn in fig. 222, producing the crease (*n h*). In like manner an intermediate crease is made in each of the other sections, so as to form a sort of fan, as represented in fig. 223. The

*Fig.* 223.

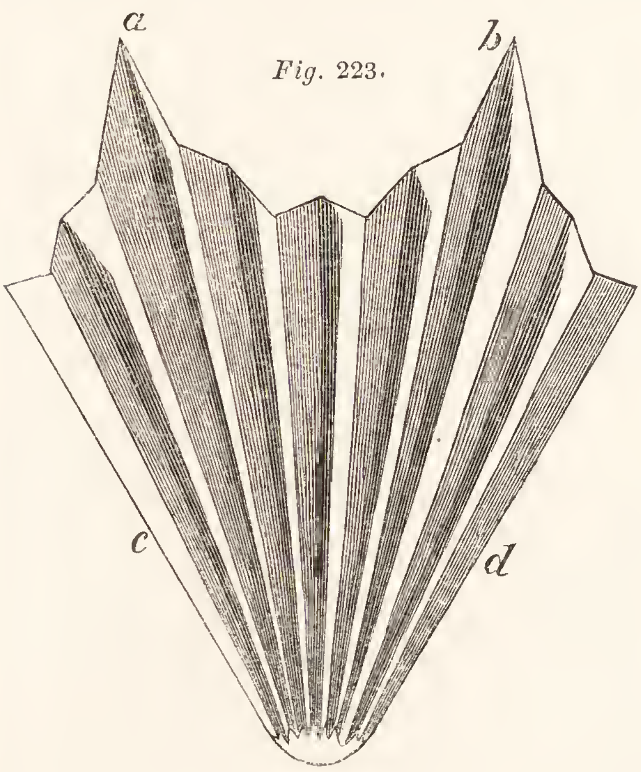
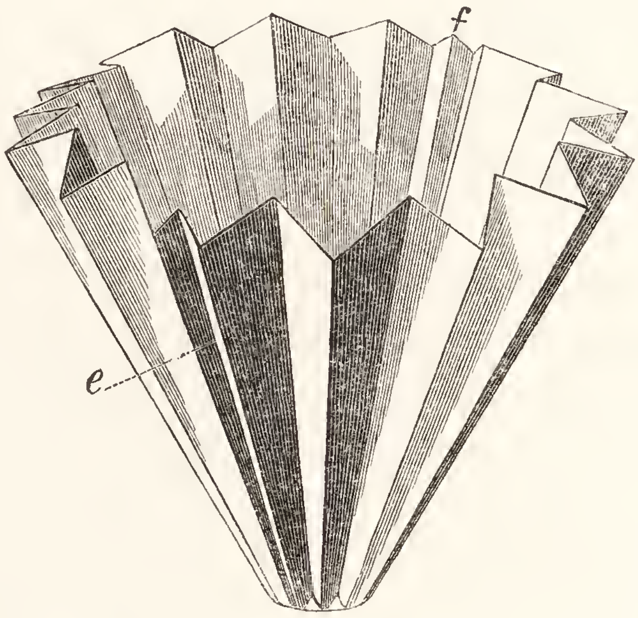



*Fig.* 224.




PLAITED FILTER.

points (*a b*) are cut off with a sharp knife or scissors, and the filter opened to its proper angle by separating the originally doubled halves of the paper without disturbing the sharpness of the creases. It will now be found to consist of alternately projecting and receding angles, forming a uniform zigzag circumference, excepting at the points (*c* and *d*, fig. 223), at each of which places two projecting angles come together. The intermediate portion of paper between these two angles should be folded so as to form a small receding angle, as shewn at *e* and at *f*, fig. 224. This figure represents the appearance of the filter when completed.

When a filter breaks, the fracture generally occurs in the apex of the cone. This is the part on which the liquid exerts the greatest pressure, and it also receives the smallest amount of support from the funnel. The plaited filter frequently breaks at this point, and to obviate this result a little tow or carded cotton is sometimes put into the bottom of the funnel, so as to form a bed on which the point of the filter may rest.

There is a method of folding a plain filter by which increased strength is given to the point. The paper used in making it is not square, but oblong. It is folded so as to bring the two short ends

*Fig. 225.*

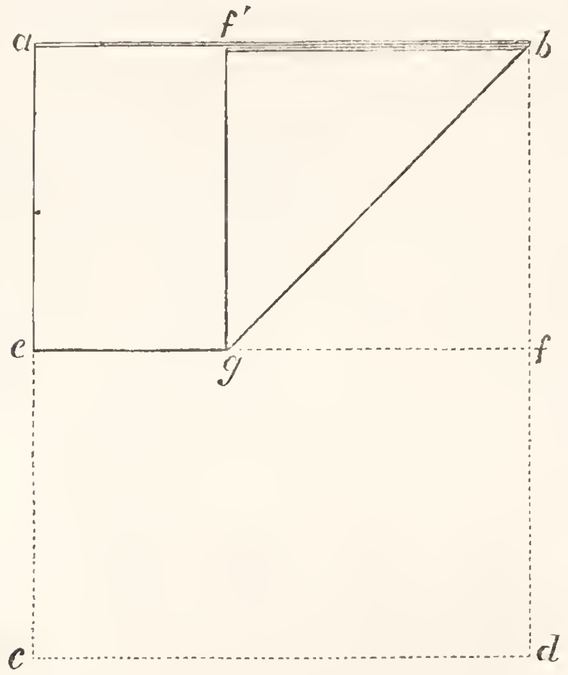
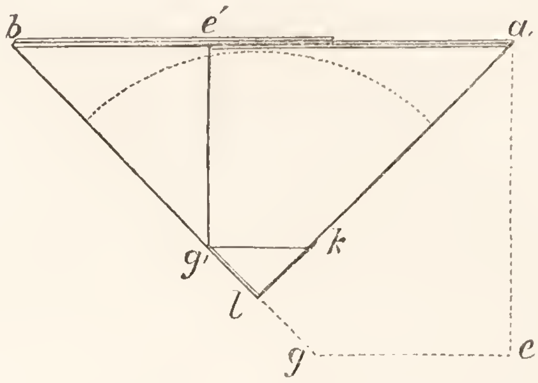



*Fig. 226.*




PLAIN FILTER WITH DOUBLED POINT.

(*a b*, and *c d*, fig. 225) together. The edge (*b f*,) is then laid over *b f′*, producing the fold (*b g*). The paper, thus folded, is now turned over, as shewn in fig. 226, and the edge (*a e*) laid over *a e′*, producing the fold (*a l*). Finally, the projecting points (*a* and *b*) are cut off in the direction of the dotted line. This filter will have a double thickness of paper at the apex (*g′ k l*).

*Fig. 227.*


AIR-TIGHT FILTER.

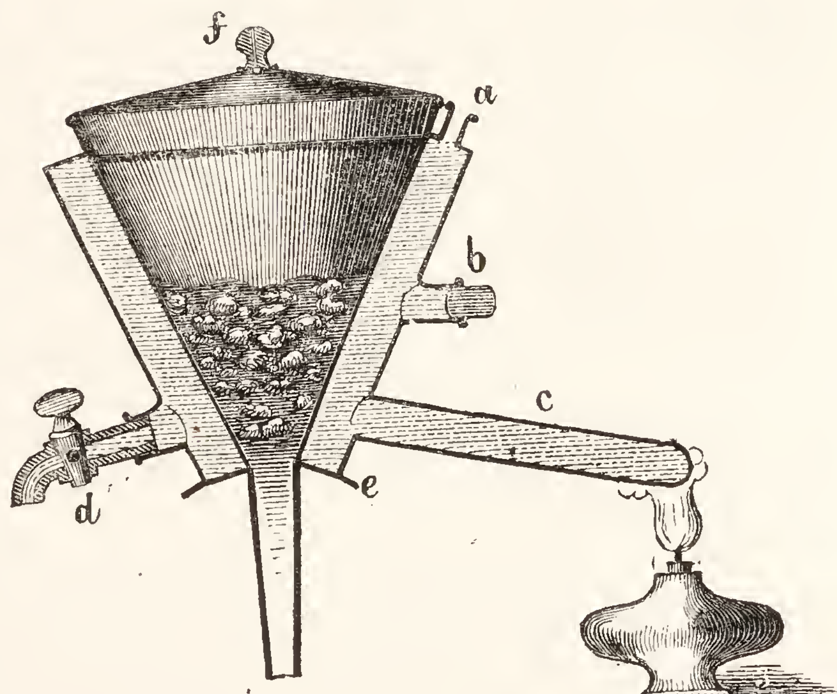
In filtering volatile liquids, such as tinctures, and especially ethereal tinctures, much loss is frequently experienced from the evaporation which takes place during the process. To obviate this inconvenience, the arrangement represented in fig. 227, may be adopted. The funnel (*a*), the tube of which is inserted through a cork in the mouth of a bottle, has its upper edge ground to a smooth, plane, surface. Over this a circular piece of plate-glass is laid, and, if necessary, a little grease, such as the mixture of wax and lard, used for luting the joints of apparatus, may be rubbed on the edge of the funnel, so as to form an air-tight joint, which, on introducing a filter with a volatile liquid, will completely prevent evaporation. It will be necessary, however, to provide a channel through which the air from the bottle below may pass into the upper part of the funnel as the liquid descends, and this may be done by placing a piece of glass tube, about the eighth of an inch in diameter, between the filter and the funnel. The lower end of this tube should be twisted in the way represented in fig. 228, to prevent it from slipping down through the neck of the funnel.

This arrangement will also be found convenient in filtering liquids, such as lime-water, and solution of caustic alkali, which it is desirable to exclude from the action of the air.

*Fig.* 228.

There are some substances, the filtration of which can only be effected with the aid of heat. Solid fats, and thick oils and syrups, are of this class. In filtering such substances, the *Water-bath Funnel* (fig. 229) will be found convenient. It is made of tin or copper, and consists of a funnel with an outside case or jacket, and an intermediate space for containing hot water. There is an opening (*a*) at the top for introducing the hot water into the jacket, and a projecting tube (*c*) near the bottom for keeping up the heat of the water by the flame of a lamp. It is convenient, but not necessary, to have a stop-cock (*d*) for drawing off the water from the jacket, and a short tube (*b*) through which steam may be introduced when it is more convenient to heat it by steam than by hot water. The projecting rim (*e*) is intended to prevent any water, running over at the tube *a*, from entering the bottle or other vessel in the mouth of which the neck of the funnel may be placed.

*Fig.* 229.

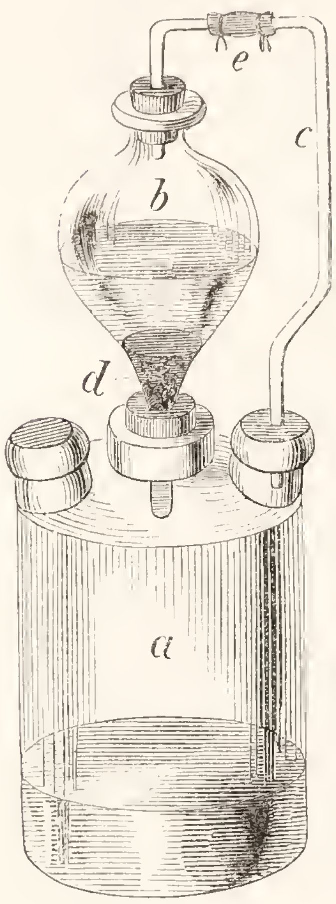



WATER-BATH-FUNNEL.

*Filters of inorganic materials* are generally made by putting a bed of the inorganic substance at the bottom of a funnel through which the liquid is allowed to percolate. When sand or pounded glass is used, it is customary, in the first place, to put a few broken fragments of glass into the neck of the funnel, so as partly to stop it up, leaving such channels as may be further closed by other smaller fragments; then, to put a layer of coarsely pounded glass or sand, and over that some of the same material more finely divided. In this way, several strata may be laid so as to form a filter capable of separating solid particles from the liquor to the required extent. Pounded rock crystal is used in a similar way. Asbestos, when used, is merely put into the neck of a funnel, so as to form a loosely compressed plug through which the liquid can pass.

The apparatus originally suggested by Mr. Donovan, is frequently found convenient for effecting the filtration of liquids through inorganic materials. The immediate object, however, of this apparatus, is to prevent the absorption of carbonic acid from the atmosphere, and also to prevent evaporation. The apparatus consists of a Wolf's bottle (*a*, fig. 230), into one of the necks of which an oil separater (*b*) is inserted through a perforated cork. The filtering medium (*d*), such as sand, pounded glass, or rock crystal, is packed in the separater in the manner already described, and the liquid to be filtered is poured over it. The mouth of the separater is closed with a cork, through which one end of the tube *c* passes, while the other end is inserted into the Wolf's bottle. The tube *c* is in two pieces, which are united by an India rubber connecter (*e*), so as to admit of the removal of the cork from the mouth of the vessel (*b*). As the liquid runs through the filter into *a*, the air passes from thence through the tube *c* into the upper part of *b*.

*Fig.* 230.




DONOVAN'S FILTER.

*Animal Charcoal* is used, for the purpose of filtration, in a somewhat similar manner to that adopted in the use of sand, glass, and rock crystal. The charcoal, in coarse grains, is made into a thick layer or bed, through which the liquid is filtered. The filters commonly employed in purifying water for domestic purposes, are made in this way. The water passes, first, through several successive strata of sand of different degrees of coarseness; then, through a thick bed of charcoal; and, lastly, through sand arranged as that through which it first passed.

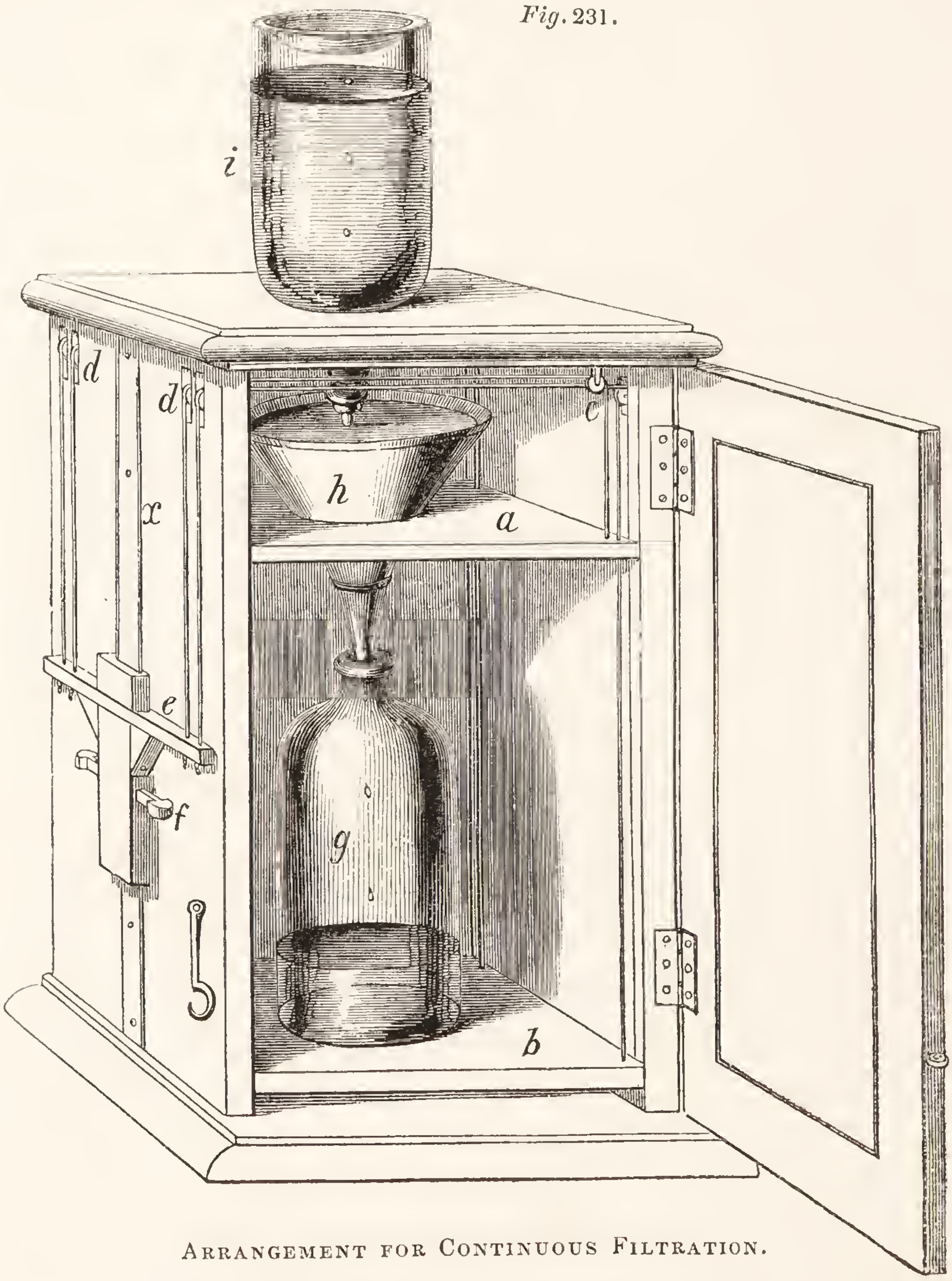
The principal use for animal charcoal is in the process of sugar-refining. The impure syrups are decolourized by passing them through beds of coarsely granulated charcoal packed in boxes or other suitable cases. As thus used, the charcoal itself forms the filtering medium, acting at the same time as a chemical and a mechanical filter. The property possessed by charcoal, and especially animal charcoal, of depriving liquids of their colour, and in some cases of removing offensive flavours, appears to depend upon its power of absorbing gases and other matters into its pores. Thus, a piece of box-wood charcoal which has been heated to redness, and while in this state, plunged into mercury, and allowed to cool out of contact with air, will absorb large quantities of gases when exposed to them. It will absorb thirty-five times its volume of carbonic acid, and ninety times its volume of ammoniacal gas. In like manner it absorbs the colouring matters of liquids, removing them from solution, and locking them up in its pores by a kind of surface attraction. Animal charcoal, made by the calcination of bones in close iron cylinders, possesses this property to a greater extent than wood charcoal, but in both cases there is a limit to the power of absorption. When the charcoal has ceased to act as a decolourizing or deodorizing agent, it may be restored to its original condition by calcining it in close vessels. The animal charcoal used by the sugar refiners is thus repeatedly restored.

In conducting the process of filtration, when a paper filter is used, and when the liquid to be filtered is an aqueous solution containing a precipitate, it is desirable, always, to wet the filter with distilled water, before pouring the solution into it. The effect of this is to cause the fibres of the paper to swell, and the pores to become smaller, so that the precipitate is less absorbed by the paper and is not so likely to pass through.

It is frequently desirable to have the means of keeping the filter constantly and uniformly supplied with the liquid to be filtered throughout the process. When this can be done it tends greatly to expedite the filtration. A method of effecting it was recommended many years ago by Berzelius, which consists in inverting a narrow-mouthed bottle, containing the liquid under operation over the filter, and fixing it in such a position that the mouth of the bottle shall be in contact with the liquid in the filter, when the latter is nearly full. While this is the case, none of the liquid will run out of the bottle, as the air cannot enter, but as the contents of the filter subside the mouth of the bottle becomes exposed, and the liquid then runs out, its place being supplied by air which enters; and this will again cease as soon as the liquid in the filter rises so as to cover the mouth of the bottle.

The arrangement represented in fig. 231, is a convenient one for conducting the process of filtration continuously. It is that adopted by Mr. Abrahams, of Liverpool. There are two shelves, *a* and *b*, suspended by cords in a square box or cupboard, the door of which opens as shewn in the drawing. There is a circular hole in the centre of the shelf (*a*), and a corresponding one in the top of the box. The cords by which the shelves are suspended from their four corners, pass over small pulleys at *c*, *c*, *d*, *d*, through the two opposite sides of the box, and are fastened on the outside. Thus the four cords by which the shelf (*a*) is supported, pass through the left hand side of the box, and are fixed to the frame (*e*), the perpendicular bar of which is attached by a groove to the lath (*x*), along which it slides. This frame may be fixed at any point by means of the wedge (*f*).

*Fig.* 231.




Arrangement for Continuous Filtration.

By loosening the wedge, therefore, and moving the frame (*e*), upwards or downwards, the position of the shelf (*a*) is easily altered, and on again tightening the wedge it is fixed in its new position. The cords by which the shelf (*b*) is suspended pass out on the opposite side of the box, and are fastened there in a similar way.

Two bottles of equal size are used in conducting the process of filtration. The bottle (*i*) is filled with the liquid to be filtered, and to the mouth of it is fitted a cork through which passes a short piece of tube about a quarter of an inch in diameter. The bottle (*g*), being empty, is placed on the shelf (*b*) to receive the filtered liquor; the filter (*h*) is supported on the shelf (*a*); and the bottle (*i*) is placed on the top of the box, with its mouth inverted, and the end of the tube in contact with the liquid in the filter. The height of the shelves is adjusted by the cords so as to bring the several parts to their proper positions. The apparatus being thus arranged, the filtration will go on until the bottle (*i*) is emptied, without any interruption occurring from the want of a uniform supply of liquid to the filter.]

Instead of having merely a straight piece of tube inserted in the mouth of the bottle from which the liquid is supplied, as in fig. 231, two tubes are sometimes used as shewn in fig. 232. In this case the efflux tube (*a*) is turned up at the end, and as the liquid runs out here air enters at *b*. The surface of the liquid into which (*a*) is immersed must, however, be so far below the lowest point of *b* as to enable the air to depress the liquid in the external ascending part of *b*, and thus to enter the bottle. This is shewn in fig. 233 by the distance between the lines (*c f* and *g h*). The size of the tubes is also so arranged that the liquid will not run from *a*, fig. 232, unless the orifice of the tube be in contact with the contents of the filter, so that the cohesive attraction of the liquid may overcome the capillary attraction. Fig. 233, will further illustrate the arrangement of the tubes. The opening (*a*) of the tube (*a*, *b*) must be higher than *b*, otherwise the fluid would spurt out at *a* as each bubble of air passed. The point (*d*) should also be higher than *b*, otherwise when the level of the liquid in the bottle became lower than *b* it would run continuously through *d*, and might cause the filter to overflow.

*Fig.* 232.

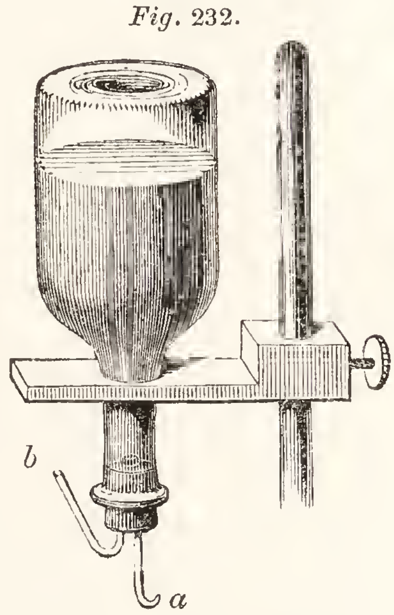
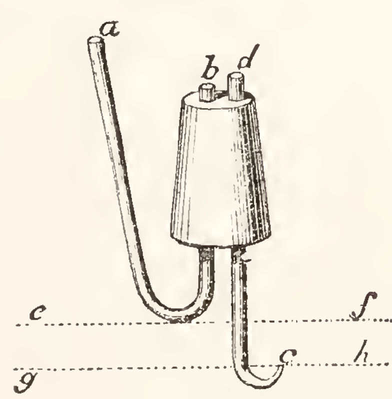
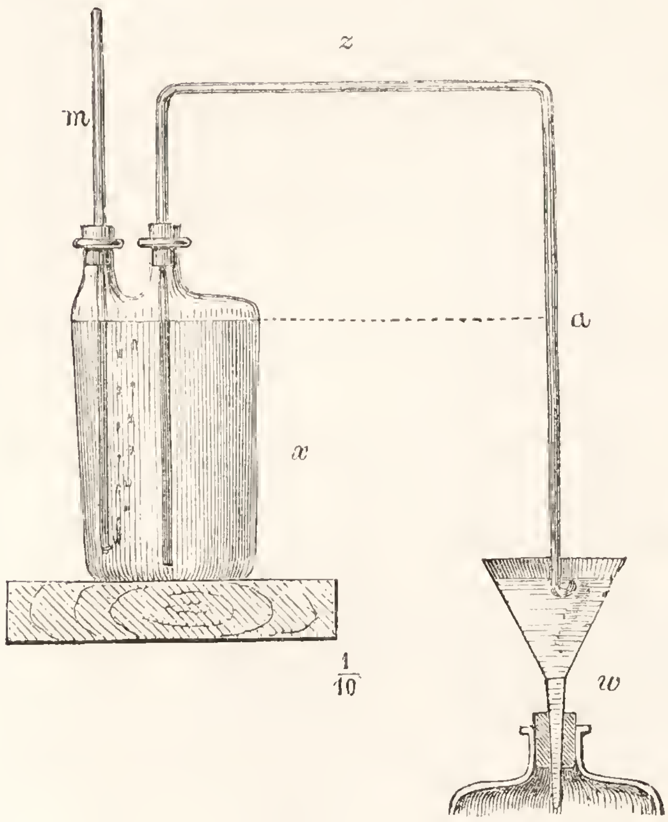



*Fig.* 233.




Gay Lussac's arrangement for continuous filtration is a good one, and in some cases is preferable to all others in use. This arrangement is represented in fig. 234. The liquid to be filtered is put into a two-necked bottle (*x*), or into a wide-mouthed bottle with a cork through which two tubes can pass. The tube (*z*) is bent twice at right angles, and one of its limbs is inserted into the bottle (*x*), so as to reach nearly to the bottom; the other limb terminates in the funnel (*w*), which is so placed that the surface of the liquid in the filter, when filled, shall be on a level with the end of the tube ($z$), in the bottle ($x$). The second tube ($m$) is also inserted into the bottle ($x$) to the same depth as $z$. On commencing the process air is blown through the tube ($m$) into the bottle ($x$) until the liquid rises in the tube ($z$), and flows into the filter. The current, being thus established, will continue until the liquid in the filter rises to a level with the ends of the tubes ($z$ and $m$) in the bottle ($x$); it will then cease, but as the liquid in the filter subsides, a fresh portion will run through the tube ($z$), so as to maintain a uniform supply, and bubbles of air will at the same time enter ($x$) through the tube ($m$). It will be obvious that in this case the tube ($z$) acts as a syphon, the force determining the current being equivalent to the weight of the column of water ($a$ $w$), and when this column exceeds that of the immersed part of the tube ($m$) air will enter $x$, and the liquid at the same time flow into $w$.

*Fig.* 234.




When the filter contains a precipitate which is required to be washed, it should first be collected into the apex of the funnel by directing a jet of water from a syringe or wash-bottle against it, and the further washing may be effected either by the same means, or by one of the continuous processes already described.

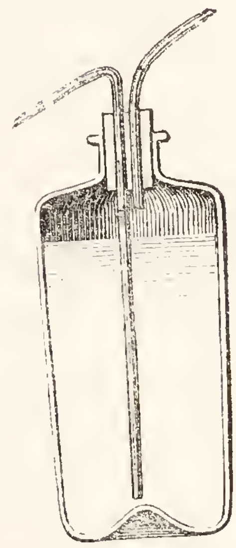
The most simple form of wash-bottle is made by inserting a glass tube, with a capillary orifice, through the cork of a bottle, such as figs. 235, and 236. In using this bottle, it is partly filled with water, and air is then blown in through the tube so as to compress that contained within; the bottle is then immediately inverted over the filter, and a jet of water is forced out by the elasticity of the compressed air.

Fig. 237, is a more convenient form of wash-bottle, in which two tubes are used, one terminating near the top, above the liquid, and the other beneath the liquid and near the bottom. Air is blown in through the former, which forces the liquid out through the latter. In this case the bottle is not inverted during the use of it, and the jet of water can be maintained without interruption, which are advantages.

*Fig.* 235.

*Fig.* 236.


*Fig.* 237.



WASH-BOTTLES.

In one respect, however, this form of wash-bottle is less convenient than the other. As the water continues to flow only so long as the blowing is continued, it is necessary in directing the jet to different parts of the filter, that the head of the operator as well as the bottle should be moved. This defect might be obviated by attaching a valve to the end of the tube through which the air is compressed. The extremity of the tube being ground perfectly flat and smooth, a piece of Indian rubber is fixed over it by two pins, as shewn in fig. 238. On blowing strongly through the tube the valve will recede, and the air become compressed within the bottle; but on ceasing to blow, the elasticity of the air pressing the Indian rubber against the orifice over which it is placed, no escape can take place here, while a continued jet of water will be forced through the exit-tube.

*Fig.* 238.

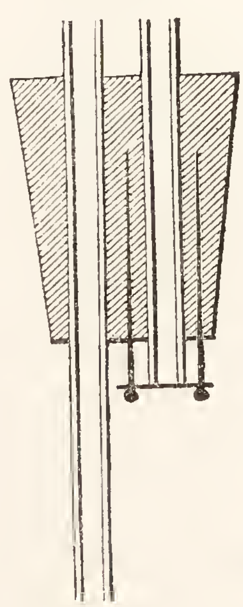
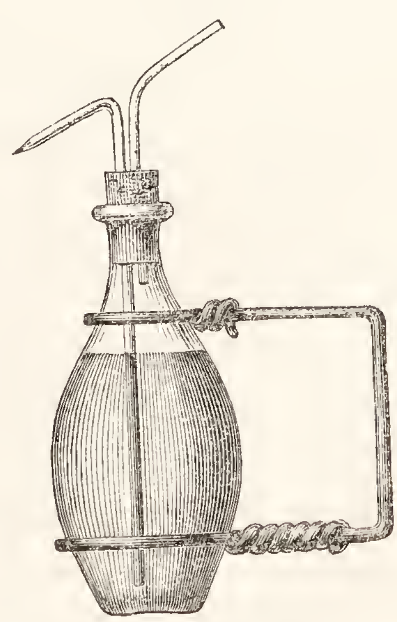


*Fig.* 239.



WASH-BOTTLE.

If it should be required to wash a precipitate with hot water, the best form of wash-bottle to use is that represented in fig. 239. This differs only from fig. 237, in being provided with a handle.

## CLARIFICATION.

[The term *clarification* is applied to processes by which mechanical separation of substances that impair the transparency of liquids is effected by means which are accessory to filtration or decantation.

In most cases in which clarification is performed for pharmaceutical purposes, it is effected through the agency of heat, but the process is varied according to the nature of the substance operated upon.

In some instances the separation of substances which occasion opacity is only prevented by the viscid character of the liquid in which they are suspended; and the mere application of heat, by increasing the fluidity of the liquid, enables the particles to separate spontaneously by virtue of their greater or less specific gravity. This is the case with honey, which is clarified by keeping it melted by the heat of a water-bath, when some of its impurities, being heavier than the honey, will subside, while others, such as wax, being lighter, will rise to the surface, and may then be removed by a skimmer. It is essential in doing this that the substance under operation should be left undisturbed by agitation while the separation is taking place.

If there should be any particles in a viscid liquid which will not separate spontaneously on the mere application of a gentle heat, in consequence of their specific gravity being the same, or nearly the same, as that of the liquid in which they are suspended, ebullition may facilitate the separation. Thus, if a liquid of this kind be boiled, the steam being generated most freely in contact with the solid particles, and small bubbles of steam remaining attached to such particles, they will be carried to the surface by the buoyancy of the steam.

It very frequently happens in pharmaceutical processes, that the clarification of a liquid takes place on heating it, in consequence of its containing a substance, originally in solution, which is rendered insoluble by the heat. This is the case with most vegetable juices which contain albumen, and this, on assuming the solid condition, envelops any particles which may be suspended in the liquid, and either carries them to the surface, or subsides with them to the bottom. It is, indeed, through the intervention of albumen that clarification is generally effected for pharmaceutical purposes, and if this substance be not one of the constituents of the liquid to be clarified, it is frequently added to ensure the desired result. In using albumen for this purpose, it must be added to the liquid before the application of heat. White of egg is the kind of albumen generally employed, and this should be first mixed with a little water, then the mixture intimately diffused through the liquid, which should be gradually heated until coagulation takes place, without disturbing it by stirring or other agitation.

It is necessary to be cautious in the use of albumen as a clarifying agent in pharmaceutical processes, as it sometimes combines with, and thus causes the separation of, some of the active constituents of the liquid to which it is added.]

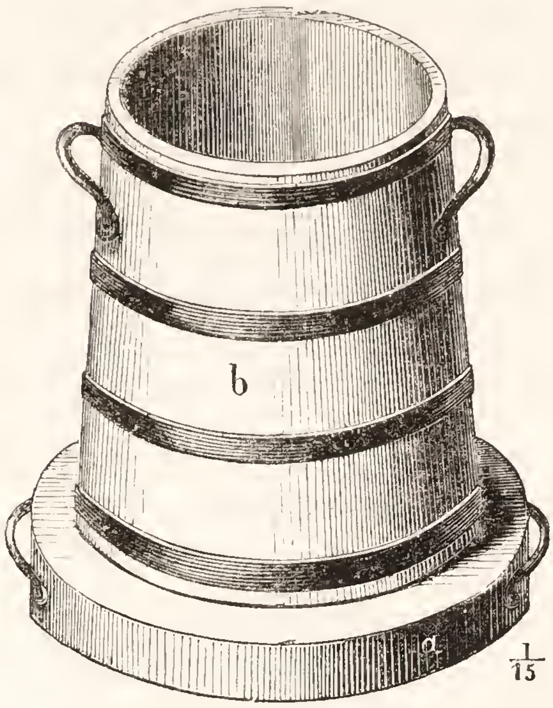
## COARSE COMMINUTION OF VEGETABLE SUBSTANCES.

A great number of vegetable substances are prepared for use by submitting them to coarse comminution. They are employed in this state for making infusions and decoctions, and many are also sold, under the name of *species*, for the purposes of private dispensing. The term species is properly applied to a mixture of several kinds of vegetable substances, but such a mixture cannot be made, so as to be uniform, without reducing all the ingredients to an equal degree of comminution. This particular kind of comminution has latterly been looked upon as the distinctive character of what are called species, and the term is therefore, now, frequently applied to coarsely comminuted vegetable substances, even when consisting of only one kind.

The means by which comminution is effected, are chosen according to the nature of the substances operated upon, and the purposes to which they are applied. If the process be adopted for the preparation of vegetable substances as species, much care should be taken to reduce the particles to as equal a size as possible, and for this purpose the *cutting or slicing-knife* is generally employed. If the substance should consist of flowers, leaves, or herbs, these are most easily comminuted by means of the *rolling-knife, or cradle-knife.* On the other hand, if the object of the process be to cut hard woods, roots, or barks, preparatory to their being powdered, the *chopping-trough* may be advantageously used. The substances cut with the last-named instrument will not be reduced to fragments of equal size, but in the cases alluded to this is not important.

*The chopping-trough*, fig. 240, consists of two separate parts, the bottom, or chopping-board ($a$), and the cylinder ($b$), which rests upon, but is not fixed to, the former. The chopping-board is about twenty-four inches in diameter, and three inches thick. It should be made of oak, or some other hard, close-grained, wood, the fibres of which run perpendicularly, or at right angles with the horizontal surface of the board. It must, therefore, be a transverse section of the trunk of a tree, and should, if possible, be in one piece, both sides of which are planed so that the chopping might be effected on either surface. It is furnished with two handles, as shewn in the drawing.

*Fig.* 240.




Chopping-Trough.

The cylinder, which is placed on the chopping-board when in use, is also made of wood, bound together with iron hoops, and furnished with two handles. It has a slightly conical form, the smaller end being uppermost, and the lower edge planed to a smooth surface so as to fit closely on to the board.

*Fig.* 241.


*Fig.* 242.

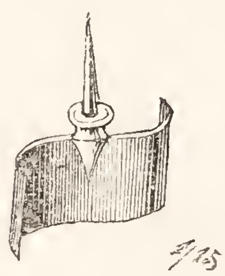
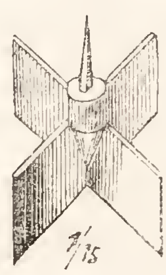



*Fig.* 243.

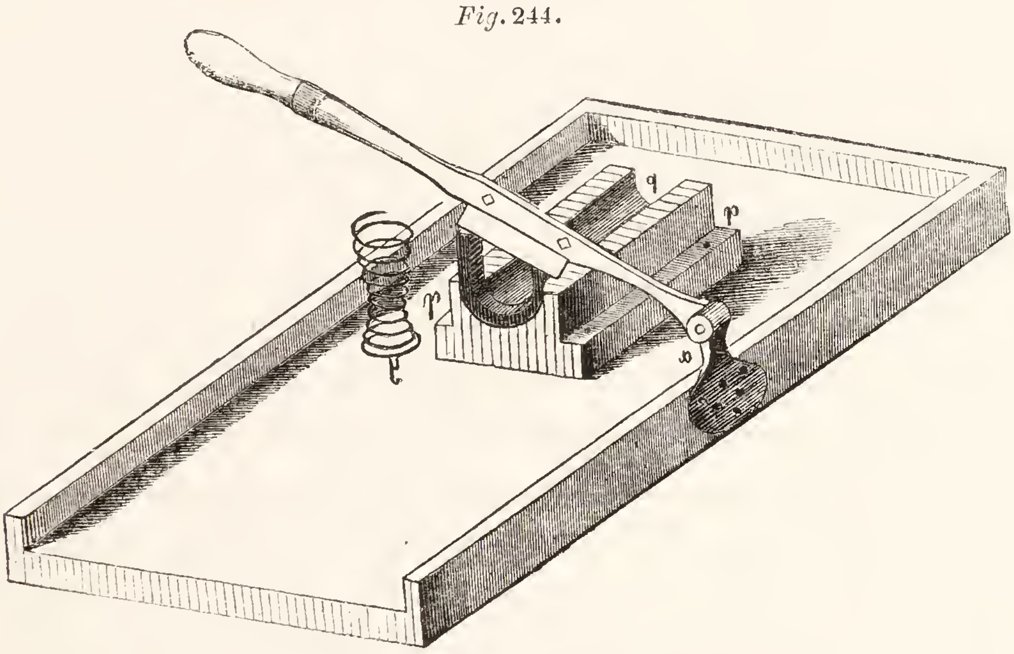



The cutting instrument, or chopper, is made of good steel, and may have the form of any one of those represented in figs. 241, 242, and 243. It is fixed by means of a spike to the end of a stick which forms the handle. This should be strong and rather heavy, and should have a crossbar near the upper end, as represented in fig. 241, by which it is grasped with the two hands in using it.

The substance to be cut is placed within the cylinder, over the chopping-board, and a series of hard blows are inflicted upon it with the chopper until the requisite degree of comminution has been effected.

*The cutting-knife or slicing-knife* is constructed in different ways. The knife itself consists of a one-armed lever attached to a frame or block of wood by a hinge which admits of motion in two directions, one vertical, the other horizontal, so that several successive slices may be cut from the substance laid on the block without moving it. Much force is required to cut hard woods with this knife. The substance lying on the block grasps the knife on either side, and the blade has to be moved with a force capable of overcoming the resistance caused by friction, in addition to that of the cohesion of the parts yet uncut. By making the blade of the knife slide upon another sharp steel edge, passing in an opposite direction, like the blades of the scissors, the resistance from friction is lessened, as the part already cut is turned out and prevented from impeding the progress of the cutting edge. This method of constructing the slicing-knife has therefore been frequently adopted latterly. Fig. 244 represents a knife which I have constructed on

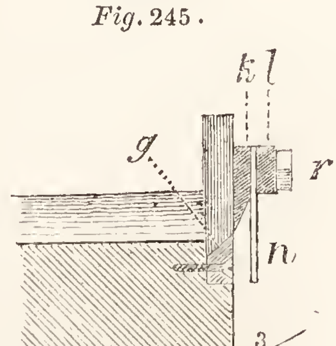
*Fig.* 244.




Cutting-Knife or Slicing-Knife.

the above principle, and in which I have also provided means for equalizing the size of the cut pieces. The knife, in this case, moves only in a vertical plane, on the hinge ($a$). The blade of the knife can be removed from the handle, to which it is fastened by screws. This is advantageous, as it facilitates the grinding of the blade, and admits of its being replaced by another in case of its being much damaged. Between the lever-bar of the knife and the blade, a plate of iron is fixed, which may be called the touch-plate. In fig. 245 this is shewn in section as seen from the point $x$, fig. 244, $k$ being the blade of the knife, $n$ the touch-plate, $l$ the lever to which the handle is attached, $r$ the screw securing these together, and $g$ the steel

*Fig.* 245.



edge fixed to the frame, and against which the knife slides. In fig. 246 the several parts are shewn as seen from above, and in fig. 247, as seen from the front, the letters being applied to similar parts in all the drawings.

The touch-plate (*n*) moves with the knife, so that on raising the

*Fig.* 246.

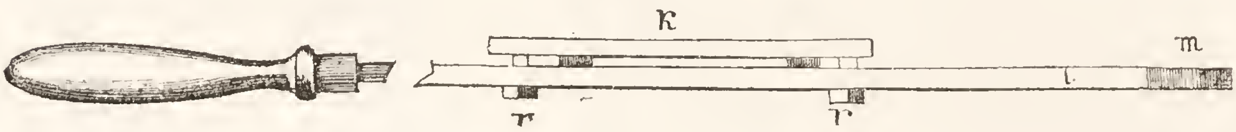
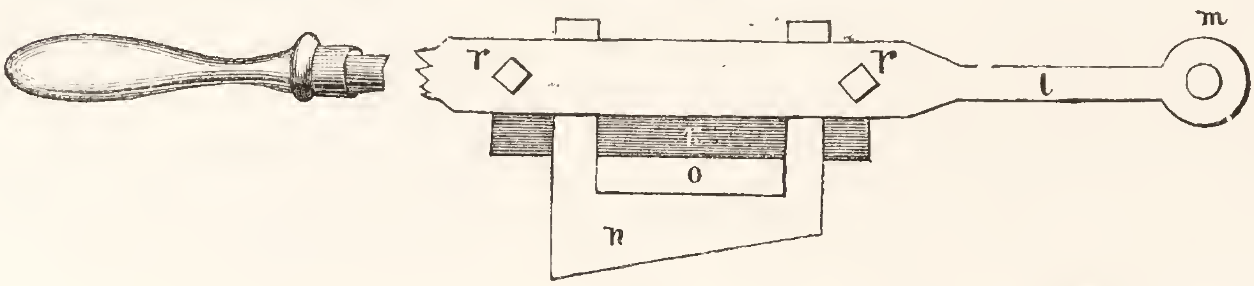


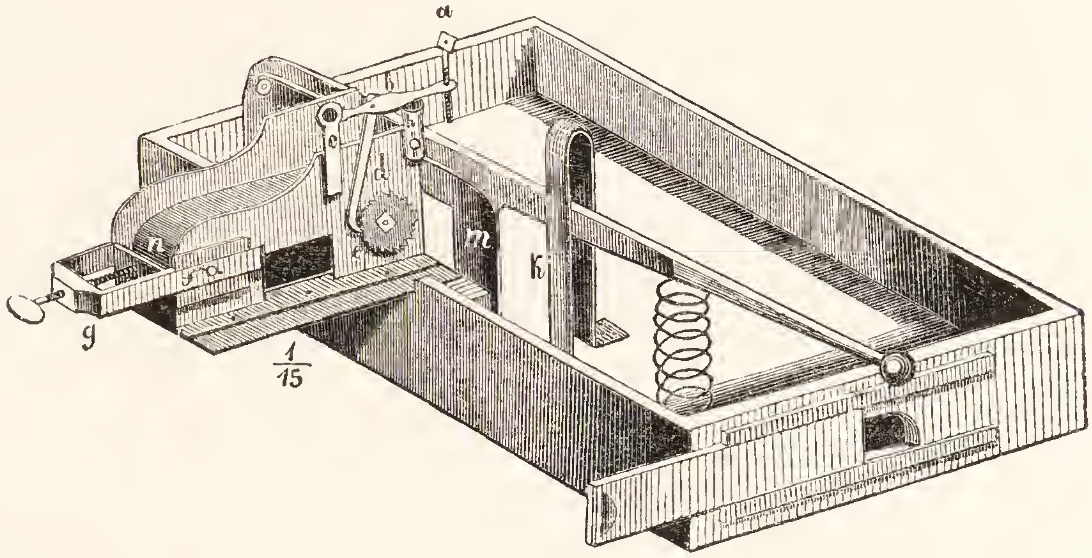

*Fig.* 247.




latter it comes in front of the substance to be cut, which is pushed forward until it touches this plate. The knife being now pressed down cuts off the advanced portion, which, on again raising the knife, falls through the opening (*o*, fig. 247). The cutting block (*p*, *p*, fig. 244) is made of a strong piece of wood having a groove (*q*) in which the substance to be cut is placed. Against the front of this groove is fixed a steel plate of the form of a horse-shoe, the sharp edge of which is opposed to the edge of the knife. There is a spring, consisting of a coil of strong wire, such as is used for the seats of sofas and chairs, placed under the lever of the knife, which, being compressed as the knife is forced down, tends to raise the handle when the pressure is relaxed. The knife should also be kept in its place, pressing tightly against the end of the block, by means of a stirrup such as is represented in fig. 248 at *k*. This stirrup and the touch-plate are omitted in fig. 244, in order that the other parts should be more clearly represented.

Fig. 248, represents the arrangement I have adopted for a *self-supplying cutting-knife*. The knife is fixed to the cutting-plate (*m*) by a rivet-hinge, and the two cutting surfaces are brought into lateral contact as the handle of the knife is depressed. The cutting-plate, and the self-acting apparatus for feeding the knife, are fixed to a wooden frame into which the cut substance falls. On lifting the knife it strikes against the lower end of the screw (*a*), and raises this together with its little lever (*b*). The lever turns on the fulcrum (*c*) and carries a hook (*d*), which bites into the cog-wheel (*e*), thus turning the wheel round its axle to the extent of two or three cogs each time the handle of the knife is lifted. The axle of the wheel (*e*) passes through the box (*n*), within which

*Fig.* 248.

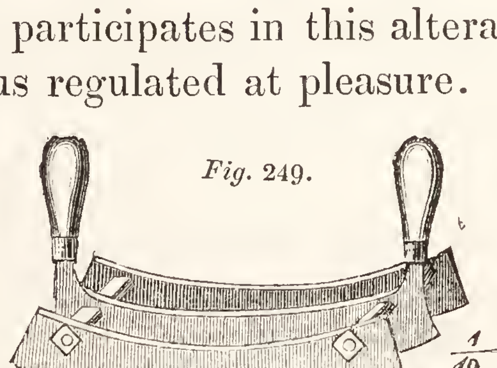



MOHR'S SELF-SUPPLYING CUTTING-KNIFE.

it carries a wooden roller. Over this roller, and over another at *f*, an endless strap is fixed, which is tightened by the screw (*g*), so that on turning the wheel (*e*), the strap is put into motion. The substance to be cut is placed upon the strap, and to the extent to which the strap moves, the substance is carried forward each time the handle of the knife is raised. No motion, however, is given to the strap until the edge of the knife has been raised above that of the cutting-plate, which is a necessary provision, as the substance could not otherwise be pushed forward. When the back of the knife comes against the screw (*a*), and lifts it, the strap is put into motion and the substance to be cut is carried over the edge of the cutting-plate to receive the knife as it descends.

There are two means for regulating the extent to which the substance to be cut is carried over the cutting-plate prior to each incision. One consists in raising or lowering the screw (*a*) ; the other in altering the position of the support (*h*) on which the lever (*b*) rests. In either case the effect is that the lever (*b*) is elevated, and the wheel (*e*) turned to a greater or smaller extent on raising the knife, and as the motion of the strap participates in this alteration the size of the pieces cut may be thus regulated at pleasure.

*Fig.* 249.

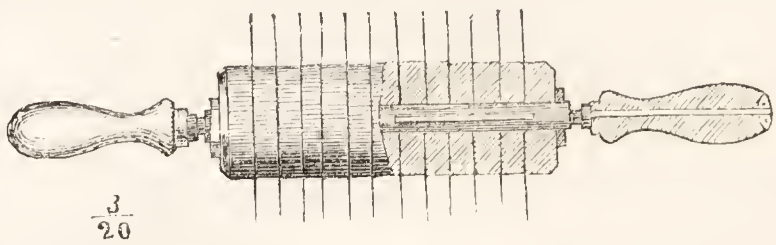



THE CRADLE-KNIFE.

*The Cradle-knife*, consists of two or three curved blades joined together, as shewn in fig. 249, and furnished with two upright handles. The substance to be cut is placed on a board beneath the knife, which is pressed down by the handles, a greater pressure being applied, first to one handle and then to the other, so as to produce a rocking motion like that of a cradle. Herbs, leaves, and flowers, are thus reduced to small fragments. The cradle-knife, however, is not a very efficient cutting instrument, and Dr. Mohr proposes to replace it by,

*The Rolling-knife.*—This instrument is represented by fig. 250. It consists of an iron axle, terminated at each end by a wooden handle, and having a number of circular steel blades fixed on the intermediate part at equal distances from each other, with disks of wood between them to keep them in their proper positions. This knife is used in the same way as a rolling-pin, and is found to be much more efficient than the cradle-knife.

*Fig.* 250.

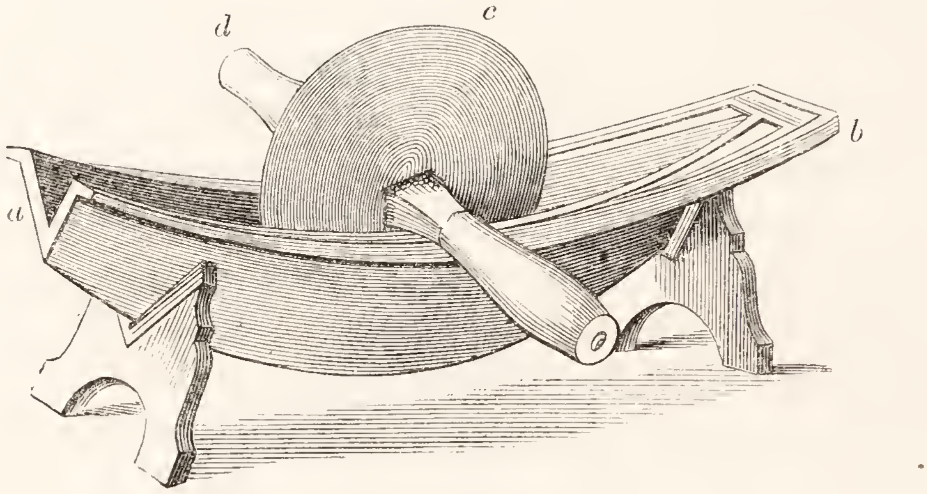


$\frac{3}{20}$

THE ROLLING-KNIFE.

[The Chinese use an instrument for cutting or grinding substances used in medicine, which deserves to be noticed here. Fig. 251, represents one of these instruments in the possession of the Pharmaceutical Society. It consists of an iron wedge-shaped trough (*a b*,) in which a circular blade (*c*) is rolled by means of the wooden handles (*d d*).

*Fig.* 251.




CHINESE CUTTING-TROUGH.

In England, the only instruments commonly employed by the pharmaceutists for the purpose of coarse comminution are those described at pages 21 and 22. The preparation of herbs for use as species, is rarely performed by the druggist, this being the proper business of the herbalist.]

PULVERIZATION.

[The operations by which drugs are reduced to fine powder are of considerable importance in connexion with the preparation of medicines. These operations, when performed by the retail pharmaceutist, are generally conducted in a room set apart for that purpose, and the instruments most frequently employed in the process are the pestle and mortar and the sieve. The porphyry slab and muller are sometimes used, and in a few instances the substance to be powdered is merely rubbed through a sieve. But, in this country, the greater part of the drugs which are used in powder are reduced to that state previously to their passing from the wholesale dealers, and in these cases the process is usually conducted by persons who make it their special business, and who are called *drug-grinders.* The establishments at which drugs are thus reduced to powder on the large scale are called *drug-mills*, and the implements used there for effecting the disintegration of the drugs, are the *grinding-mill* and the *stamping-mill.*

There are, therefore, several methods or processes by which drugs are reduced to powder, the process being varied to suit the nature or the quantity of the substance to be operated upon.

*Contusion.*—The pulverization of drugs by contusion is usually effected with a pestle and mortar made of some hard metal, such as iron or bell-metal. It is thus, in operating on the small scale, that all hard and tough substances are reduced to a state of disintegration. At the drug-mills contusion is also effected by the pestle and mortar, but the pestle being worked by machinery, the apparatus is there generally called a *stamper*, or *stamping-mill.*

In casting the mortars they are formed after different patterns or designs, but their general character is such as is represented in figs. 252 and 253. The bottom of the mortar should be perfectly flat on the outside, so that it may stand firmly, with a solid bearing; it should also be thicker at the bottom than at the sides. The upper edge is sometimes made like that of fig. 252, with a projecting rim and a groove on the outside, which admits of the leather cover being secured with a cord to this part. In fig. 253 there is a rim of a different kind, intended to receive a wooden hoop or circular frame, to which the leather is tacked, and this frame is fastened down by a cord on two opposite sides of the mortar. There are sometimes two cylindrical projections from the sides of the mortar, as in fig. 252, by which it is moved, and to which the top might be tied.

The pestle is most frequently made of wrought iron; in some instances, however, it is made of cast-iron. It should weigh from twelve to twenty, or even thirty, pounds, the weight varying according to the purpose to which it is applied. The end of it which comes into contact with the mortar should have a curve corresponding with that of the bottom of the mortar. There is a hole or eye at the other end for the reception of a hook, attached by a cord to the spring.

*Fig.* 253.

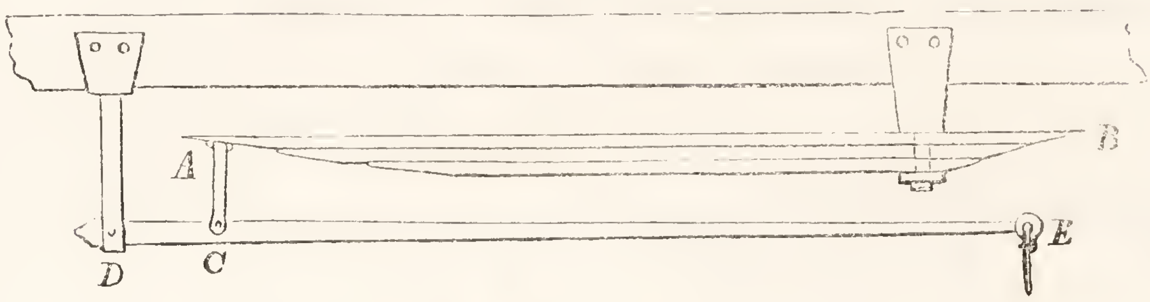
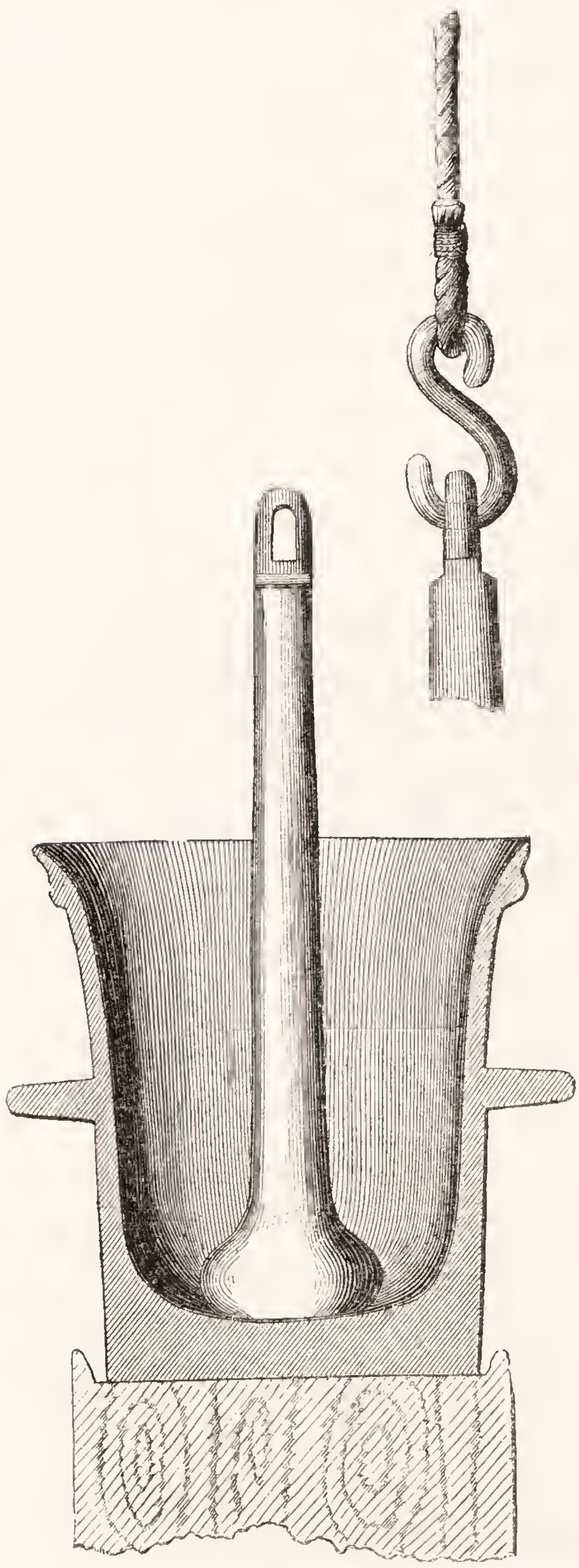
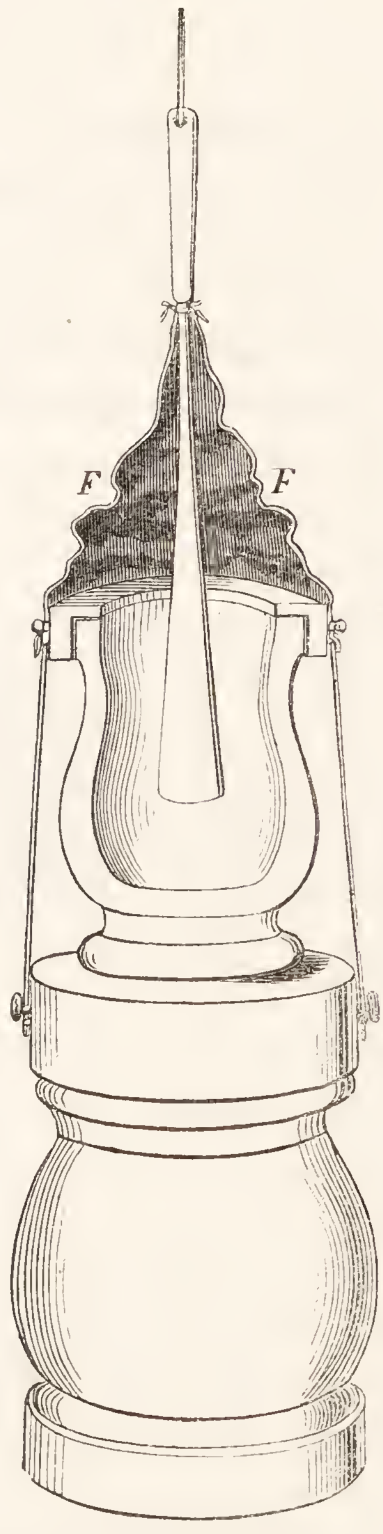



*Fig.* 252.






Mortar and Spring Pestle.

The mortar stands on a wooden block, at such a height that the arms of the operator holding the pestle shall not strike against it.

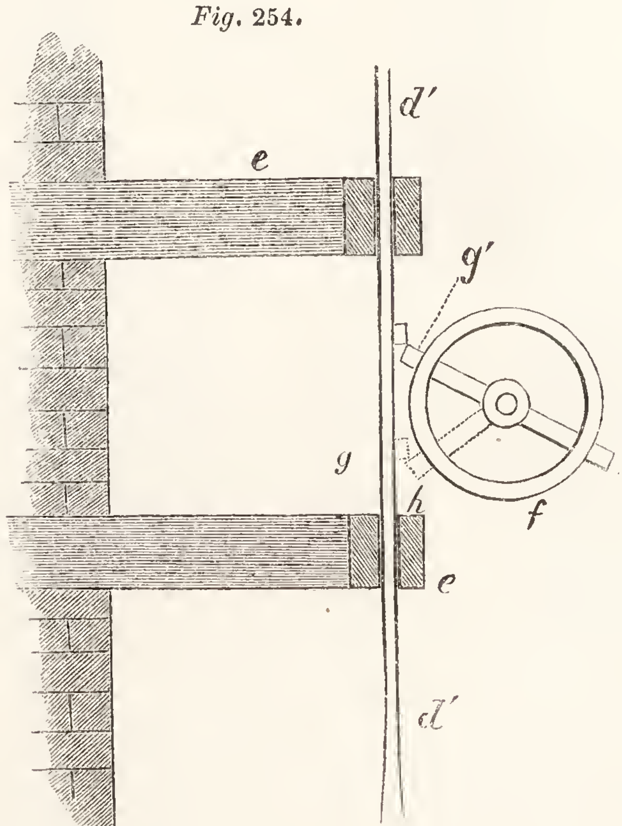
The labour of lifting the heavy pestle is lessened by suspending it from a spring, which, being bent when the pestle is brought down in contact with the bottom of the mortar, carries it up again by the force of its elasticity, without the aid of the arm. The pestle thus suspended is called the *spring-pestle.* The spring generally consists of a thin fir-pole, the thickest end of which is fixed to the ceiling or to the wall, while the pestle is attached by a cord to the other extremity. The length and size of the pole must be suited to the weight of the pestle it is intended to carry.

In fig. 253 a spring of a different kind is represented, the construction of which has been already described at page 24.

The spring should be very securely fastened to a part of the building capable of bearing the continued vibration to which it will be exposed.

The pestle and mortar of the drug-mills differ only from those used in private establishments in regard to the manner of raising the pestle. The whole of the machinery being worked by steam-power, the pestles or stampers are raised by projecting arms attached to a revolving shaft, which carries them to a certain height, and then allows them to fall with the impetus of their own weight. The arrangement by which this is effected is represented in fig. 254, where *d′ d′* is the elongated pestle passing through a frame (*e*); *f* is the revolving shaft, the arm (*g′*) of which, when in the position of the dotted lines at *h* catches a projection on the pestle and carries it up to the point *g′*, from whence it falls. There are generally several of these mortars placed in a row, the pestles of which are all worked by the same shaft. In fig. 266, page 236, two mortars or stampers (*b b*) are represented in connexion with other arrangements of a drug-grinding-room.

*Fig.* 254.



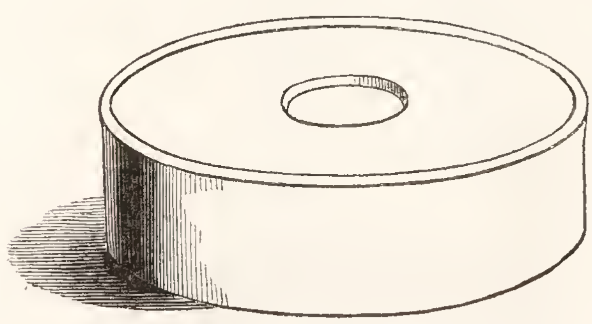

A large and heavy pestle can only be used with good effect when the mortar and its stand are of proportionate size and weight. If the mortar or its stand be too light in relation to the pestle, the blows inflicted by the latter will cause the former to vibrate considerably, without producing an effect upon the substance pounded adequate to the power employed.

In performing the process of pounding, such a quantity of the substance operated upon should be put into the mortar as will form a stratum at the bottom of about three quarters of an inch or an inch in thickness. If more than this be put into the mortar at once, the particles will not be so efficiently comminuted.

It is generally necessary to have a cover to the mortar to prevent particles from being projected out by the force of the blows, and especially to confine the finer particles which, in powdering some substances, become diffused through the atmosphere, causing loss of product, and often much annoyance to the operator.

The most simple kind of cover for the mortar consists of a circular piece of board of the size of the top of the mortar, with a round hole in the centre, through which the pestle passes, and a broad and flat wooden hoop around the circumference, projecting two or three inches below the lower surface of the board, and fitting loosely over the outer rim of the mortar. This is represented in fig. 255. It is the best kind of cover to use in powdering substances which do not become diffused through the air during the process, but some of the particles of which would, nevertheless, be projected out of the mortar if there were no cover to it. As it merely rests on the top of the mortar, and is not fastened down, it is easily removed and replaced, without loss of time, in transferring the pounded substance to the sieve. But this cover, although a sufficient security against the loss of coarse particles, will not prevent the escape of light powders which rise from the mortar through open crevices, and remain suspended for some time in the air. In such cases the leather cover represented in fig. 253 is used. It consists of a conical leather bag (*F F*), which is tacked to a circular frame fitting closely on to the top of the mortar. The pestle passes through the top of the bag which is tied to it with a cord, and the frame is fastened down with string on two opposite sides of the mortar.

*Fig. 255.*



COVER FOR MORTAR.

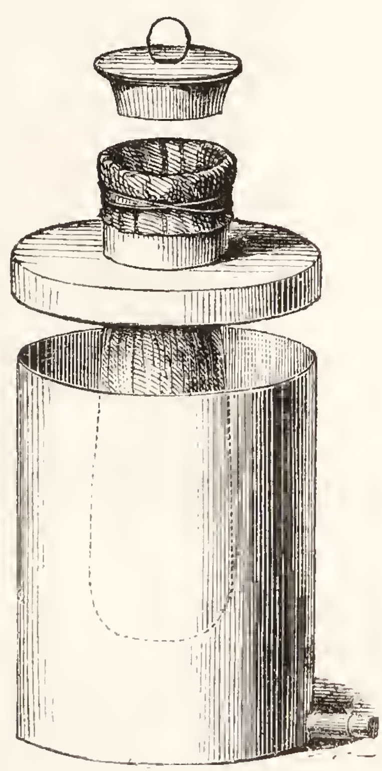
The substance to be powdered having been previously dried in the drying closet, is pounded in the mortar until well comminuted, and the finer particles are then separated from the coarser by means of the sieve. The sieves used for this purpose are called *drum-sieves.* They consist of three parts,—the sieve, its head or cover, and the bottom or receptacle for the sifted powder; these are fitted together so as to prevent the escape of any of the powder during the process of sifting. When the finer particles of the powder have passed through the sieve, the residue is returned to the mortar and further comminuted; the sifting process is then repeated; and thus, by alternately pounding and sifting, the greater part of the substance is obtained in a state of minute division. There will, however, be a residue ultimately left, which will not pass through the sieve, and which is called *gruffs.* This residue is usually kept until more of the same substance is powdered, when it is added to the fresh portion, and again submitted to the process of comminution.

It is sometimes found necessary to dry the substance under operation, and also the sieve, several times during the process, in consequence of the absorption of moisture from the air.

Formerly very fine powders were obtained by the use of what are called *dusting-bags*, and this method appears to be still adopted occasionally in Germany. The dusting-bag is a kind of sieve; it consists of a bag made of lawn or other similar material, which hangs inside a wide-mouthed bottle or a tin canister, to the mouth of which it is secured. The comminuted substance is put into the bag, and the mouth being closed by means of a cover, the apparatus is shaken so that the finer particles of powder pass through the bag, and are collected in the bottle or canister. Figs. 256 and 257 represent the kind of canisters used for this purpose, and fig. 257 also shews the method of placing the bag.

*Fig.* 256.

*Fig.* 257.

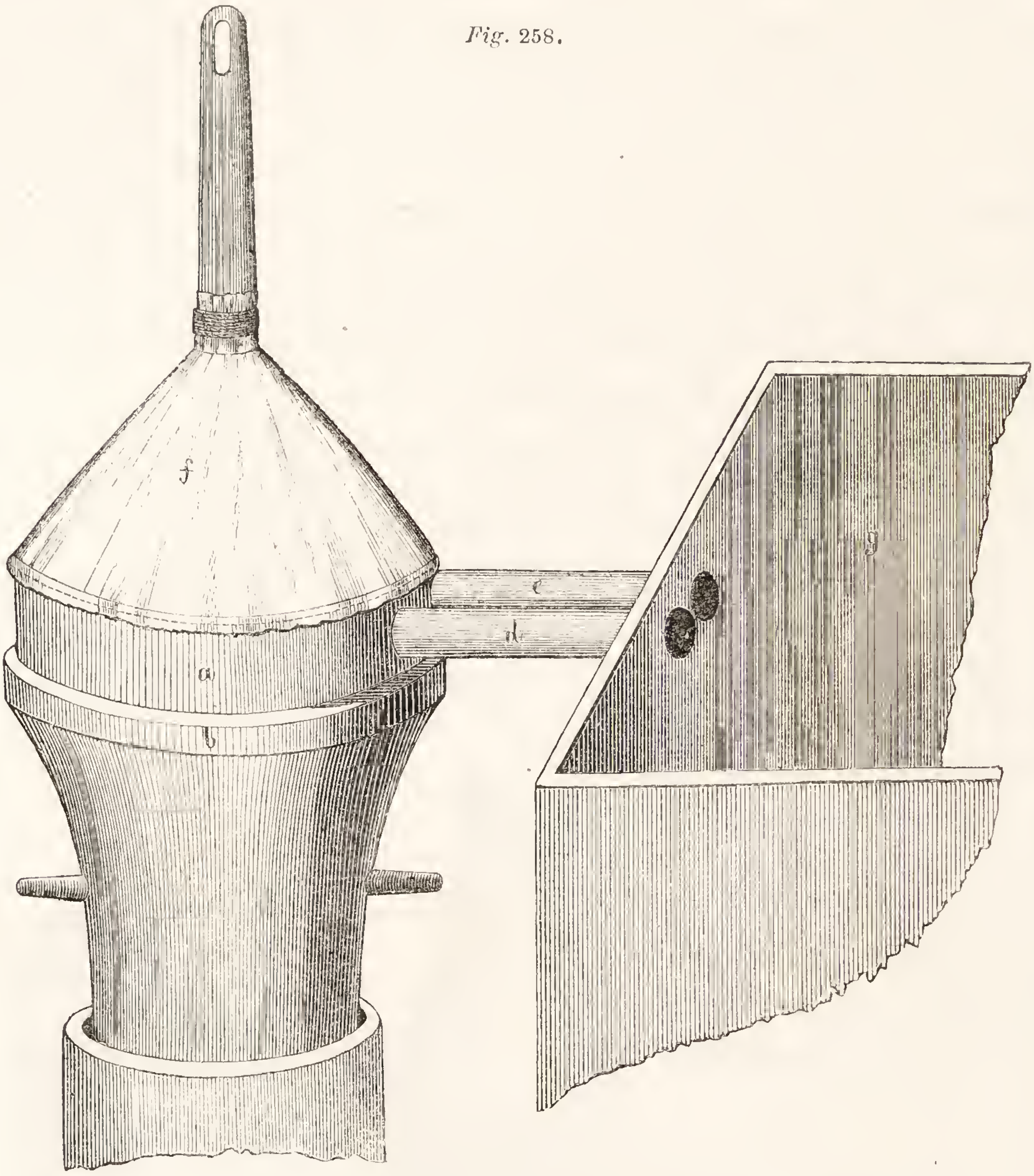


DUSTING BAG.

Dr. Mohr describes an arrangement of apparatus which he has so constructed that the process of comminution and that for the separation of the finer from the coarser particles of powder are carried on simultaneously. This arrangement is represented in the

258. It consists of a mortar (*b*), on the top of which a sheet-iron cylinder (*a*) is fitted, and the leather bag (*f*) is tied to the top of this cylinder, and also to the pestle. Two tubes (*d e*) are inserted in the side of the cylinder, and also into a large square box (*g*).

*Fig.* 258.



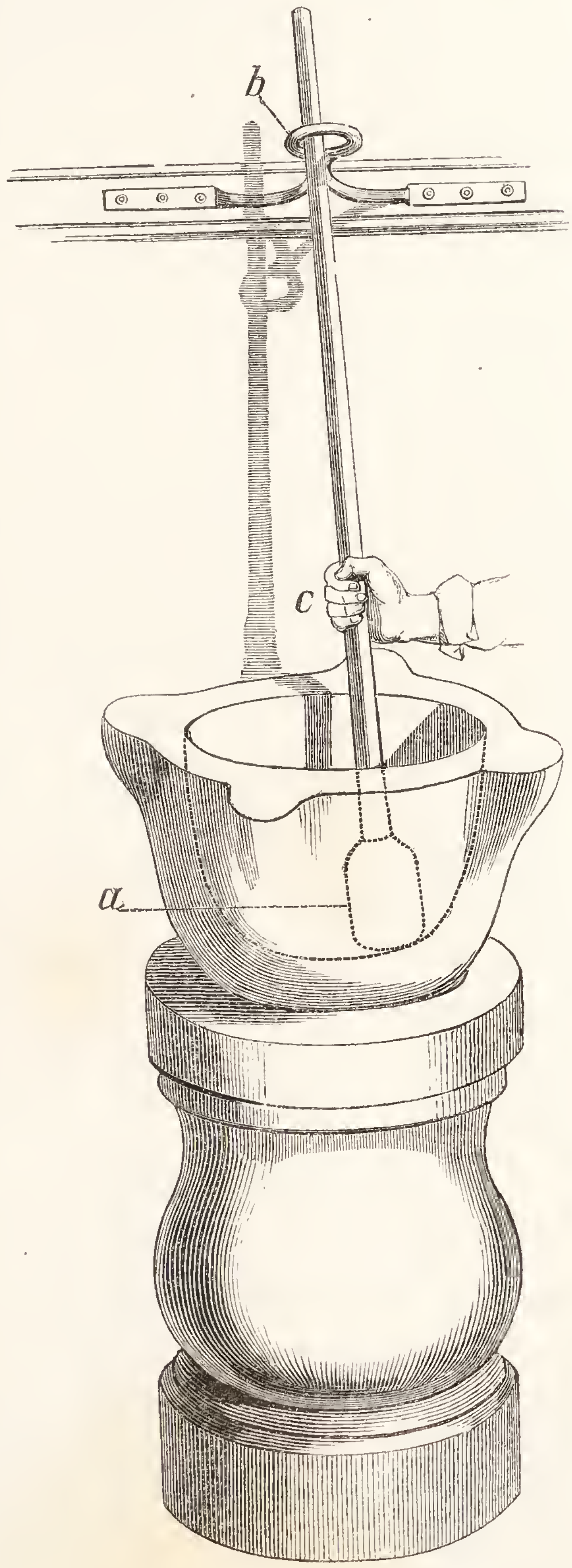

Apparatus for Powdering Drugs.

There is a valve in each of these tubes, one opening towards the box and the other towards the mortar.

The substance to be powdered is put into the mortar and pounded. As the pestle descends, the leather bag being depressed, forces some of the air from the interior of the mortar into the box (*g*) through the tube, the valve of which opens in that direction; and as the pestle again ascends the air is drawn back through the other tube. When the substance in the mortar has been reduced to powder the finer particles, being suspended in the air, are carried over with it into the box, where they subside and are collected. The top of the box is covered with a fine cloth, which allows air to pass, but not the powder. This method of operating is said to answer very well in powdering bark and some other substances, the powders of which are light and readily diffused through the air.

*Trituration.*—The process of trituration, when applied to the pulverization of drugs, is sometimes effected by a pestle and mortar. This, at least, is the usual method of operating when the process is conducted on the small scale. The mortars used in these cases are made either of marble or Wedgewood-ware. Fig. 259 represents a large marble mortar such as is used for trituration. The pestle (*a*), which is generally made of lignum vitæ or other hard wood, but sometimes of marble or stone, has a long handle which passes through a ring (*b*) fixed to the wall at a height of four or five feet above the mortar. The operator holding the pestle at *c*, and, pressing it with greater or less force against the bottom of the mortar, moves it in a circular direction, occasionally enlarging or contracting the extent of the circle, so as to expose the powder more completely to the action of the triturating surfaces. In this way many salts and crystalline and other easily pulverized substances are reduced to powder. The ingredients of compound powders are also mixed by a similar process of trituration.

*Fig.* 259.




Marble Mortar for Trituration.

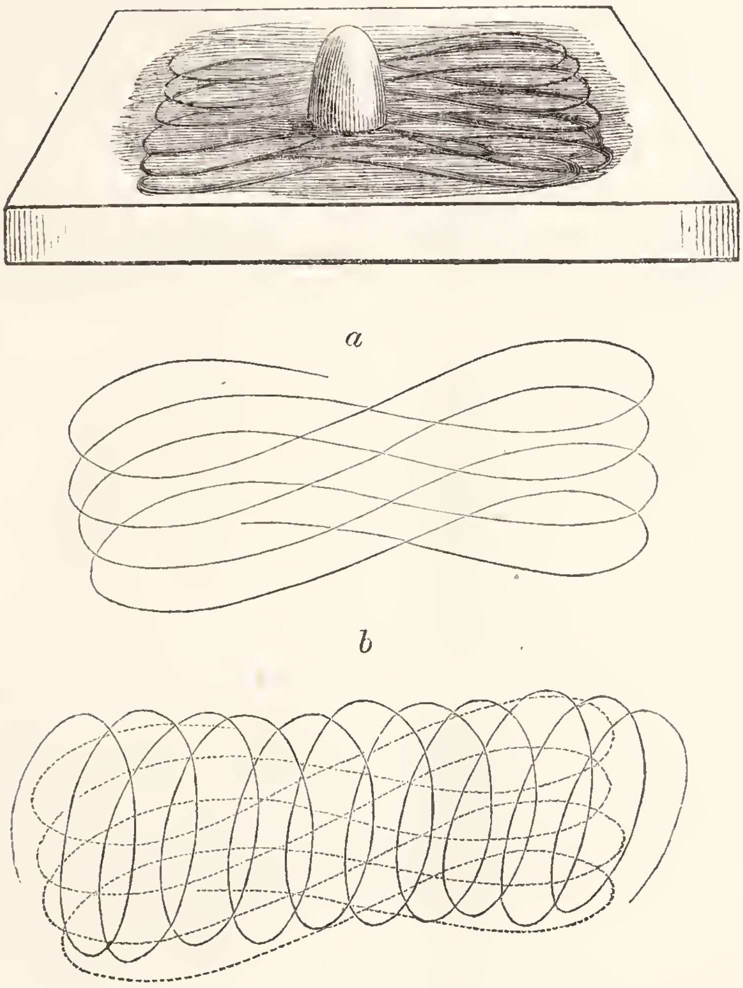
The largest sized triturating mortars commonly used are made of marble, but the use of this material is by no means unexceptionable. It is easily acted upon by acid salts and other substances which may be put into the mortar; moreover, the surface of the marble is readily abraded by the triturating process, and the substance operated upon would thus become contaminated with calcareous matter.

It appears to be difficult to find a good substitute for marble in the construction of mortars for trituration. Wedgewood-mortars are not made of sufficient magnitude or thickness to be suitable for some of the processes alluded to, and porphyry, which would be quite unobjectionable in other respects, is too expensive for common use. Some pharmaceutical implements made of porphyry, including slabs and mortars, were imported from the continent a few years ago, but they were found to be unsaleable, in consequence of their high price. Among them was a triturating mortar of very large size, being twenty-nine inches in diameter, which was purchased by Mr. Bell, of Oxford Street. It has proved to be a most valuable implement in the laboratory, as it resists the action of most chemical agents, and is hard enough and strong enough to admit of the process of contusion, as well as that of trituration, being effected in it. The price originally asked for this mortar was fifty guineas. It is possible that glass, which is now so advantageously applied to the construction of culinary implements, might be formed into mortars of the requisite size for the process here contemplated. Even dolomite or magnesian limestone would probably be better than marble, and would be inexpensive.

Trituration is sometimes effected with the *porphyry slab and muller* (fig. 260). This method, however, is but rarely adopted for powdering drugs. The process by which substances are thus comminuted is called *porphyrization*. The substance under operation is placed on the slab in coarse powder, and if unacted upon by water, is formed into a thick magma with that liquid. It is then distributed in a thin stratum, and triturated by means of the muller, which, being grasped with the two hands of the operator, is rubbed with some degree of pressure over the surface of the slab. In performing this operation the muller is made to describe, in its course, certain regular curvilinear figures, representing either a figure of eight, as at *a*, or a series of intersecting circles, as at *b*; and these figures are alternated from time to time, so that by changing the direction in which the muller is moved a fresh set of particles may be brought under its action. In this way comminution is effected over an extended surface upon a very thin layer of the triturated substance, and the action is therefore more complete and uniform than that produced by the use of the pestle and mortar.

Trituration over a slab, usually of slate, with a great number of mullers worked in different directions by machinery, has been very successfully applied in the manufacture of blue pill and mercurial ointment.

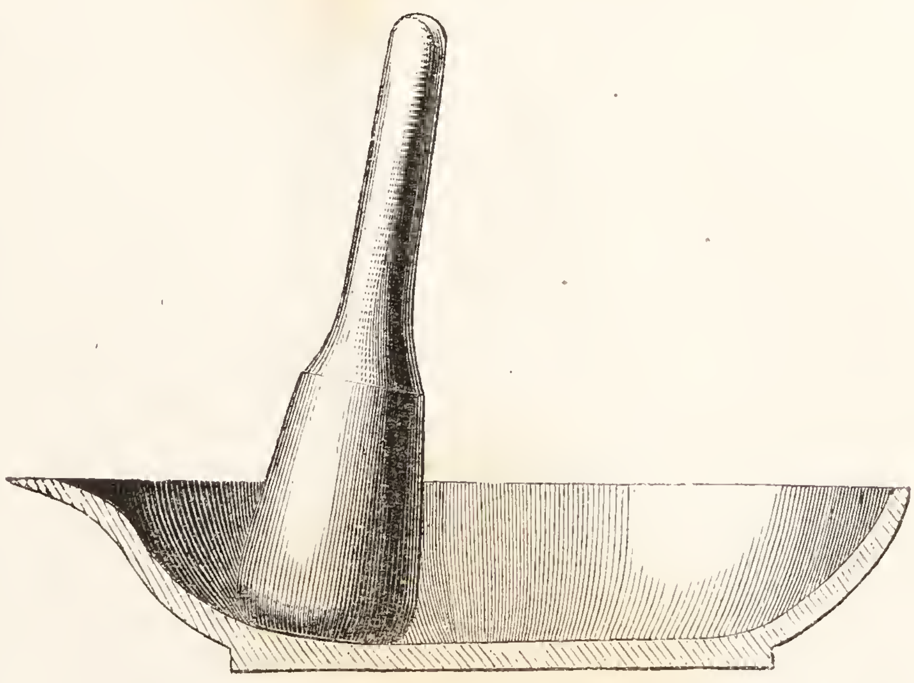
*Fig.* 260.



PORPHYRY SLAB AND MULLER.

The process by which substances are reduced to a state of minute division by rubbing them between two hard surfaces when formed into a paste with water, is sometimes called *levigation*, and is thus distinguished from ordinary *trituration*, in which the comminution is effected without the intervention of a liquid.

*Fig.* 261.



LEVIGATING VESSEL.

In Germany a shallow porcelain vessel is substituted for the porphyry slab, in the levigation of substances which are triturated with water. Fig. 261 represents a section of the vessel thus used.

In performing the process of levigation it is necessary to apply some amount of pressure beyond that which the weight of the pestle, as usually constructed, would produce; and this is most conveniently effected by means of an elastic pole fixed to the ceiling, as shewn in fig. 264. The wooden spring (*c*) is fixed to a beam in the ceiling at *a*; it is also secured by a staple at *b*; and there is a square block of wood attached to it at *d*, with a conical hole in the centre, in which the pointed end of the handle or shaft of the pestle works.

Fig. 262 is a representation, on a larger scale than fig. 264, of the pestle, standing in a levigating vessel, with a view of the end of the spring, and the arrangement by which the length of the shaft of the pestle is lengthened or shortened. The dotted lines (*a*) shew the position of the spring in its unstrained state, before applying any pressure. On lengthening the shaft (*d*) by means of the binding screws (*e f*) the spring will be raised to the position of *b*, and the pressure of its elasticity will be imparted to the pestle.

Fig. 263 represents another method of adjusting the length of the shaft of the pestle, and thus regulating the amount of pressure.

*Fig.* 262.

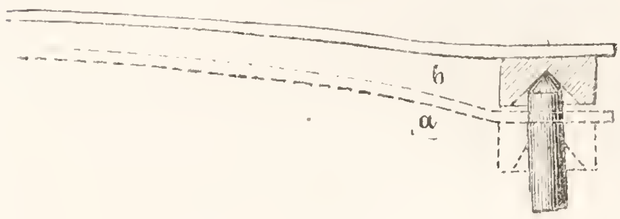
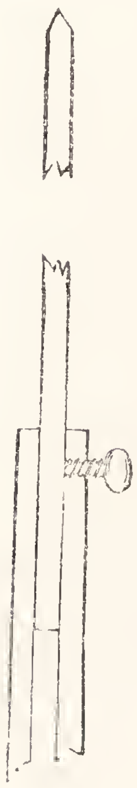
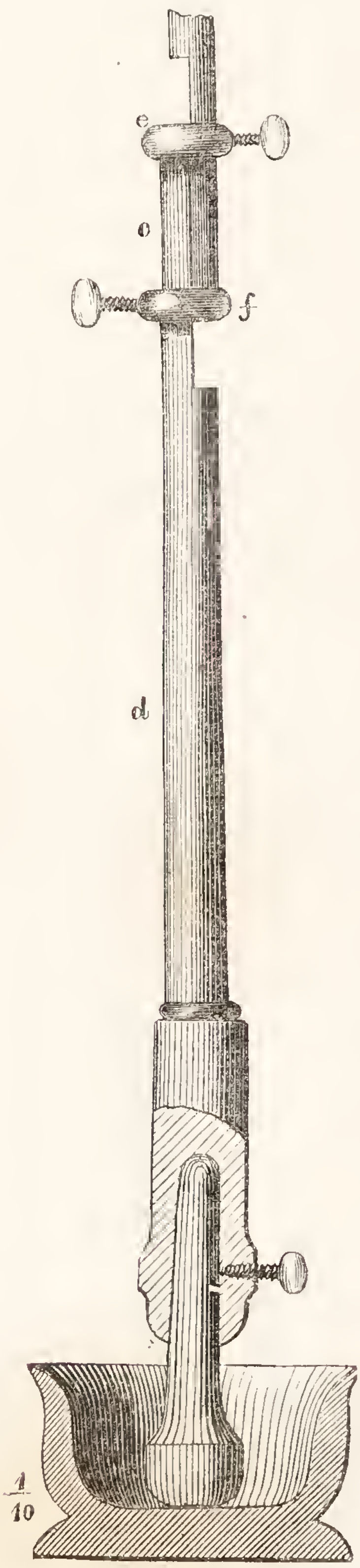



*Fig.* 263.

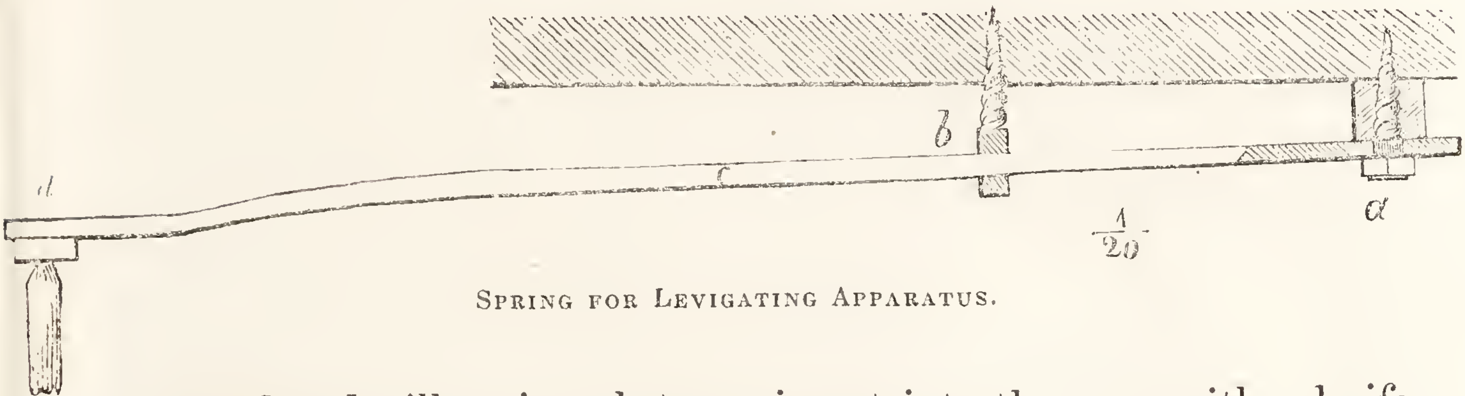





Spring Pestle for Levigation.

Substances which have been prepared in a finely divided state by levigation are sometimes formed into little conical masses while in the moist state, with the view of facilitating their subsequent desiccation. This is effected by means of a small mould, such as that represented by fig. 265. The mould consists of a hollow metallic cone (*d*), which is fixed in a circular wooden frame (*b*), having a small leg or support (*a*), and a handle (*c*). The apparatus being supported in the position shewn in the drawing, the

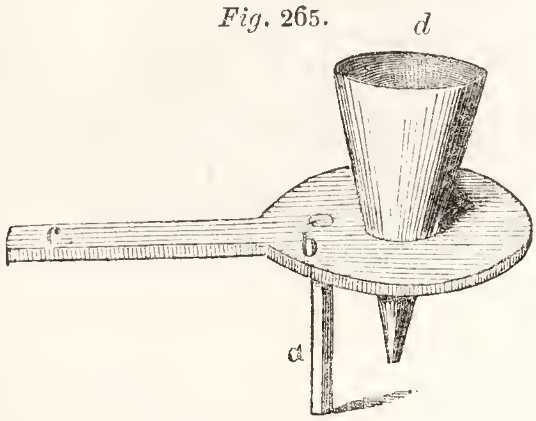
*Fig.* 264.




SPRING FOR LEVIGATING APPARATUS.

levigated and still moist substance is put into the cone with a knife, and the mould is then inverted over a chalk-stone or other absorbing surface, and the leg (*a*) slightly tapped until the conical mass falls out. The nodules, thus prepared, are subsequently dried by exposure to a current of air. In this way the conical nodules of levigated chalk, bole, and other substances, are made.

*Fig.* 265.

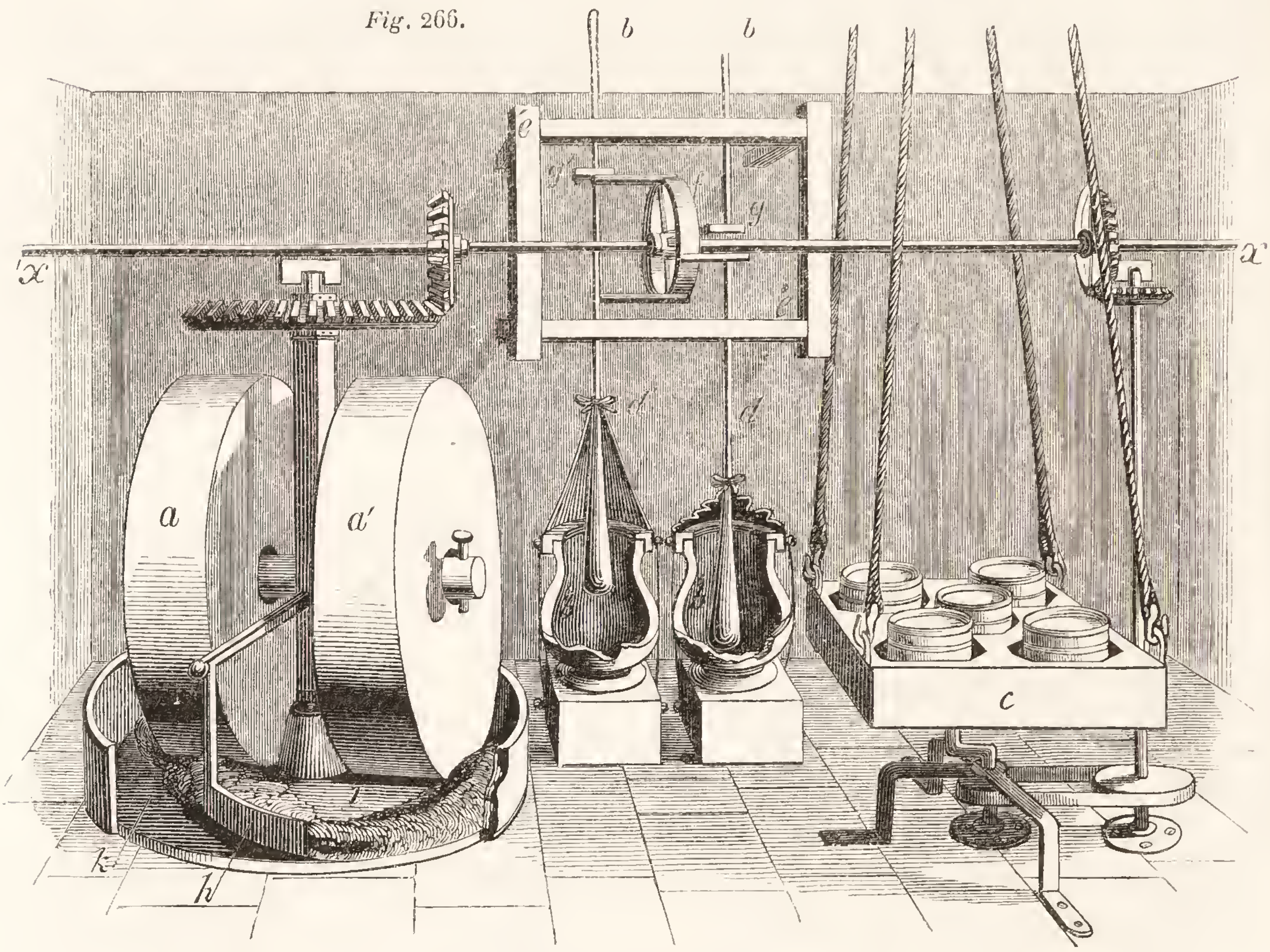



CONICAL MOULD FOR LEVIGATED CHALK, &c.

There yet remains to be described a method of effecting the comminution of drugs by trituration, which is that principally adopted by drug-grinders. The apparatus employed for this purpose is similar in construction to that which has been already described as the drug-mill or pugging-mill, at page 82. When used for powdering drugs it is generally made with two stone runners, as shewn at *a a′*, fig. 266. The runners work on a platform of hard stone or iron, on which the substance to be powdered is placed, and they are put into motion by steam-power, communicated through a revolving shaft (*x x*), which extends across the room. The plough (*h*) gathers the powder which has been scattered by the stone that has passed, and turns it into the path of the approaching stone, as shewn at *i* and *k*.

This mill is a most efficient instrument for effecting the comminution of drugs. The runners, which are made of granite or other hard stone, and usually weigh a ton or more, break down or tear asunder the hardest and toughest substances. The disintegration is effected partly by the weight of the stone, and partly by the grinding action produced in consequence of the outer and inner edge of the revolving cylinder (*a*), which are both equal, being made to perform unequal circuits in the same time. Thus, if either

*Fig.* 266.




APPARATUS FOR DRUG-GRINDING.

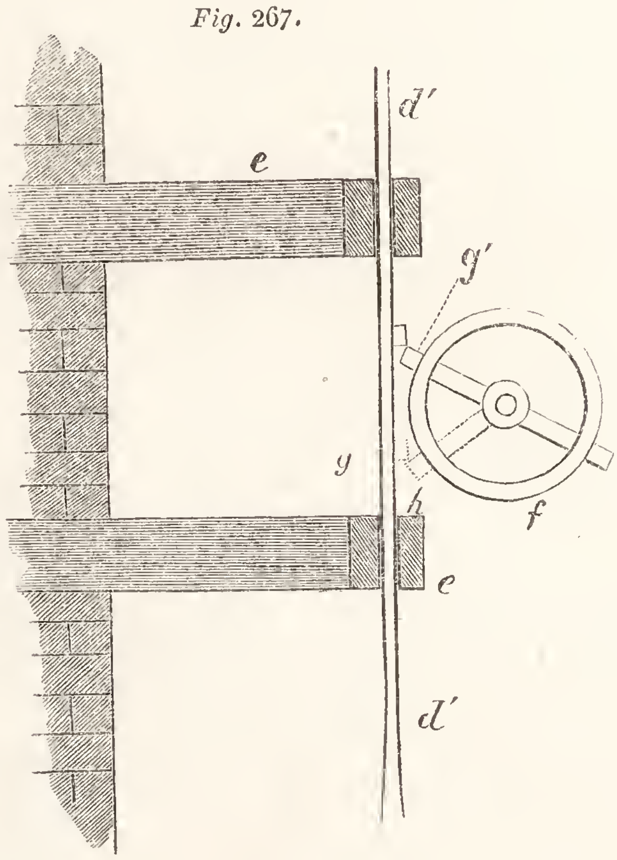
*a a′.* Drug Mill. *h.* The Plough. *b b.* Stampers.
*e e.* The Guiding-frame for Stampers. *c.* Sifting Apparatus.

of the cylinders were simply trundled, without control, it would proceed in a straight line, but being made to describe a circle immediately around the central beam, the outer edge of the cylinder has to travel through a longer path than that assigned to the inner edge: so that every advance onwards, by which the weight or pressure is imposed upon a new surface, is accompanied by a lateral friction caused by the unequal progression of the two edges of the cylinder.

*Drug-grinding.*—The operations connected with the pulverization of drugs on the large scale, commonly called drug-grinding, present some points of interest even to the retail pharmaceutist. The implements used by the drug-grinder for effecting comminution are, as already stated, the grinding-mill and the stamper. The former of these is principally used, the stamper, or pestle and mortar, being employed only in some particular cases, where the quantity to be operated upon is small, or where it is important to confine very carefully the dust arising from the process.

A drug-grinding-room usually contains a pair of stones ($a$ $a'$) fig. 266; a set of stampers, such as $b$ $b$, and a sifting apparatus ($c$). These are all worked by the same shaft ($x$ $x$), which extends across the room.

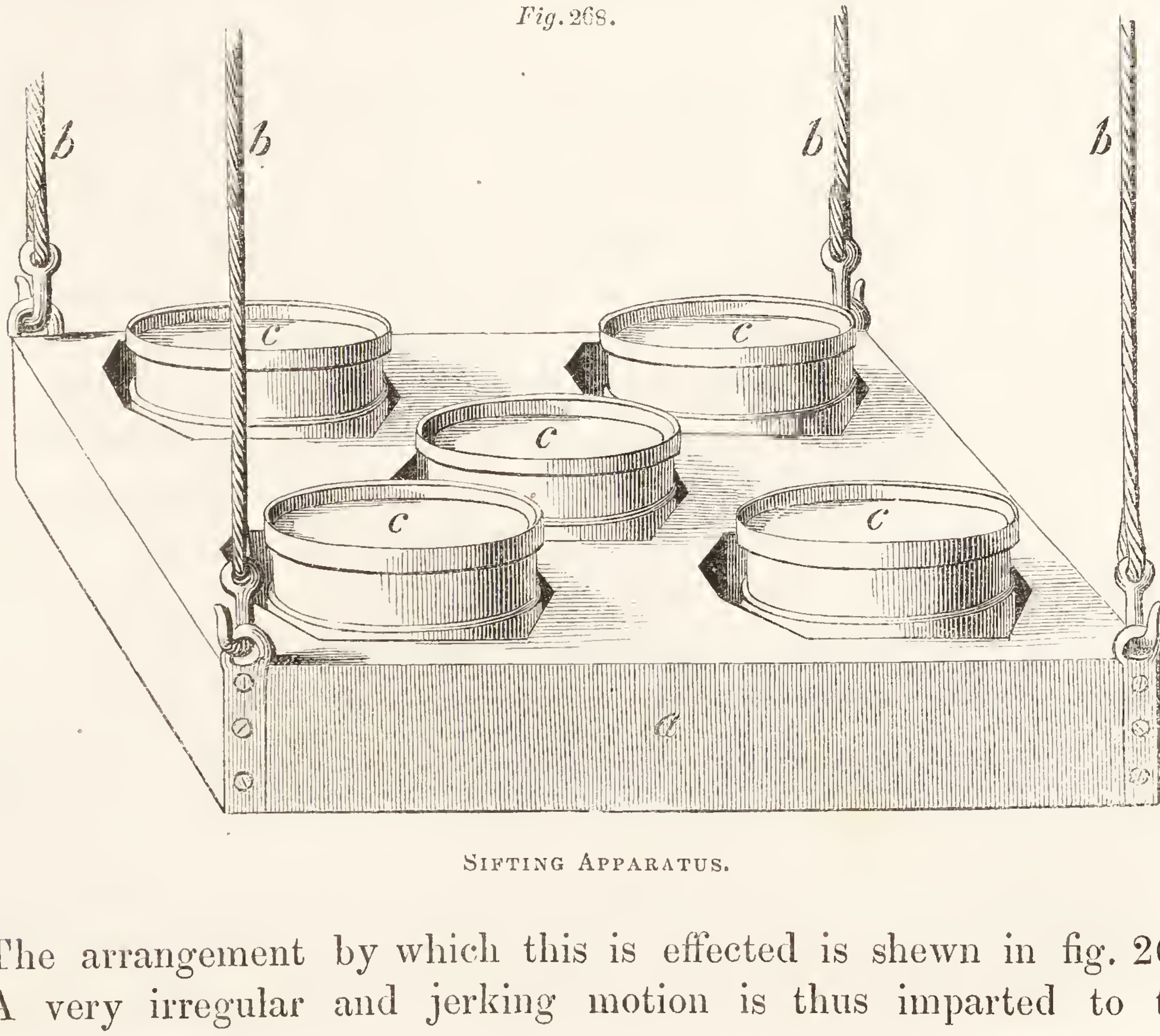
*Fig.* 267.




The stampers ($d'$ $d'$), which pass through the guiding-frame ($e$ $e$) are raised by the arms ($g$ $g'$) of the revolving wheel ($f$), as shewn in fig. 267.

The sifting apparatus consists of a square wooden frame ($a$), fig. 268, in which there are five or six octagon-shaped holes for the reception of the drum-sieves ($c$). This frame is suspended from the ceiling by four ropes or chains ($b$). The frame is put into motion by a spindle ($e$), fig. 269, which works in a square socket in the bottom of the frame, and is turned by an endless strap ($d$).

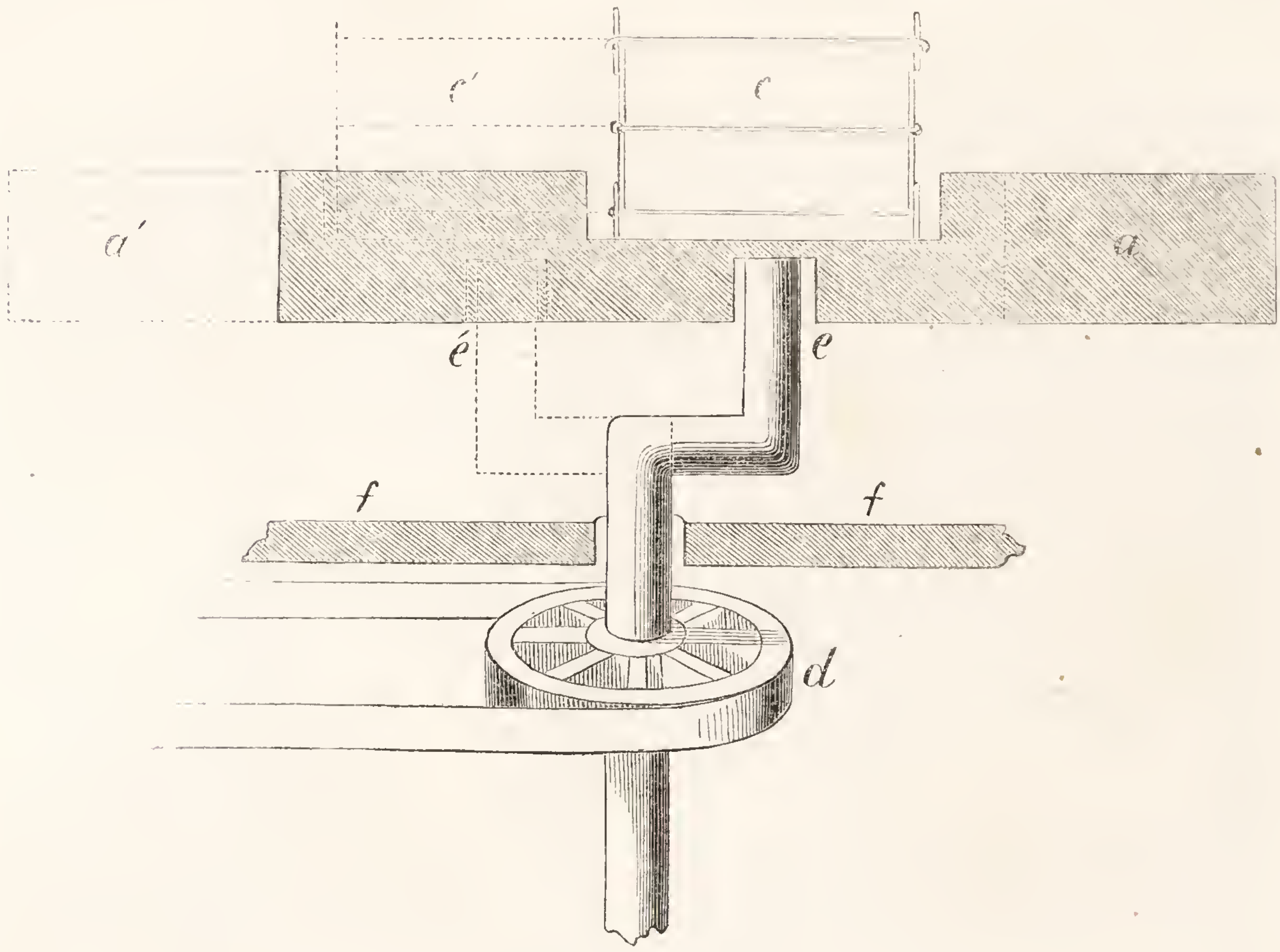
*Fig.* 268.




Sifting Apparatus.

The arrangement by which this is effected is shewn in fig. 269. A very irregular and jerking motion is thus imparted to the frame (*a*), and from thence to the sieves (*c*), by the joint action of the revolving crank and of the ropes by which the frame is

*Fig.* 269.




SIFTING APPARATUS.

suspended. The sieves employed in the process are the common drum-sieves.

The first operation connected with the grinding of drugs consists in drying them. If they are in large masses, these are cut or broken into small pieces to facilitate the drying process, and also to prepare them for being put under the stones when dry enough to be powdered. The drying is generally effected in a room heated to about 120°, by means of a stove or steam-pipe. The most common method of heating the drying-room appears to be by the use of a cockle, that is, a stove having an outer case or jacket, between which and the fire-case there is a space for the circulation of air. A great many different forms are given to the cockle, which is sometimes made of iron, and sometimes of brick, but it should always be so placed that the fire can be fed from the outside of the room, so that the atmosphere of the room may not be contaminated with smoke or dust. The substances to be dried are spread out on trays of similar construction to those described in connexion with the drying-closet at page 26.

The drying process being completed, the substance is placed on the platform of the mill, in the path of the stones (*a a′*), where it is ground until sufficiently comminuted for the commencement of the next operation, namely, that of sifting it. The two operations of grinding and sifting are then continued simultaneously, the operator transferring a portion of the powder from the mill to one of the drum-sieves (*c*), which latter, with its contents, is put into its appropriate receptacle in the frame of the sifting apparatus, where it is subjected to the requisite succussion. The residue, which does not pass through the sieve, is returned to the mill, and a fresh portion of powder taken out to be sifted; and this mode of proceeding is continued without suspending the motion of any part of the machinery, until the process is finished.

In using the stampers, it is necessary to suspend the pounding or stamping, while the substance under operation is being removed from, and introduced into, the mortar, which somewhat retards the process.

The facility with which drugs are reduced to powder by the means which have been described, depends in great measure upon the extent to which they are previously dried. If they be not deprived of their hygrometric water to the greatest extent practicable by exposure in the drying-room, it will be difficult, if not impossible, to produce perfectly smooth and impalpable powders, such as are now generally used in medicine. This drying is, of course, accompanied by a loss of weight, arising from the water which is driven off, and which varies considerably in different drugs, and also in different specimens of the same kind of drug. There is always, however, a little moisture again absorbed during the process of grinding. In some cases this re-absorption takes place to a considerable extent, so that it may be necessary to renew the drying before the process is concluded, if the atmosphere of the room be at all damp. This is the case with squills, jalap, rhubarb, aloes, and colocynth.

There are some drugs which, however carefully they may be dried, are, nevertheless, with great difficulty reduced to powder by the ordinary method of proceeding. Nux vomica, St. Ignatius' beans, and the tuberous roots of the orchis, belong to this class. They are tough and horny, and can hardly be powdered without a particular treatment. The best method of preparing nux vomica and St. Ignatius' beans for pulverization is, to expose the seeds to the action of steam until they have swelled to about twice their original size, and then to dry them rapidly in the drying-room. The roots of the orchis, which are ground to make saloop powder, should be macerated in cold water until they have become soft, and then dried as in the other case. After being thus treated they are easily powdered.

Some substances cannot be powdered alone; they require the addition of other bodies which facilitate the disintegration. Thus the addition of a few drops of spirit renders the pulverization of camphor easy, although it could not be effected without it. The process, when thus conducted, is sometimes called *pulverization by mediation.*

It is a common practice with drug-grinders to add a small quantity of olive oil or oil of almonds to some drugs during the process of grinding. This is found to facilitate the comminution, and greatly to improve the appearance of the powder.

Agaric is a substance which it is extremely difficult to powder alone, and a method has therefore been proposed for powdering it by mediation. It is cut into small pieces, wetted with mucilage of tragacanth, and then dried, previously to submitting it to the process of grinding. The addition of a foreign body, which the powder retains, cannot, however, be sanctioned, excepting under particular circumstances, such as the impossibility of otherwise effecting the object. It is stated in some pharmaceutical works that colocynth is powdered by mediation, in the same way as that above described for the pulverization of agaric; but in this case the addition of a foreign body is certainly unnecessary, and I believe that no such addition is made by the drug-grinders in this country.

Phosphorus is powdered by mediation, and this, indeed, is the only way in which it can be obtained in a state of minute division. The best mediatory substance to use is spirit. The phosphorus being put into a bottle with some spirit, a gentle heat is applied, by plunging the bottle into warm water, until the phosphorus melts; the mouth of the bottle is then closed and brisk agitation continued until it has cooled, when the phosphorus will be found to be in a finely-divided state. Water might be substituted for spirit, but does not answer so well.

A method of a somewhat analogous nature to that last described is adopted for powdering some salts which are not easily reduced to powder by trituration. The salts are dissolved in water, and the solution evaporated to dryness whilst constant and active agitation is maintained. This is a very convenient and economical method of obtaining salammoniac in powder. It is also adopted for granulating salt of tartar, and tartrate of potash.

Substances, the particles of which readily adhere when submitted to pressure, but which, nevertheless, are not held together by a strong cohesive force, are sometimes powdered *by friction* over a perforated surface. Thus magnesia and other similar substances, are merely rubbed over the surface of a sieve.

Such are the various methods adopted in effecting the pulverization of drugs, and which are applied, according to the requirements of the several cases, to most kinds of solid substances employed in medicine—to some, in order to make them more suitable for administration—to others, in order to fit them for subsequent operations. It is, therefore, an interesting and important subject of enquiry, in connection with a process of such general use in the preparation of medicines,—how far is it practicable to preserve the chemical condition of the substances operated upon unaltered, and their medicinal efficacy unimpaired?

The operations connected with the processes of drug-grinding do not seem to be calculated to promote chemical change in the constituents of the powder; for, although the disintegration, by exposing a larger surface to the action of the air, may be somewhat unfavourable to the permanence of the proximate constituents of vegetable substances, yet the complete desiccation which forms part of the process will exercise a conservative influence to probably an equal extent. This, at least, would be the case if the powder, when prepared, be put into close bottles and kept for only a moderate length of time.

The principal, if not the only necessary, cause of deterioration to the product in the process of drug-grinding, is the long-continued application of heat to which the drugs are exposed in the drying-room. There are many substances which cannot be thus dried without having a portion of their active volatile ingredients driven off, as well as the water they contained. The strong smell which fills the drying-room when opium, or myrrh, or cinnamon, are under operation, affords sufficient evidence that some volatile matter besides water is escaping, and that the resulting powders cannot strictly represent the drugs from which they are made. All substances which contain volatile principles must lose a portion of these during the drying process which precedes and sometimes accompanies that of pulverization; and if the efficacy of the medicine depend upon these volatile parts, the product must be injured by the process to which it is submitted. Thus, myrrh, valerian, cardamoms, cinnamon, and spices generally, lose some of their efficacy in being reduced to fine powder.

But a large proportion of our drugs are not subject to deterioration from loss of volatile constituents; and in these cases, if care be exercised in conducting the process of drying, the powders obtained by the usual method of operating, will possess all the medicinal properties of the crude materials. Thus, rhubarb, jalap, ipecacuanha, colocynth, scammony, gamboge, and many other drugs, are not necessarily injured in the process of powdering.

There are some drugs which not only suffer no injury in being powdered, but which actually contain, when pulverized, a larger proportion of the active constituents than were present in the crude unpowdered substance. This arises from the circumstance that the less active parts are separated and rejected during the process. Thus, for instance, the powder of ipecacuanha, if properly prepared, contains more of the emetic principle than the root from which it is made. The principle upon which the emetic property of ipecacuanha depends, exists chiefly in the cortical part of the root, and as this is the most easily pulverizable, it passes first through the sieve, while the less active ligneous part, being more tough, remains to the last, and may be, and generally is, rejected as gruffs.

Besides the loss of water and other volatile constituents, which are driven off in the drying-room, there is also, necessarily, a dissipation and loss, to a certain extent, of solid particles of powder, which are diffused through the atmosphere of the room in which the pulverization is conducted, or which adhere to the apparatus.

With these exceptions the product, including the gruffs or unsifted part, ought to be identical with the substance it represents; that is to say, should consist of the same particles, and no others, in the same chemical condition as they existed in previously to the process of powdering.

If no active constituents be lost in the drying process, the strength of the powder will be greater than that of the crude drug, to the extent of the quantity of water and inactive matter which have been separated and rejected. It would be very desirable to ascertain what the average increase of strength is in those drugs which suffer no deterioration in the process of powdering; and also what is the exact nature of the deterioration necessarily sustained by drugs such as myrrh, ginger, cardamoms, and cascarilla, which contain, and must therefore lose, active volatile constituents.

Next to the preservation of the medicinal efficacy of the drug, the most important object for attainment is uniformity of strength in the product. What security has the physician that a grain of opium, or ten grains of jalap, obtained from a particular source, shall be equivalent to the same quantities of those substances obtained elsewhere?

There are several causes which tend to affect the uniformity of the strength of those medicines which consist of parts or crude products of plants. In the first place, these drugs, in their natural or original state, are not uniform in composition and properties. Different specimens of cinchona bark yield very different proportions of the alkaloid, upon which the efficacy of the drug depends; other drugs differ to an equal extent,—in fact, what drug can be mentioned of which there are not good and bad specimens in the market. The practical knowledge and experience of the druggist are called into requisition in selecting the good from the bad, and thus two classes, at least, are formed. It must be admitted, however, that the criterions of excellence usually adopted in these cases are often founded upon qualities of an extrinsic character, which have no definite relation to medicinal properties.

There are other causes which affect the uniformity of strength and properties of drugs in their more advanced states of preparation.

That drugs are sometimes adulterated is a notorious fact. That the practice of adulteration has prevailed to an extent greatly prejudicial to the advancement of the science of medicine, and discreditable to the medical legislation of the country, admits not of a doubt. But a great and progressive improvement has certainly taken place within the last few years, and there is, at the present time, an evident desire among wholesale and retail druggists, to discourage and suppress the sale of bad drugs.

We may discard as unworthy of notice the exaggerated statements which have been published with reference to the wholesale substitution of fabricated powders for genuine drugs. Such cases, if they ever existed, must have been isolated and extraordinary exceptions to the practice generally pursued. There is reason to believe, however, that absolute identity of composition between the powders used in medicine, and the drugs they represent, is not always maintained to the greatest practicable extent; and among the causes tending to this effect, there is probably none more influential than the conventional practice of the trade, in reference to the allowance for loss of product during the process of drug-grinding.

It has already been stated that the loss of weight which drugs undergo in the process of grinding is occasioned by the evaporation of water and other volatile constituents in the drying-room, and by the waste from dissipation in the form of dust, and from adhesion to the apparatus in the grinding-room. It must be obvious that the amount of loss thus sustained will not be uniform; it will vary according to the nature of the substance under operation, and even with substances of the same nature the loss will depend upon the quantity operated upon at a time and their state of dryness when sent to the mill. Some drugs are frequently met with in commerce in a perfectly moist state, such as opium, aloes, scammony, and jalap. The loss of weight in drying these drugs must of course be considerably greater than that which occurs with other less moist specimens, or with substances such as rhubarb, ipecacuanha, or bark, which are never met with in a moist state. Now there is in this variable condition of drugs as to dryness, a source of disagreement between the druggist and the drug-grinder, which probably has led to the adoption of a practice that has prevailed throughout the trade, with one or two recent exceptions, of making a uniform allowance for loss of weight in grinding, whatever the nature or quality of the drug might be.

The rule which for many years has been adopted among the London drug-grinders, is to allow four pounds on every hundred-weight of the substance ground for loss in the process. Thus, if a hundred-weight (112 lbs.) of rhubarb be sent to the drug-grinders, 108 lbs. of powder, including the gruffs, are returned. It matters not what condition the rhubarb may be in, the drug-grinder is expected to produce 108 lbs. of powder from the hundred-weight of raw material. The same allowance is also made, unless otherwise agreed between the parties, for all other drugs which require drying previously to their being powdered. In some cases the practice appears to be to receive 116 lbs. of the undried drug, and to return 112 lbs. of dry powder. This is called the four per cent. system; four pounds being the allowance for loss upon every hundred-weight of substance powdered. Some substances, however, such as cream of tartar and sulphuret of antimony, do not require to be dried before being powdered, and the allowance for loss on these substances is only two per cent.

There has, until quite recently, been only one exception to the adoption, to a greater or less extent, of this, which is called the per centage or four per cent. system, by the drug-grinders of London; and so completely does the system appear to have been established by long custom, that although several attempts have been made to relinquish it, yet there are still some druggists who contend that the specified allowance is a fair average of the loss necessarily occurring in the process of drug-grinding.

I am indebted to Messrs. S. and G. Allen, for a statement extracted from their books, shewing the loss of weight sustained in powdering drugs at their mills. Every drug powdered at this establishment is weighed when received at the mill; and the ground products, consisting of fine powder and gruffs, are again weighed before being returned to the druggist. These weights are all entered in their books, a separate account being kept for each kind of drug; so that by taking an average of the results upon large quantities, consisting of a great number of specimens received from different druggists, a near approach to a correct estimate is no doubt attained.

The first column of figures in the following table represents the whole quantity of the specified drug which has been ground at several different periods; the second column indicates the greatest amount of loss on any one specimen; the third column indicates the smallest amount of loss on any specimen; and the last column gives the average upon the whole.

| Name of drug. | Total weight. | Greatest loss per cwt. (112 lbs.) | | Smallest loss per cwt. (112 lbs.) | | Average loss per cwt. (112 lbs.) | |
|---|---|---|---|---|---|---|---|
| | lbs. | lbs. | oz. | lbs. | oz. | lbs. | oz. |
| Aloes, Barbadoes | 379 | 9 | 12 | 0 | 7 | 5 | 12 |
| „ Hepatic | 997 | 16 | 8 | 3 | 8 | 9 | 6 |
| „ Socotrine | 882 | 12 | 0 | 4 | 0 | 9 | 4 |
| Calumba root | 733 | 12 | 0 | 1 | 12 | 6 | 6 |
| Canella alba | 460 | 12 | 0 | 1 | 0 | 9 | 0 |
| Cantharides | 1006 | 3 | 0 | — | | 1 | 8 |
| Cardamoms | 348 | 9 | 8 | 2 | 10 | 5 | 12 |
| Cascarilla bark | 794 | 8 | 14 | 2 | 0 | 6 | 0 |
| Cinchona bark, pale | 1547 | 7 | 8 | 4 | 0 | 6 | 6 |
| „ yellow | 1039 | 11 | 0 | 2 | 8 | 6 | 2 |
| Colocynth | 1034 | 11 | 8 | 3 | 8 | 6 | 8 |
| Cubebs | 1551 | 2 | 10 | — | | 1 | 10 |
| Dragons blood | 1004 | 13 | 0 | 1 | 4 | 5 | 12 |
| Elecampane | 1585 | 16 | 0 | 2 | 12 | 9 | 3 |
| Fœnugreek | 2593 | 13 | 0 | 2 | 0 | 7 | 10 |
| Gamboge | 1009 | 6 | 8 | 1 | 0 | 2 | 12 |
| Gentian root | 5368 | 16 | 0 | 4 | 0 | 9 | 4 |
| Ginger, Jamaica | 8046 | 12 | 8 | 6 | 0 | 7 | 10 |
| Gum Arabic | 11,215 | 12 | 0 | 4 | 0 | 8 | 0 |
| Ipecacuanha | 2579 | 7 | 0 | 1 | 4 | 5 | 3 |
| Jalap | 9446 | 15 | 8 | 5 | 0 | 8 | 12 |
| Liquorice | 1255 | 12 | 0 | — | | 6 | 3 |
| Myrrh | 2762 | 16 | 0 | 3 | 12 | 8 | 6 |
| Opium | 505 | 18 | 0 | 6 | 0 | 14 | 14 |
| Orris root | 3625 | 10 | 12 | 4 | 3 | 6 | 12 |
| Rhatany | 81 | 8 | 0 | 2 | 10 | 6 | 0 |
| Rhubarb, English | 1346 | 12 | 0 | 3 | 0 | 7 | 13 |
| „ Indian | 5777 | 7 | 0 | 2 | 0 | 6 | 0 |
| „ Turkey | 2018 | 8 | 4 | 3 | 0 | 5 | 12 |
| Sarsaparilla, Jamaica | 689 | 14 | 0 | 1 | 12 | 10 | 1 |
| Scammony | 1161 | 13 | 0 | 2 | 8 | 7 | 4 |
| Seeds, Anise | 2839 | 16 | 0 | 1 | 0 | 5 | 12 |
| „ Caraway | 1569 | 13 | 8 | 2 | 8 | 8 | 12 |
| „ Coriander | 1063 | 16 | 14 | 1 | 4 | 5 | 9 |
| „ Cummin | 1142 | 12 | 0 | 1 | 4 | 5 | 4 |
| Senna | 606 | 11 | 8 | 3 | 8 | 6 | 6 |
| Squill | 974 | 15 | 0 | 8 | 0 | 12 | 8 |
| Tormentilla root | 231 | 12 | 8 | 2 | 0 | 6 | 12 |
| Tragacanth | 2077 | 13 | 12 | 6 | 12 | 8 | 4 |
| Turmeric | 5663 | 8 | 0 | 1 | 8 | 4 | 0 |
| White Hellebore | 5533 | 10 | 12 | 2 | 2 | 6 | 4 |
| Valerian root | 279 | 16 | 8 | 4 | 0 | 8 | 8 |

It appears from this table that the average loss in powdering drugs is more than four per cent. in nearly all cases, and that in some it is considerably more. Now, can it be reasonably supposed that, in these cases, the drug-grinder will supply good rhubarb or jalap, gentian or ginger, for the water which has been imbibed in a damp warehouse or cellar? He is required to make up a certain quantity of powder, evidently more than the crude drug produces, but how is he to do it? Does he keep a stock from which to supply the deficiences of all the drugs he grinds, and go to market and purchase more when his stock is exhausted; or is there some magical power in his mill?

A drug-grinder's mill (*a a*, fig. 266) is a very different thing from the pestle and mortar of the druggist, although they are both employed for the same purpose. The druggist, when he has used the pestle and mortar, cleans it preparatory for the next operation, by washing it out with water. The drug-grinder also requires to clean his mill. Rhubarb must not be ground after aloes, nor ginger after jalap, without previously well cleaning the ponderous stones and other parts of the apparatus. But how shall this be done? A drug-mill cannot be cleaned by washing it with water,—if for no other reason, it would be objectionable on account of its making the room and apparatus damp, which are required to be perfectly dry. Instead of water, sawdust is used for cleaning the drug-mill. After grinding any drug, in order to remove the adhering particles from the mill, sawdust is ground until the mill is rendered sweet and clean.

Sawdust, then, is indispensable at a drug-mill, as necessary as water is in a druggist's shop, and if the druggist sends damp jalap, containing fifteen per cent. of water, to be ground, and requires dry powder to be returned, with only four per cent. of deduction for loss, he adopts a conventional method of asking for some of the rinsing of the mill,—a veritable "powder of post."

The four per cent. system cannot fail to induce a reduction in the strength of powdered drugs. If this reduction tended to equalize the strength of different specimens, there might be some excuse for it; but the effect of the system must obviously be to cause a reduction, in an inverse ratio to the previous strength of the drugs, so that the weakest and worst drugs will be most diluted. But this objection, which applies to the very principle of the system, is not the most serious objection to which it is subject. It sanctions the practice of admixture, and affords facilities for those, who are so disposed, to pursue a ruinous competition in price at the sacrifice of quality.

There are two causes which, I believe, principally tend to frustrate the efforts of those who are endeavouring to put a stop to the adulteration of drugs ; one is, the sale of cheap medicines by grocers and others not educated as pharmaceutists, who are unable to distinguish the good from the bad, or indifferent as to which they sell ; and the other is, the continuance of the four per cent. system in connexion with drug-grinding,—a system which has no claim for support, save the long-established usage of the trade. It should be the enlightened policy of an educated body of pharmaceutists to afford a fair remuneration for honest industry, and this being secured, both druggist and drug-grinder would rejoice to be relieved from the hereditary trammels of the present system.]

## GRANULATION OF METALS.

[There are some metals, such as zinc and tin, which, previously to their application for certain purposes, are reduced to a granular condition. The process by which this is effected is called *granulation.*

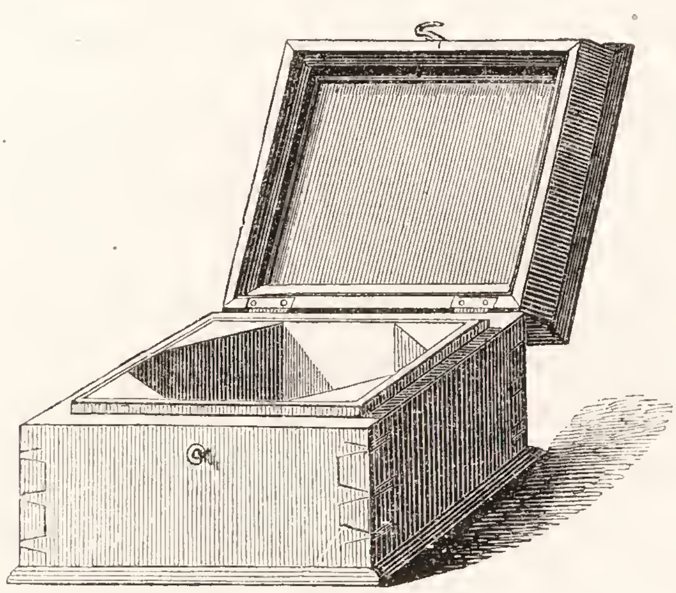
*The granulation of zinc* is effected in two different ways, one being intended for the reduction of the metal to a coarse, and the other to a more minute state of division.

*Coarsely granulated zinc* is prepared by melting the metal in an iron ladle, and pouring it in a thin and intermitting stream into a large pan filled with water. Little conical nodules are thus obtained, which present the metal in a convenient form and condition for acting upon it with acids. In performing the process it is necessary to be careful that the melted metal be not too rapidly poured into the water, and that there is a sufficient quantity of water in the pan to prevent the projection of hot metal or water over the operator.

*Finely granulated zinc* is prepared by rubbing the melted metal in an iron mortar, and continuing the process until it has become solid. In its ordinary condition, as obtained by casting it in blocks, zinc is rather brittle, but sufficiently tough to resist any efforts at powdering it, as antimony is powdered, by mere contusion in a mortar. If heated to about 300° F., it becomes malleable and ductile, and if submitted to the process of rolling while at this temperature, it not only readily admits of extension into sheets, but afterwards retains its malleability when it has cooled. At a temperature of 400° or a little higher, it entirely loses its ductile property, and becomes so brittle that it can be rubbed to powder in a mortar with the greatest facility. It melts at 773° F., so that its melting point is many degrees above that at which it becomes most brittle. The object contemplated in the above process for powdering or granulating it, is, by beginning the trituration at an elevated temperature, to ensure its passing, as it cools, through the state most favourable to its disintegration. It is desirable, however, that the cooling should not take place very rapidly, and especially that the metal should remain for some minutes at a temperature between 400° and 500°. The mortar in which the trituration is effected should, therefore, be thick, and it should be made hot before the introduction of the zinc, by putting ignited charcoal into it, or by some other means. After rubbing the metal to powder in the mortar, the finer particles are to be separated from the coarser by passing them through a sieve.

*The granulation of tin* may be effected in a similar manner to that last described for granulating zinc. Tin is very brittle at a temperature a little below its melting point, and at that temperature it may be easily rubbed to powder. There is, however, a still easier and more expeditious method of granulating tin, which consists in pouring the melted metal into a strong wooden box, such as fig. 270, and, after securing down the closely-fitting lid, shaking the box until the metal has become hard. On opening the box the tin will be found to be in small grains. Many pounds of tin may be granulated in this way in a few minutes. The grains will not be all of one size, but they may be sorted either by the use of sieves, or by elutriation.

*Fig.* 270.



GRANULATING-BOX.

It is important, in the foregoing processes, that no more heat than is necessary should be applied. Much metal is often wasted by allowing it to remain in the fire after it has melted, when oxidation rapidly proceeds.

Zinc, at an elevated temperature, undergoes combustion, and the oxide thus formed diffuses itself in a cloud through the air. Tin is also rapidly oxidized when exposed to the air in a melted state. But in the case of tin, the application of more heat than is necessary for its fusion is also objectionable on account of its causing the carbonization of the granulating-box. It is customary to guard against this effect by rubbing some chalk over the inner surface of the box. This tends to protect the wood, but it causes the granulated tin to be contaminated with chalk, which has to be subsequently removed by washing the metal with diluted acetic acid.

*Iron is granulated* by the mechanic's file, which supplies the filings so frequently employed in the laboratory. But iron filings obtained from this source are very impure, and it is necessary to submit them to some process of purification before they are used for any pharmaceutical preparations. They are generally contaminated with grease which is used in the process of filing, and they also contain a considerable quantity of oxide.

The best method of purifying iron filings is to triturate them in a Wedgewood's-ware mortar with solution of caustic potash, pouring off the solution, from time to time, while the oxide remains suspended in it, and repeating the trituration with fresh potash, or, after the second or third addition, with pure water; thus removing impurities partly by solution, and partly by elutriation. The filings will speedily become bright and clean with this treatment, and when the oxide has been entirely removed,—the elutriation being always effected with pure water towards the latter part of the process,—they are to be drained for a few minutes, then washed with a little spirit, and dried quickly over a stove.

*Gold and silver* are sometimes reduced to powder or small grains, and the processes by which the disintegration of these metals is effected are peculiar.

*The powder either of gold or of silver* may be prepared by rubbing the metal, in the form of leaf, on the porphyry slab with some honey until it is reduced to a finely-divided state, and then dissolving out the honey with water. Sulphate of potash or cream of tartar is sometimes substituted for the honey, or used with it, in which case hot water is employed as a more ready solvent of the salt. If required in larger quantity, gold may be obtained in powder by first forming an amalgam with it, and then distilling off the mercury. Silver may also be treated in the same way. A convenient method of obtaining pure silver in the form of powder or minute grains is, to reduce chloride of silver by boiling it with solution of caustic potash and a little honey.

Some salts, such as salt of tartar, are said to be granulated when they are obtained in small, irregular crystals, by a particular treatment, which has been already described in connexion with the pulverization of drugs.]

## ELUTRIATION.

[The process of elutriation has been already alluded to as a method by which the finer particles of a powder are separated from the coarser. The process consists in diffusing the powder through water, allowing the larger and heavier particles to subside, and then decanting the liquor, with the smaller particles still held in suspension, into another vessel, and allowing them to subside there. It is obvious that the process can only be applied to those substances which are not dissolved or chemically acted upon by water. It is used for separating impurities from chalk. It is also applied in the separation or sorting of the different sized grains of emery. The process is a very convenient one for dividing a powder consisting of different sized grains into several parts, each containing particles of tolerably uniform dimensions. On mixing the powder in its original state with the water, the largest particles subside the soonest, and the longer the mixture is allowed to rest the more uniformly small will be the particles remaining in suspension. If the liquor containing these be now decanted, and more water added to the powder that remains, another set of particles less finely comminuted will be obtained by allowing rather a shorter time for subsidence. The process may thus be repeated for an indefinite number of times, according to the kind of separation required.

Powdered or granulated tin is one of the substances which is frequently sorted by elutriation. Iron-filings are purified by this process.]

## DECANTATION.

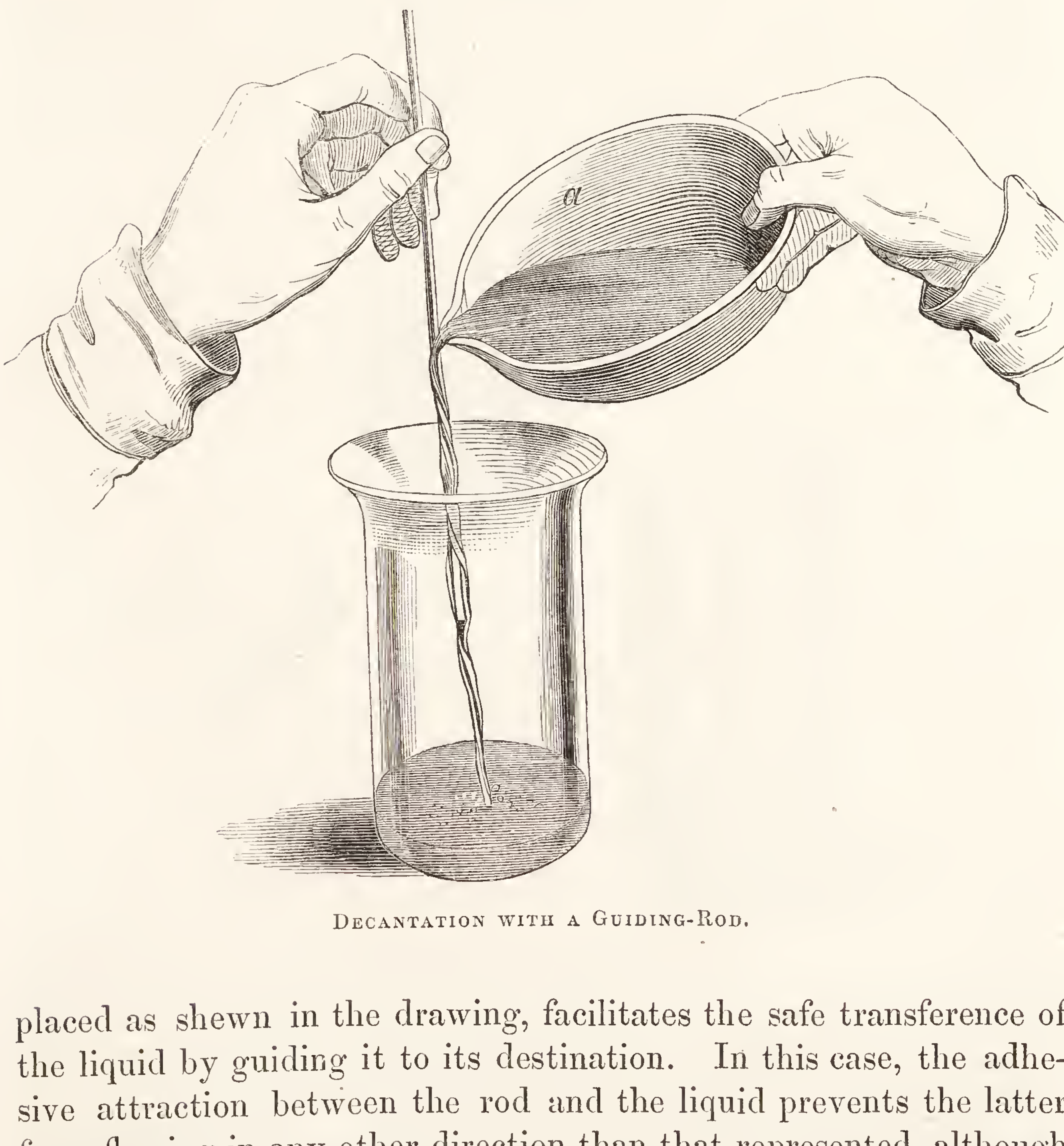
[The term *decantation* is applied in pharmacy to the act of pouring a liquid from a precipitate or sediment contained in the same vessel. Cases constantly occur in the laboratory in which this operation is required to be performed. Thus, in the process of elutriation, the liquor containing a part of the powder originally diffused through it, is decanted from that part of the powder which has subsided.

The mere pouring of a liquid from one vessel to another, however simple it may appear, is not always an easy operation, especially to the uninitiated. The form of the vessel, the extent to which the liquid fills it, and the nature of the liquid, materially influence the facility with which the operation is performed. The difficulty is also enhanced when the precipitate is light and easily caused to diffuse itself through the supernatant liquor by a slight agitation.

The objects to be attained in performing this operation are, to pour or otherwise remove the liquid from the containing vessel without spilling any of it, and without disturbing the sediment. If the vessel containing the liquid be provided with a suitable lip or spout, there may be no difficulty in pouring the contents into another vessel without any loss; but, in the laboratory, decantation has to be performed with vessels of all kinds, and with some the operation is not an easy one.

In pouring from a vessel, such as the dish (*a*, fig. 271), a rod

*Fig.* 271.




DECANTATION WITH A GUIDING-ROD.

placed as shewn in the drawing, facilitates the safe transference of the liquid by guiding it to its destination. In this case, the adhesive attraction between the rod and the liquid prevents the latter from flowing in any other direction than that represented, although if the rod were not used, a portion of the liquid would run down on the outside of the dish, and form a separate stream distinct from that in which the principal part of the liquid flowed. The guiding-rod will prevent this splitting of the current, so long as the quantity of liquid flowing be not too great in proportion to the size of the rod, and provided that it flow over the edge of the vessel, at a certain inclination, in a cylindrical stream, and not in a wide current or sheet of liquid. If the circumference of the vessel be large, it will be difficult, if not impossible, to pour with the guiding-rod; and this will especially be the case if, in addition, the sides of the vessel be perpendicular, and the quantity of liquid contained in it such as nearly to fill it.

When the form of the vessel or the quantity of liquid which it contains, precludes the possibility of pouring over the edge without spilling, merely with the aid of the guiding-rod, the object may still be attained, by rubbing a little grease over the part at which it is intended that the liquid should flow. This prevents adhesion of the liquid to the surface of the vessel, and the liquid being therefore subject only to the force of cohesion among

*Fig.* 272.

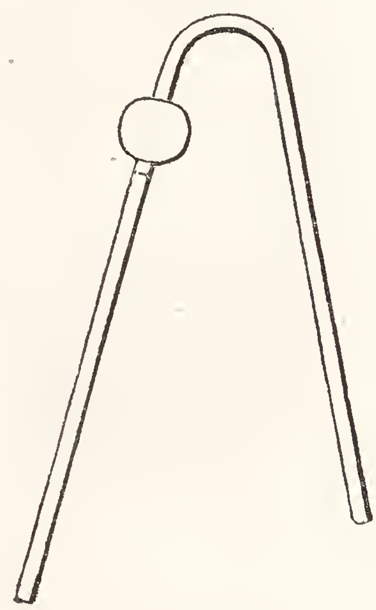

Decantation over a Greased Rim.

its own particles, forms a more contracted channel, and runs in a more cylindrical stream than would otherwise be the case. Fig. 272 is intended to illustrate the effect of applying a little grease to the edge of the vessel ($a$) from which a liquid is being poured.

But cases constantly occur in which decantation cannot be effected by pouring the liquid over the edge of the vessel, whatever means be adopted for facilitating the operation. Moreover, it is always difficult, and sometimes impossible, to incline the position of the vessel to the required extent, without disturbing the precipitate. In these cases decantation is effected with a syphon.

*The syphon* is a tube bent as represented in fig. 273. It consists essentially of two limbs, which communicate at the bend, while the lower extremities are open and unconnected. The two limbs are usually of unequal lengths. If the short limb of the syphon be plunged into a vessel filled with some liquid, which is made to fill the interior of the tube by sucking air from the outer extremity, or in any other way, the liquid will discharge itself from the end of the longer limb, and will continue to flow as long as this end of the tube is below the level of the liquid in which the other end is immersed.

*Fig.* 273.

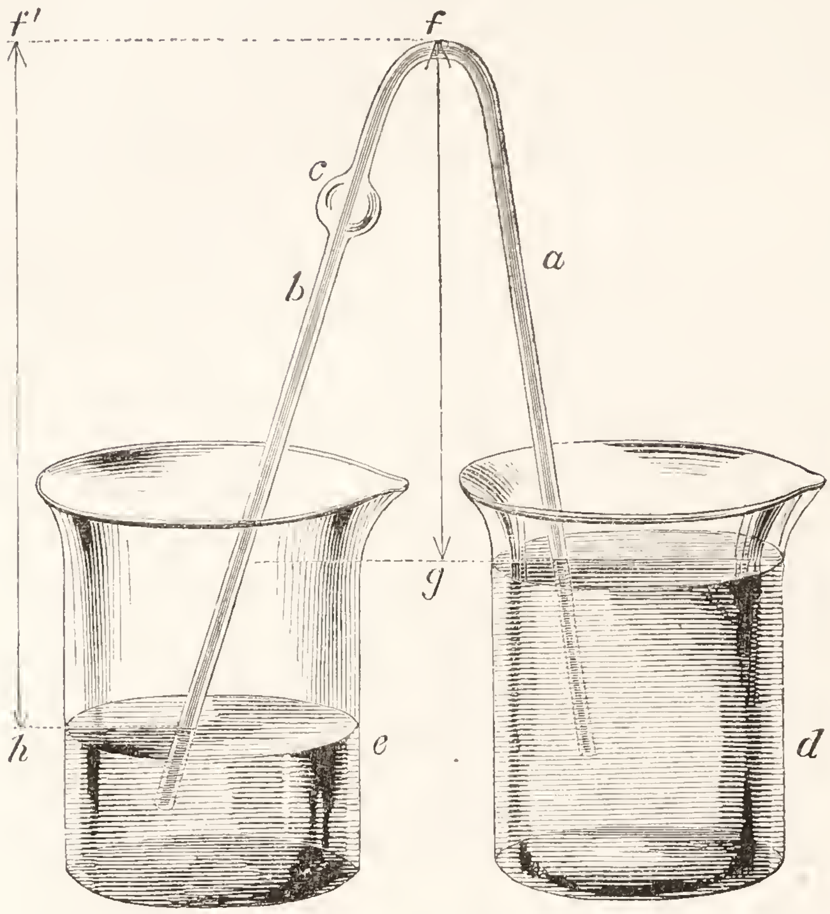


SYPHON.

The uninterrupted efflux is caused by the unequal pressure of the columns of liquid in the two limbs of the syphon. The effect may be thus explained :—

If the syphon (*a b*, fig. 274) be filled with water, and the open extremities plunged into two vessels (*d e*) containing the same liquid, there will be in the contents of each limb of the syphon two pressures exerted,—a pressure downwards, caused by the gravitating force of the liquid,—and a pressure upwards, caused by the gravitating force of the atmosphere exerted upon the surface of the liquid in the vessels, and communicated in accordance with the law of hydrostatics. These two forces, the one antagonistic to the other, would be similarly exerted if the two limbs of the syphon did not communicate at the bend. The force upwards, which is equal to the weight of a column of air having the circumference of the column of water in the tube and the height of the entire atmosphere, will be sensibly the same in both limbs of the syphon. The force downwards, which is proportionate to the perpendicular height of the column of water in the tube above the level of the water in the vessel into which the tube dips, will be greater in the long limb than in the short one. In the short limb the pressure of the atmosphere is opposed to the weight of a column of water (*f g*). In the long limb the pressure of the atmosphere is opposed to the weight of a column of water ($f'$ $h$). In either case the atmospheric pressure will preponderate over that of the liquid so long as the height of the column of liquid (water) is less than thirty-three or thirty-four feet; and the water is supported in the tube by the excess of the upward over the downward pressure. The excess or balance in favour of the upward pressure is obviously greatest in the short limb, and therefore, if the two limbs communicate at the bend ($f$) the upward pressure in the short limb will overcome the upward pressure in the long limb, and a current will be determined towards the open end of the long limb, where the liquid will be discharged. This current will continue until ($f$ $g$) and ($f'$ $h$) are equal, when the upward pressures in the two limbs will exactly counterbalance each other, and the current will then cease. The effect would be the same, if the limb ($f$) of the syphon did not dip into the liquid contained in the vessel ($e$). The pressure of the atmosphere would then be exerted directly upon the liquid contained in the tube, instead of being communicated through that contained in the vessel.

*Fig. 274.*




SYPHON.

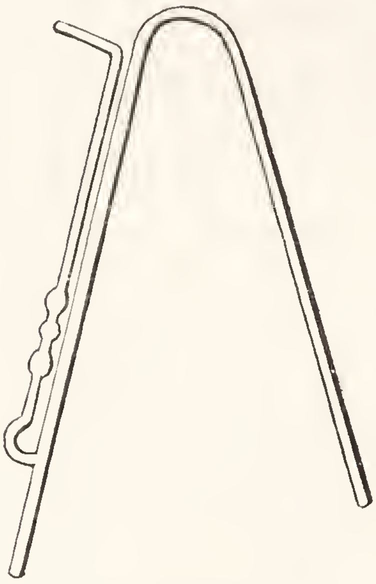
The length of either limb of the syphon is estimated from the surface of the liquid into which its end is immersed, the part of the tube which is beneath the surface of the liquid having no influence on the result. It is not, therefore, necessary that the two limbs of the instrument should be of unequal length, as the immersed limb might be shortened by dipping it deeper into the liquid; it is, however, found practically convenient to have one limb longer than the other, so that by always immersing the short limb, and keeping the instrument in an upright position, the operator may be certain that the external limb contains the longest column of liquid, and that the current will therefore be continuous.

The bulb represented in the upper part of the long limb of the syphon in figs. 273 and 274, is not essential, and is not taken into account in the foregoing description, but will be alluded to hereafter.

In using a plain syphon, consisting simply of a bent tube, such as fig. 273, without the bulb, it is necessary to get it filled with the liquid to be decanted, either by withdrawing the air with the mouth from one extremity while the other extremity is immersed in the liquid, or by inverting the tube, pouring the liquid in at one of the open ends until both limbs are full, then stopping the two orifices with a finger of each hand, and immersing the end of one of the limbs while the liquid is allowed to run from the other. The former of these methods is inelegant, and with some liquids is impracticable. The latter method is also impracticable in some cases, as for instance, where the liquid is of a strongly caustic character, into which the finger could not be safely introduced, or where it has to be decanted from a vessel the mouth of which would not admit the hand.

Two modifications have been made in the form of the syphon with the view of remedying the above defects. One of these modifications consists in having a bulb blown in the long limb of the instrument, as shewn in fig. 273. In using this form of syphon, the tube is inverted and liquid poured in until it is entirely full, the extremity of the long limb is closed by placing a finger over it, and the instrument being restored to its proper position, the contents of the short limb are allowed to run out ; the end of the short limb is now immersed in the liquid to be decanted, and on removing the finger from the other end, the fluid descending from the bulb by its own weight, draws the liquid from the vessel into the short limb until a current is established throughout, as shewn in fig. 274, the bulb remaining partly empty. It is necessary, in this case, that the capacity of the bulb shall be rather more than equal to that of the short limb of the syphon, so that the air originally present in the tube (*a*) may be retained in the bulb while the current of liquid passes through its centre. The other modification is represented in fig. 275. It consists in having a small tube attached to the long limb near to its lower end, and extending upwards to the bend, where it is turned outwards. This tube is used for withdrawing the air with the mouth while the end of the short limb is immersed in the liquid to be decanted, and a finger is placed over the orifice of the long limb. In withdrawing the air, the syphon should be turned until the long limb is nearly horizontal, the end to which the suction-tube is attached being the most elevated part, so that the air may be entirely removed from the two limbs of the instrument before the liquid enters the suction-tube. When the syphon has been thus filled with liquid it is to be restored to its vertical position before the finger is withdrawn from the orifice of the long limb.

*Fig.* 275.

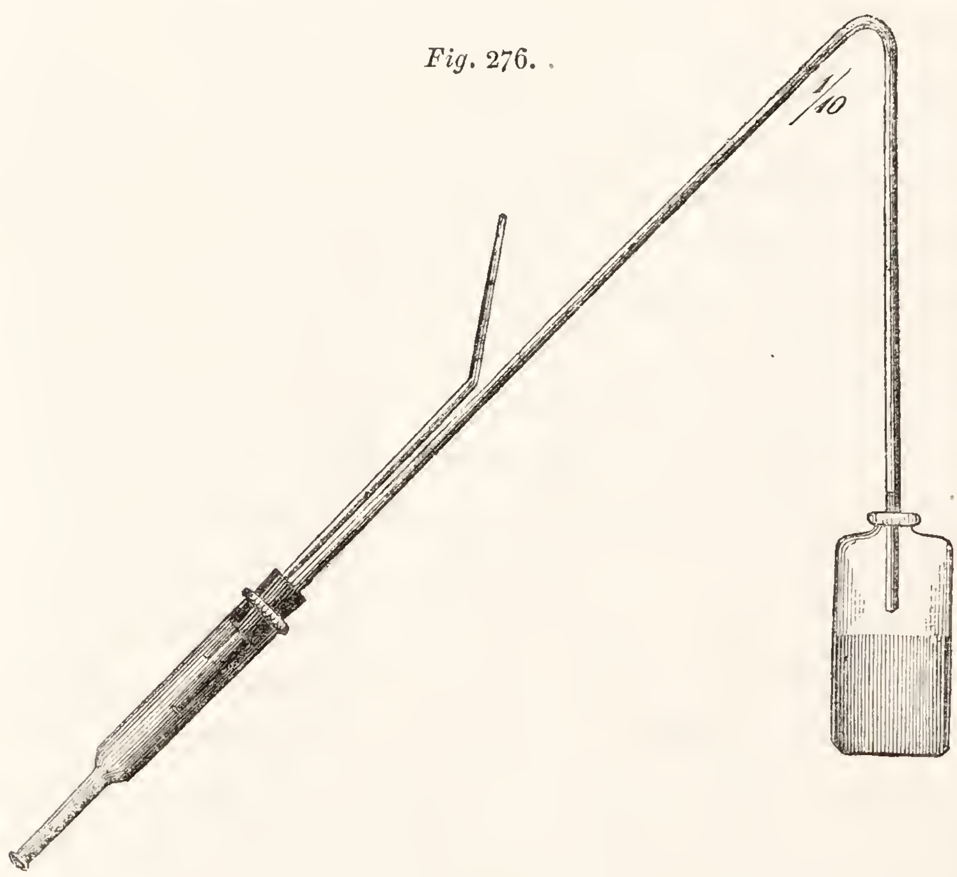


SYPHON.

Dr. Mohr has described the following ingenious method of constructing a syphon with a suction-tube.]

The bottom is cut off from an eau de Cologne bottle of the long cylindrical kind. This may be done by making a scratch with a file and then applying the point of an incandescent piece of charcoal, in a manner to be hereafter described. The sharp edges of the newly-cut surface are to be removed with a file, so that the open end of the bottle may receive a cork. This being done, a tube of suitable length for the syphon is to be bent to an angle of about forty-five degrees; and the end of the longest limb of this tube, and also another tube, of smaller diameter, to be used as a suction-tube, are inserted by means of a perforated cork into the bottle, as represented in fig. 276.

*Fig.* 276.

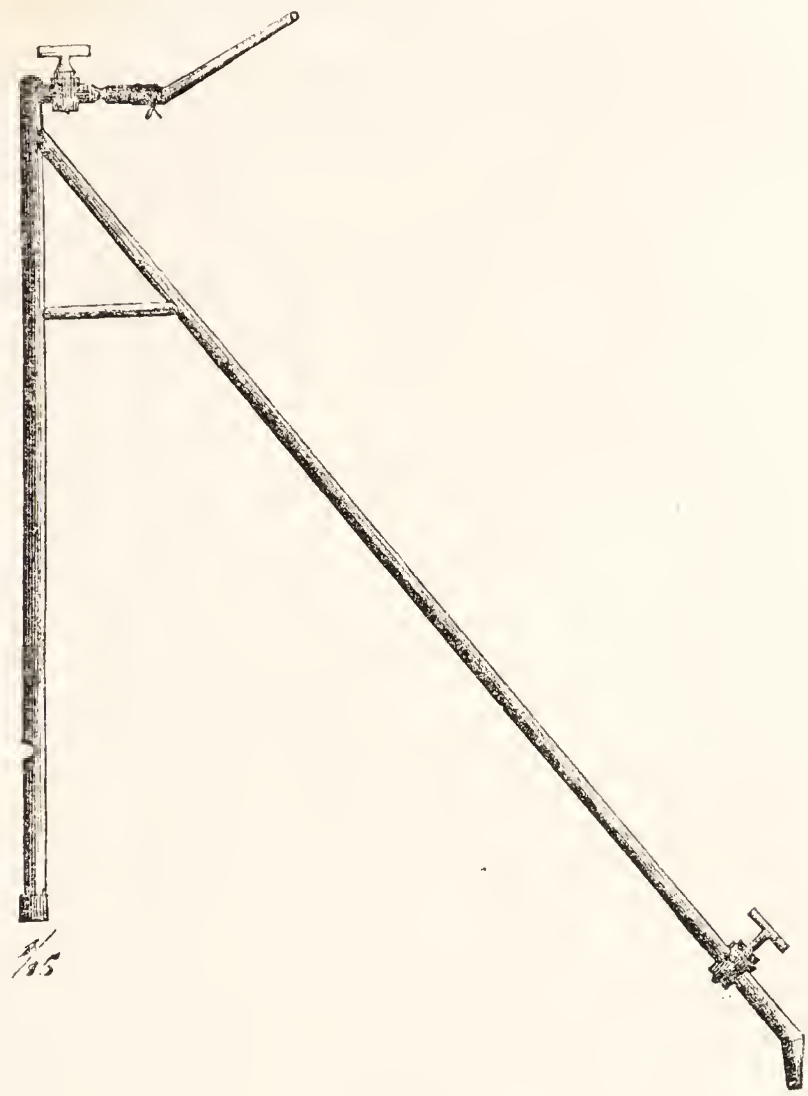



SYPHON.

This forms a very convenient syphon. The end of the short limb being plunged into the liquid to be decanted, and the other extremity closed by applying a finger to it, the air is removed with the mouth applied to the suction-tube until the liquid has partly filled the eau de Cologne bottle. On removing the finger the current will be established.

When the syphon is made of a metallic tube, the suction-tube may be conveniently attached to the upper part of it, as in fig. 277. In this case there are two stop-cocks used, —one at the end of the long limb, and the other in the suction-tube. The latter of these is necessary, but the former might be dispensed with if the length of the syphon be such as to admit of the orifice of the long limb being closed with the finger while the mouth is applied to the suction-tube. In using this instrument, the air is drawn out until the liquid rises into the suction-tube.

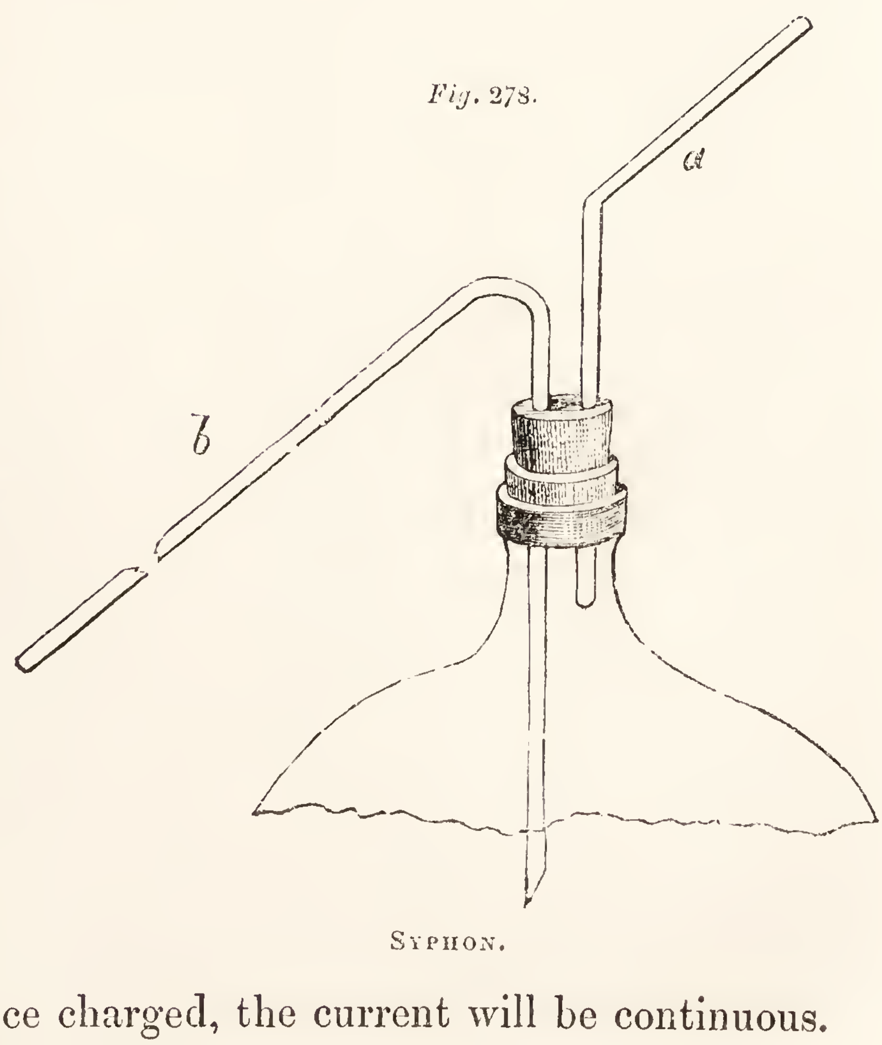
*Fig. 277.*



SYPHON.

In decanting a liquid from a bottle or carboy, the arrangement represented in fig. 278, may be conveniently adopted. A plain syphon-tube (*b*), and also a tube (*a*), are made to pass through a perforated cork which fits the mouth of the bottle, and while the cork is thus inserted, air is blown from the mouth through the tube *a*, until the liquid is forced into the syphon, and the latter being once charged, the current will be continuous.

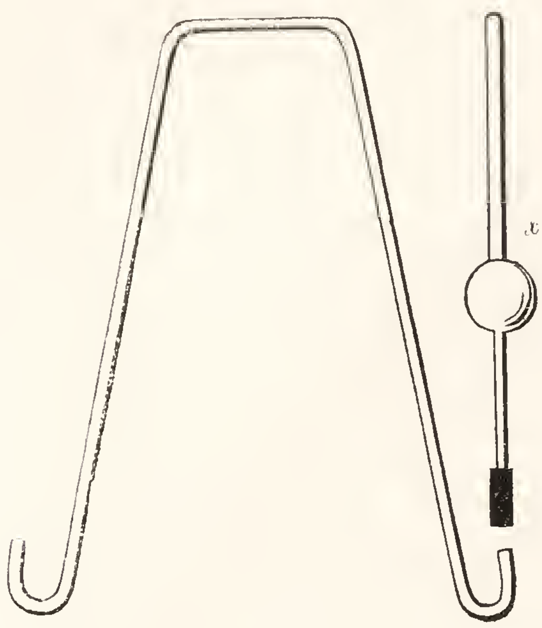
*Fig. 278.*




SYPHON.

[In the forms of syphon hitherto described, the current, when established, continues without interruption until the short limb of the instrument ceases to be immersed in the liquid, or until the descending column of liquid in the tube ceases to be longer than the ascending column; and the liquid then discharges itself from the syphon, which latter requires to be re-filled before it can be again put into operation. This necessity for refilling the syphon each time it is used is sometimes found to be a great inconvenience, to obviate which, the form of instrument represented in fig. 279, has been adopted. In this the two limbs are of equal length, and the extremity of each limb is turned up, so that, when the tube is filled with liquid, it will retain the charge, and may be used for an unlimited number of times without the necessity of refilling it. The bulbed tube ($x$) is used for charging the syphon, the Indian rubber connecter attached to its end being placed over the end of one of the limbs of the syphon, and the air sucked out by the mouth, while the other end is immersed in a liquid. When thus filled it may be removed from the liquid, and if the two ends be kept in an horizontal plane, the liquid will not run out from either of them; but if one of the limbs be immersed in a liquid until the orifice of the tube is beneath the surface, the liquid will begin to flow at the opposite extremity, and will continue to do so until the surface of the liquid from which decantation is being effected sinks to a level with the orifice of the efflux tube. The current will then cease, but the syphon will not discharge its liquid contents. On lowering the immersed end, the current will again commence, and it may be thus renewed and stopped at pleasure; or the syphon may be transferred to another vessel, and used there, without requiring to be refilled.

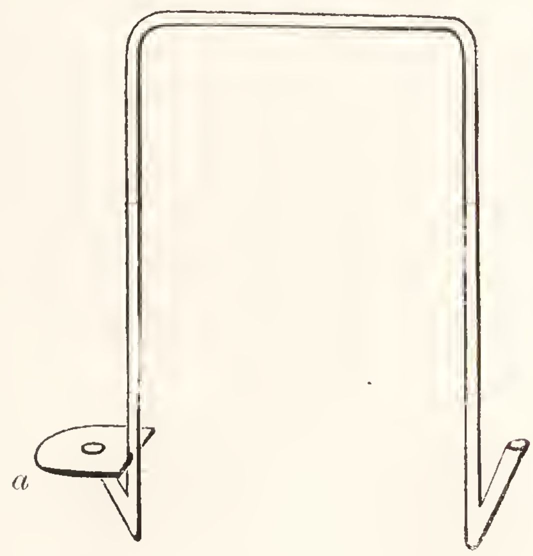
*Fig. 279.*




SYPHON.

This is a most convenient syphon for effecting decantation, especially in those cases in which the precipitate is easily disturbed, or in which it is desirable to suspend and renew the decantation several times during a process. If the instrument be made of metal it will be found advantageous to have it constructed like fig. 280. The only essential difference in this modification of the instrument is, that a metallic plate ($a$) is fixed to one end of the tube in such a way as to prevent the liquid entering the tube at this end from forming a current upwards, and thus disturbing the precipitate. It will be obvious that the liquid in approaching the orifice of the tube must pass either in a descending or horizontal direction.

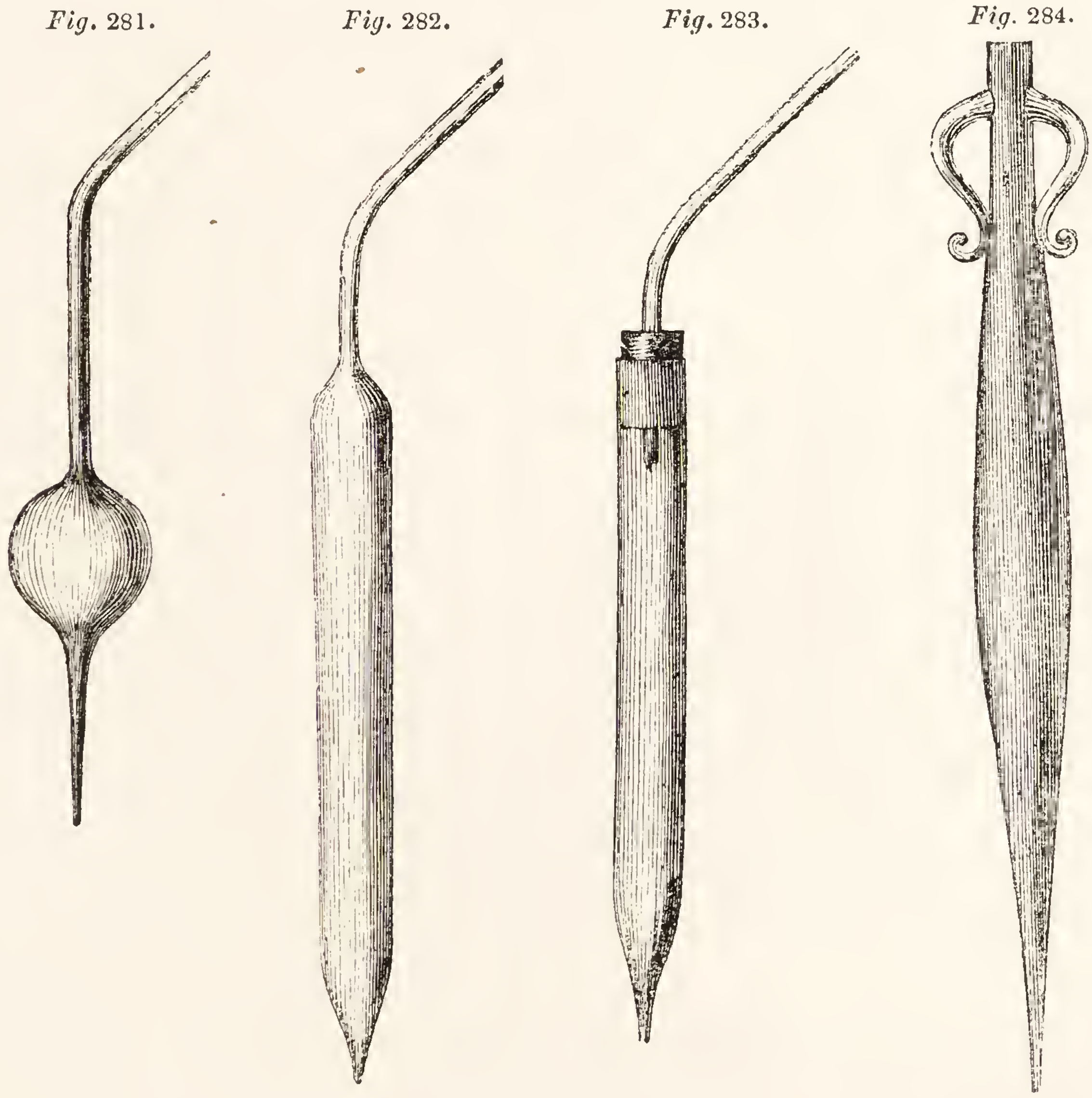
*Fig.* 280.




Syphon.

*Pipettes* are sometimes used for withdrawing small quantities of liquid from the surface of precipitates, or from places from which it would be difficult otherwise to remove them. The most common form of the pipette is that represented in fig. 281. It consists of a glass-tube in which a bulb is blown, and the lower extremity of the tube is drawn to a capillary opening, while the upper end is bent to an oblique angle. The point of the instrument being placed in contact with the liquid to be removed, the latter is sucked into the

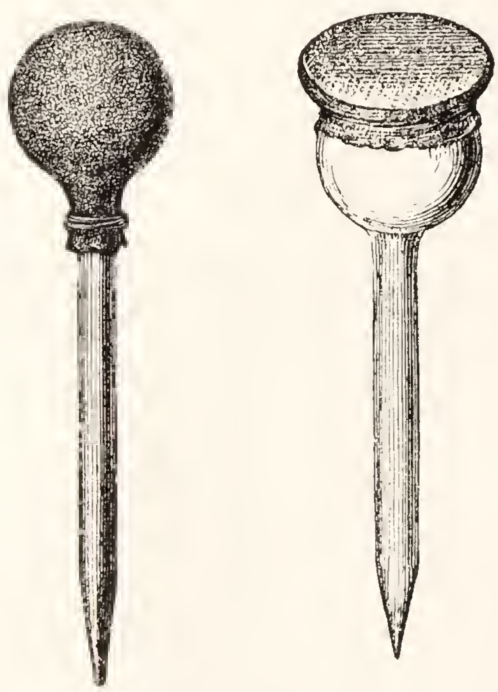
*Fig.* 281. *Fig.* 282. *Fig.* 283. *Fig.* 284.



Pipettes.

bulb by applying the mouth to the other end of the tube. Fig. 282 is another form of the apparatus, which is made by uniting a piece of narrow tubing to one of larger diameter, the lower extremity of the latter being drawn to a capillary bore. Both these kinds of pipette are made by the aid of the blow-pipe, and some skill and experience are required in making them. Fig. 283 represents a pipette, which any operator may make in a few minutes without possessing any experience in glass-blowing. It consists of a piece of tube about three quarters of an inch in diameter and six or seven inches long, which is drawn to a capillary bore at one end, and rounded off in the flame of the lamp at the other end, where a piece of narrow tubing, bent as represented, is inserted through a cork. Figs. 285 and 286 represent other forms of the apparatus. That shewn in fig. 285 is a glass tube, to the end of which an Indian-rubber bottle is attached. In using this some of the air is forced out by compressing the Indian-rubber, and the point of the tube being then applied to the liquid, the Indian-rubber is allowed to resume its original form, in doing which it sucks up the liquid. Fig. 286 is made from the end of a tube-funnel, over the mouth of which a piece of sheet Indian-rubber is tied.

*Fig.* 285. *Fig.* 286.



PIPETTES.

The glass syringe (fig. 292) might be used instead of either of these pipettes, and for most purposes to which the pipette is applied it forms a convenient substitute. Sometimes, however, the pipette is used, not merely for removing liquids in the manner above described, but for taking a specimen, sometimes a measured specimen, from a vessel into which it is plunged. The instrument used for this purpose, of which fig. 284 is a common form, is called the *plunging-syphon.* It is immersed into the liquid and allowed to remain there until full, when the opening at the top is closed with the thumb, and the instrument, with its contents, thus removed, and the latter subsequently discharged by allowing the air to enter at the top.]

## WEIGHING AND MEASURING.

[Among the operations performed in the preparation of medicines there are none which are of more frequent occurrence, or which require greater care and precision in performing them than the operations of weighing and measuring. In selling medicines, in dispensing medicines, and in preparing or manufacturing the different medicinal compounds, there are constant occasions for the use of the *balance* and the *measure*. These instruments are intended for the accurate adjustment of the quantities of the substances employed in our operations; but the full accomplishment of the object con templated will depend in a great degree upon the proper construction of the instruments, the care with which they are preserved, and the manual dexterity with which they are used.

The weight of a body is the measure of its gravitating force, and this is in direct proportion to its mass, or the quantity of matter which it contains. This force is expressed with relation to some known standard of resistance, which is just sufficient to prevent the body from falling to the ground. The standards thus used, however, are perfectly arbitrary, and they frequently differ in different countries, which is a great evil.

In the first instance, some natural products, such as seeds, which were easily attainable, and the weight of which was pretty uniform, were used as units, from which other denominations of weight were calculated. Thus, by a law passed in the year 1266, it was enacted, "That an English penny, called a sterling, round and without clipping, shall weigh thirty-two *wheat corns*, from the midst of the ear, and twenty pence shall make an ounce, and twelve ounces one pound."

Not only have different countries adopted different standards of weight, but even in the same country, as in this and others, two or more different standards have been recognized and used at the same time. The inconveniences resulting from this practice have long been felt, and the attention of scientific men has, for many years, been directed to the subject, with the view of fixing upon one standard which could at any time be tested by comparison with some phenomenon of constant and unvarying occurrence. Such a standard, it is hoped, will ultimately be adopted by all civilized countries, to the exclusion of every other.

In this country an attempt has been made to introduce a greater degree of uniformity and certainty than originally existed with reference of our weights and measures.

The imperial standard weight, or troy pound of 5760 grains, from which all our other weights are now calculated, is determined, in case of any doubt, by comparison with a given measure of distilled water, weighed at a temperature of 62° Fahr., the barometer standing at thirty inches. Thus, a cubic inch of distilled water weighed in air with brass weights, at the temperature above stated, "is equal to two hundred and fifty-two grains and four hundred and fifty-eight thousandth parts of a grain, of which, as aforesaid, the imperial standard troy pound contains 5760."

The measure from which the weight is estimated, is determined by means of a pendulum vibrating seconds of time, in a vacuum, at the latitude of London, and at the level of the sea. It has been found that the length of such a pendulum, in comparison with our yard of thirty-six inches, would be thirty-nine inches and one thousand three hundred and ninety-three ten thousandth parts of an inch (39·1393 inches). This, then, is the foundation of our standard both of weights and measures; and if, from any circumstance, all the weights and measures in the country, including those which are kept for comparison in the custody of the Clerk of the House of Commons, should be destroyed, we have the means of renewing them with the absolute certainty of their being the same.

But all that our legislature has done, has been to fix and afford the means of perpetuating certain standards of weight and measure which were previously in use among us, excepting in regard to some slight alterations which were, at the same time, made in some of of the minor divisions.

In France, in the days of the memorable revolution of 1792, when all regard for ancient customs and institutions was openly repudiated, a much more sweeping and radical change was made, and a system established, which is admitted by all scientific men to be the most complete, philosophic, and generally convenient, that the wit of man has yet suggested. The French philosophers were not satisfied with attempting to reconcile old standards with new and scientific principles;—they did not merely propose to frame a system of weights and measures for the use of the French people; but their ambition fostered the belief that they were framing systems for the whole world, and in this particular instance it is not improbable that their anticipations may be realized. Already French weights and measures are adopted by scientific men throughout a great part of Europe; and even in England, where they have not yet been generally adopted, the feeling is daily becoming stronger in their favour.

In the French system, as in ours, the unit from which all the other calculations are made, is a measure of extension. They did not, however, take the pendulum for estimating their unit, but the measurement of the meridian of the earth. Thus, the ten millionth part of a quarter of the earth's meridian, is the unit from which their calculations are made. This unit, or first measure, is called the *metre* (from the Greek word μετρον, measure). It is thirty-nine inches and three hundred and seventy-one thousandth parts of an inch of our measure (39·371 inches). The metre is divided into ten parts, each of which is called a *decimetre*; and this is again divided into ten parts, each of which is called a *centimetre*.

A cubic decimetre is called a *litre*, and this is taken as the unit of measures of capacity.

A cubic centimetre of distilled water, at its maximum density, that is at a temperature of 39·5° Fahr., is taken as the unit of weights, and is called a *gramme*. All the subdivisions and multiples of these units, are by tens, and the system is, therefore, called the *decimal system*.

The importance of having a good and uniform system of weights and measures, cannot be too highly estimated in a scientific point of view.

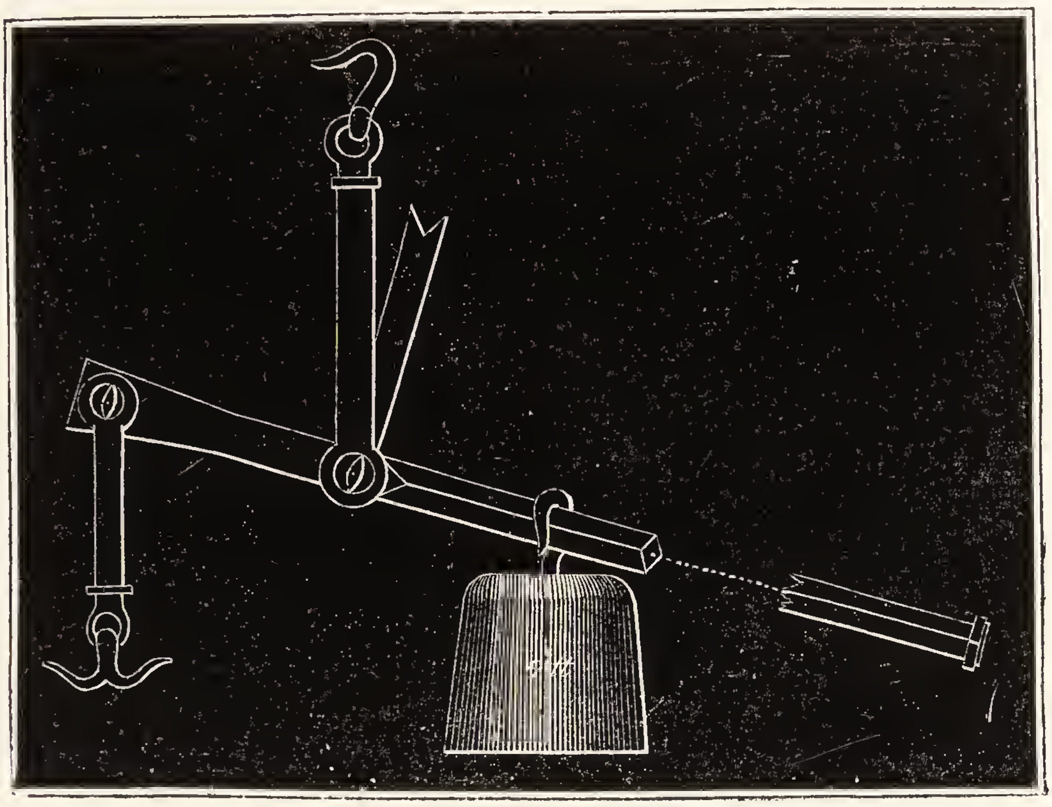
Weights, as already stated, are used for estimating the resistance required to overcome the gravitating forces of bodies. In applying them, an instrument is employed, which is called the *balance*. This instrument is a lever, supported at its centre of gravity, in such a way as to afford to it the greatest practicable freedom of motion. Different forms and degrees of sensibility are given to the balance, so as to adapt it for the different circumstances under which it is applied. The lever, or beam, is generally supported on knife-edges, and, according to the sharpness of these, and the hardness of the planes on which they rest, will be the delicacy of the indications. In some cases several grains are required to give the preponderance to one end of the lever over the other, while the most delicate balances will turn with the five hundredth or one thousandth part of a grain. Inflexibility in the lever, and perfect equality in the length of its arms, are the most important points in reference to the truthfulness of a balance as usually constructed. The slightest variation in these respects would entirely vitiate the result of a weighing.

But, however accurate may be the weights, and however delicate and well constructed the balance may be, the indications afforded are not, in the majority of cases, the true weights of the bodies weighed. The means usually adopted for determining the weight of a body are, in one respect, defective. We weigh bodies in a gravitating medium, and therefore do not determine their absolute gravitating force. Every one is familiar with the fact, that if a solid body be put into water, the force required to prevent it from sinking is less than that which would be required for supporting it in the air. In fact, when a body is immersed in water there is a force equivalent to the weight of the volume of water displaced by the body, which presses it upwards, and thus counteracts its gravitating force. The weight of a body in water, therefore, is less than its true weight; so also is the weight of a body in air. Air is a gravitating fluid like water, although its weight is very much less; and the weight of a body weighed in air is either more or less than its true weight to the extent of the weight of a volume of air equal to the difference between the volume of the weighed substance and that of the weights used. This source of error is never practically taken into account.

There are, however, some sources of error in weighing and measuring which it is important to guard against. He who properly estimates the importance of accuracy in weighing and measuring medicines will satisfy himself that his balances and measures are true and his weights correct. Nor is accuracy in these respects the only necessary consideration. It is equally important to make a selection of instruments suitable for the purposes to which they are to be applied. In a pharmaceutical establishment several balances of different degrees of delicacy are required. When heavy weights are employed the lever and other parts of the balance must be proportionately strong, and in these cases the knife edges are generally less sharp, and the indications consequently less delicate than are those of the balances used for weighing smaller quantities. It is customary in the retail department of the shop to have at least two kinds of balances,—one for weighing quantities varying from a quarter of an ounce up to a pound or two pounds, and the other for larger quantities. The former of these balances should be sensibly affected by the preponderance of a grain or two in either pan; the latter will not generally be sensible to less than twenty or thirty grains.

In the warehouse, balances of a still larger and stronger description are required, the indications afforded by which are even less accurate than the above. For approximative indications the steel-yard may be sometimes conveniently used, as the weighing is effected with a single weight. Fig. 287 is a representation of this instrument. It consists of a lever, the two arms of which are of unequal length. The weight used is suspended from the long arm of the lever in such a manner that it may be moved to any part of it, and according to its position will the weight of the substance attached to the other or short end of the lever be estimated. Thus, supposing *h*, fig. 288, to be the point of suspension of the lever, and *l* the end of the short arm to which the substance to be weighed is fixed, a weight placed on the long arm would change its value according to its position, at the several divisions. If the weight were eight pounds it would have that value when placed at the eighth division from *h*, and would change its value if moved either

*Fig.* 287.



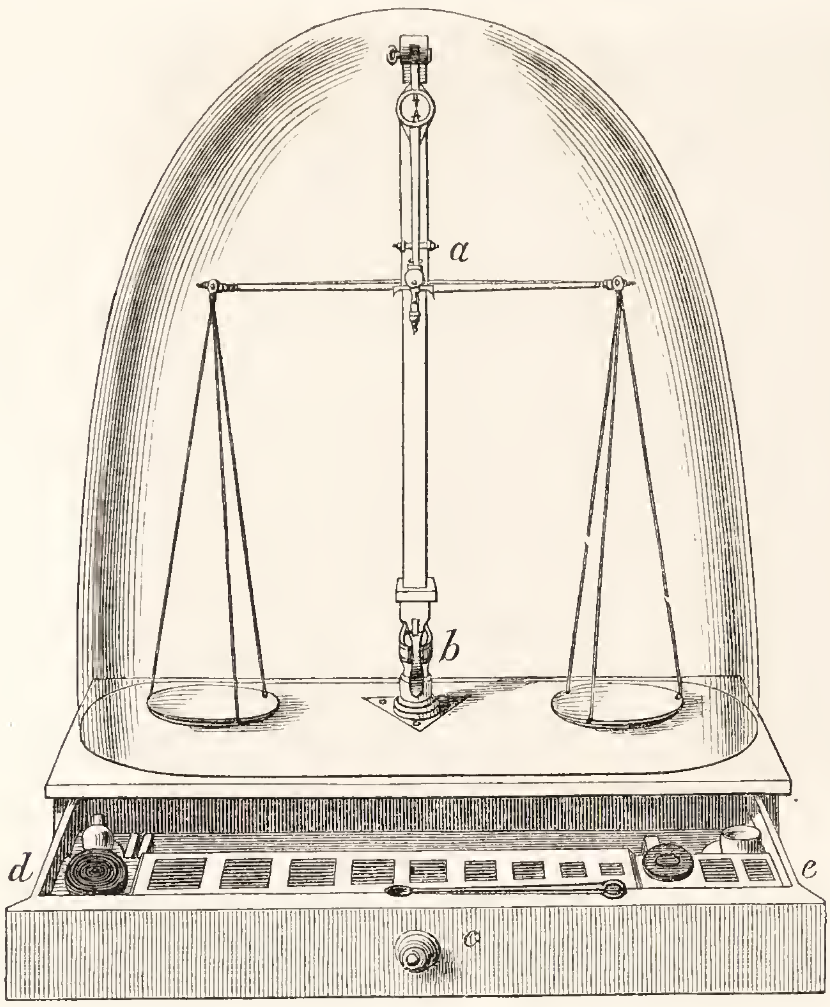
nearer to or farther from the point of suspension of the lever, having the value of one pound at the first division, and of twenty-four

*Fig.* 288


pounds at the last division. In like manner a weight of eight ounces would give similar indications of smaller amount.

Other balances, again, are required for the purposes of dispensing. There are two kinds of dispensing balances commonly used,—one is suspended from a fixed pillar, as represented in fig. 289,—the other is suspended, when used, from the hand of the operator (see fig. 293), and is kept in a box containing the weights when not in use. The dispensing balance should be sensible to variations of a tenth-part of a grain, or even less. The standard balance is not so convenient for dispensing as that which is supported in the hand, the processes of weighing being conducted much more expeditiously with the latter than with the former; the hand-balance is therefore used in all establishments where there is much dispensing business. But should the standard-balance not be used in dispensing, it would nevertheless be desirable that the pharmaceutist should have a balance such as fig. 289, or such as fig. 290, for occasional use in taking specific gravities, and for other purposes in which some degree of delicacy of indication is required. The balances represented in the drawings are made by Messrs. Degrave and Company, and are well adapted for pharmaceutical purposes. They are either of them sensibly affected by the twentieth part of a grain. That represented in fig. 290 is capable of bearing three or four pounds in each pan, and yet of turning with the tenth part of a grain. The pans (*a a*) are moveable, being supported on the cross-bars beneath. There are two small hooks at (*b b*), from which flasks or other vessels which would not stand on the pans may be suspended. The pans of this balance, when at rest, are not in contact with the slab to which the pillar is fixed, and the beam is prevented from oscillating by the supports (*c c*), which are pressed down by means of the lever (*d*) when the weighing is performed. There is a small moveable bar (*e*) which turns in a horizontal plane on a vertical pin fixed over the centre of the beam. The object of this is to afford an easy method of adjusting the equilibrium of the pans if they should not exactly balance, by turning the projecting end of the little bar towards the lightest end of the beam, and thus throwing additional weight on that side.

*Fig.* 289.

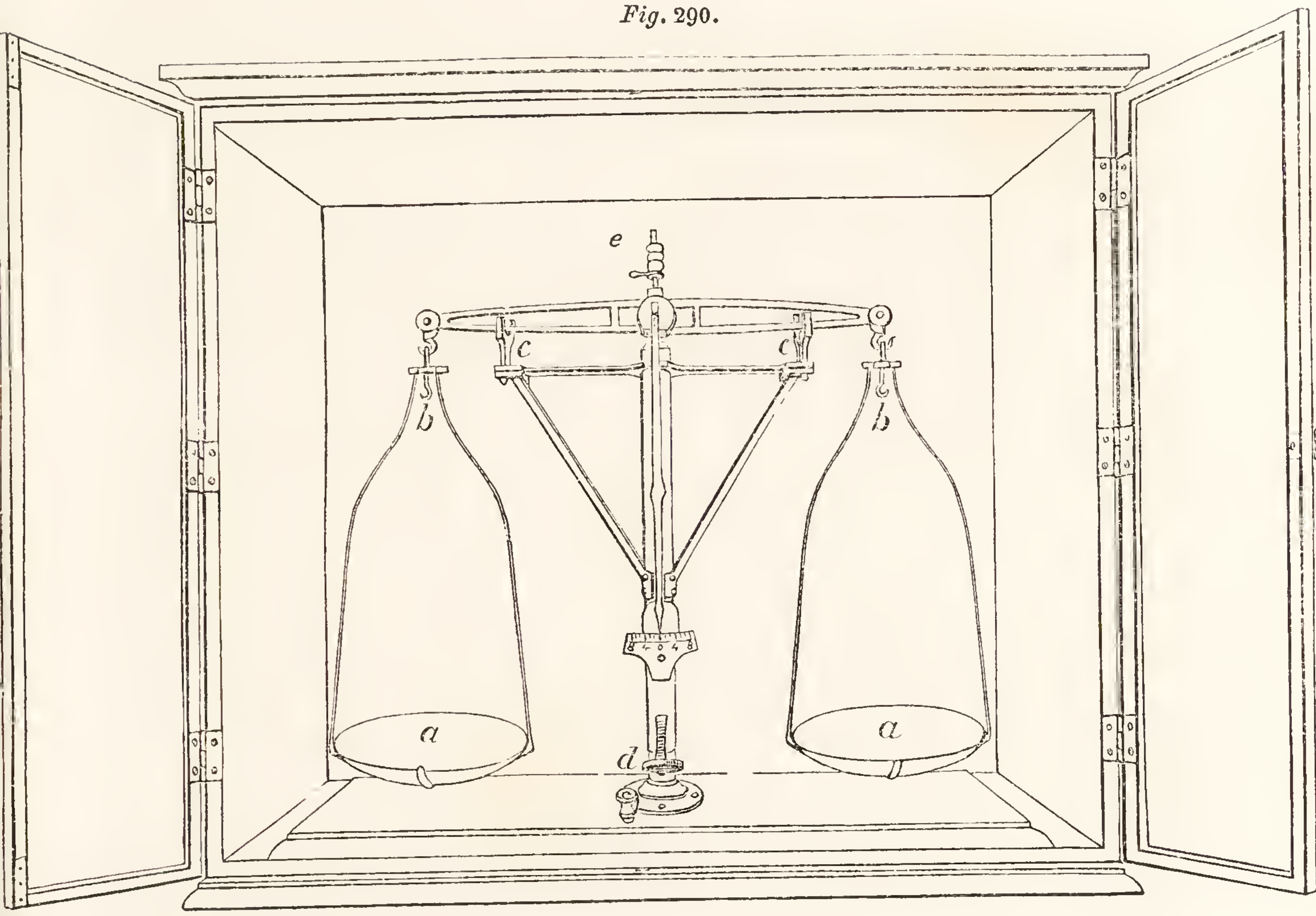



Still more delicate balances are required for analytical purposes.

There are two kinds of weights required to be used by the pharmaceutist. The weights indicated in prescriptions, and those expressed in the formulæ of the pharmacopœias, appertain to apothecaries' weight, while those by which merchandize, including medicines, are bought and sold, appertain to avoirdupoise weight. Sets of weights of each of these denominations must therefore be kept.

It is not customary for pharmaceutists to keep more than a set or two of apothecaries' weights, and those extending only up to a

*Fig.* 290.

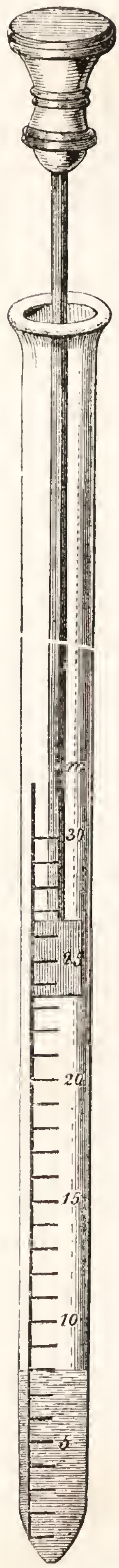



pound. One such set there certainly ought to be for use when required. Of avoirdupoise weights much more comprehensive sets are required, as even in preparing medicines, the substances are weighed with these weights when the quantities are large. I have given a comprehensive table of the equivalents of troy and avoirdupoise weights, in the *Supplement to the Pharmacopœia*, which will be found useful in facilitating the necessary calculations when the one denomination of weight is substituted for the other in any formulæ.

The measures used for pharmaceutical purposes when intended for measuring quantities not exceeding a pint, are made of glass; and these are graduated so that the same instrument will indicate several different quantities.

Very small quantities of liquids are sometimes measured by dropping them from the lip of the bottle, the stopper being slightly raised from its place, so as to allow the liquid to pass; but this method is subject to much inaccuracy, as not only do the drops of different liquids vary considerably in size, but so also do those of the same liquid when dropped under different circumstances. Mr. Alsop, several years ago, published the result of some experiments which he made with the view of shewing the extremes of variation to which this mode of measuring is liable. The variations, depending not only on the degree of tenacity of the fluid, but also on the extent of moist surface to which the suspended drop is attached before it falls, were found to be influenced by the size of the bottle, and the angle of inclination at which it is held during the operation of dropping. The following are some of Mr. Alsop's results, shewing the number of drops required to measure a fluid-drachm, when dropped from a large or a small bottle:—

*Fig.* 291.



Alsop's Minim-Meter.

| | Dropped from a large bottle. | Dropped from a small bottle. |
|---|---|---|
| f℥j. Diluted sulphuric acid . . | 24 drops. | 84 drops. |
| „ Scheele's hydrocyanic acid . | 35 „ | 70 „ |
| „ Distilled water . . . | 31 „ | 54 „ |
| „ Solution of ammonia . . | 40 „ | 48 „ |
| „ Tincture of opium . . . | 84 „ | 135 „ |
| „ Rectified spirit . . . | 100 „ | 130 „ |
| „ Tincture of muriate of iron . | 100 „ | 150 „ |

It is obvious, therefore, that medicines ought not to be measured by drops; and there is some difficulty in apportioning minute quantities of powerful liquid medicines by the use of the common minim-measure. *Mr. Alsop's minim-meter*, fig. 291, was introduced with the view of obviating this difficulty, and it has been found from practical experience completely to answer the intended purpose. The minim-metre acts upon the principle of a syringe. In using it, it is necessary to keep the packing of the piston moistened with a little water. This being done, the piston is raised about half an inch: the point of the syringe is then dipped into the liquid to be measured, and the required quantity, or a little more, is drawn into the tube by further elevating the piston; any excess, beyond the quantity required, is forced out by carefully depressing the piston, and the measured quantity thus adjusted, is transferred to the bottle, or other vessel, by forcing the piston completely down. After a little practice this may be done in less time than would be occupied in the operation of dropping. A stratum of air intervenes between the piston and the surface of the liquid, as will be seen in the figure, which is represented as containing eight minims.

The best method of cleaning the measure after using it, is to draw a little water into it, then to stop the opening at the point by placing the finger over it, and to force down and again raise the piston, thus forcing the water through the packing and effectually cleansing it.

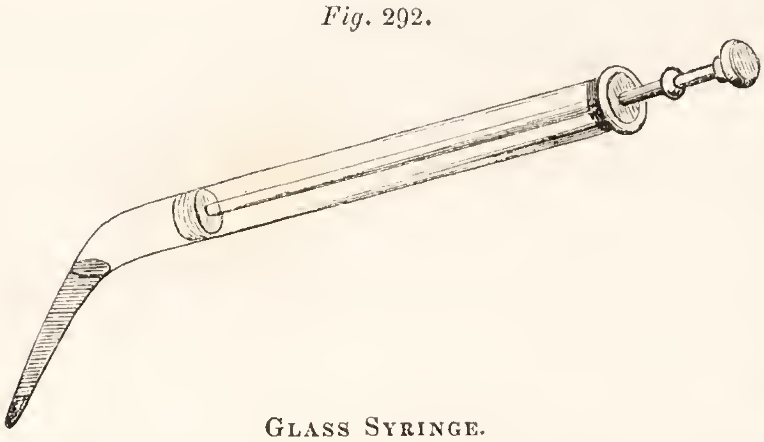
Measures of a greater capacity than a pint are generally made of tinned copper.

Every pharmaceutist ought to test the accuracy of his weights, measures, and balances.

Balances, although apparently correct, when unloaded, the two pans being in equilibrium, may, nevertheless, give incorrect indications when loaded, in consequence of one arm of the lever being longer than the other. The best test for this defect is carefully to weigh some substance, bringing the scales to a perfect equilibrium, and then to transpose the weights and the substance weighed, and observe whether this alters the result. If the balance be correct the result will be unaltered. There is an easy method of guarding against errors arising from defect in the construction of the balance, which is, to adopt what is called *double weighing.* This consists in putting the substance to be weighed into one of the pans of the balance, and any suitable substance, such as sand, into the other pan, so as exactly to counterpoise it; then, having removed the former, weights are substituted for it until the equilibrium is restored, and these weights will correctly represent the substance weighed. This method of weighing will afford correct results with any balance that is capable of turning with sufficient delicacy.

The graduation of measures is frequently incorrect, and ought therefore to be verified before the measures are used. Sometimes there is found to be a difference of half an ounce or an ounce in the capacities of two pint measures, in which case one, if not both, must be wrong. The correctness of the graduation of a measure is easily tested. In performing this operation, it is desirable to have a perfectly level place on which to put the measure. A particular part of the counter, or any other fixed horizontal board, which has been ascertained, by means of a spirit level, to be perfectly horizontal, should be selected; and this spot might always be used as a standing-place for measures in testing their accuracy. The measure is intended to indicate the volume of a certain weight of distilled water at a temperature of 62° Fahr.; and the verification is therefore effected by introducing as many ounces, avoirdupoise weight, of distilled water, at the above temperature, as the measure indicates in fluid ounces. Thus, the imperial pint contains twenty ounces, avoirdupoise, of distilled water, by weight. Of course it is necessary to use accurate weights and a good balance for this operation. The balance, fig. 290, is suitable for the purpose. A glass syringe, such as fig. 292, will be found convenient for adjusting the exact quantity of water required. The water may be introduced into, or removed from the measure with great precision by means of this syringe, without wetting the sides of the vessel.

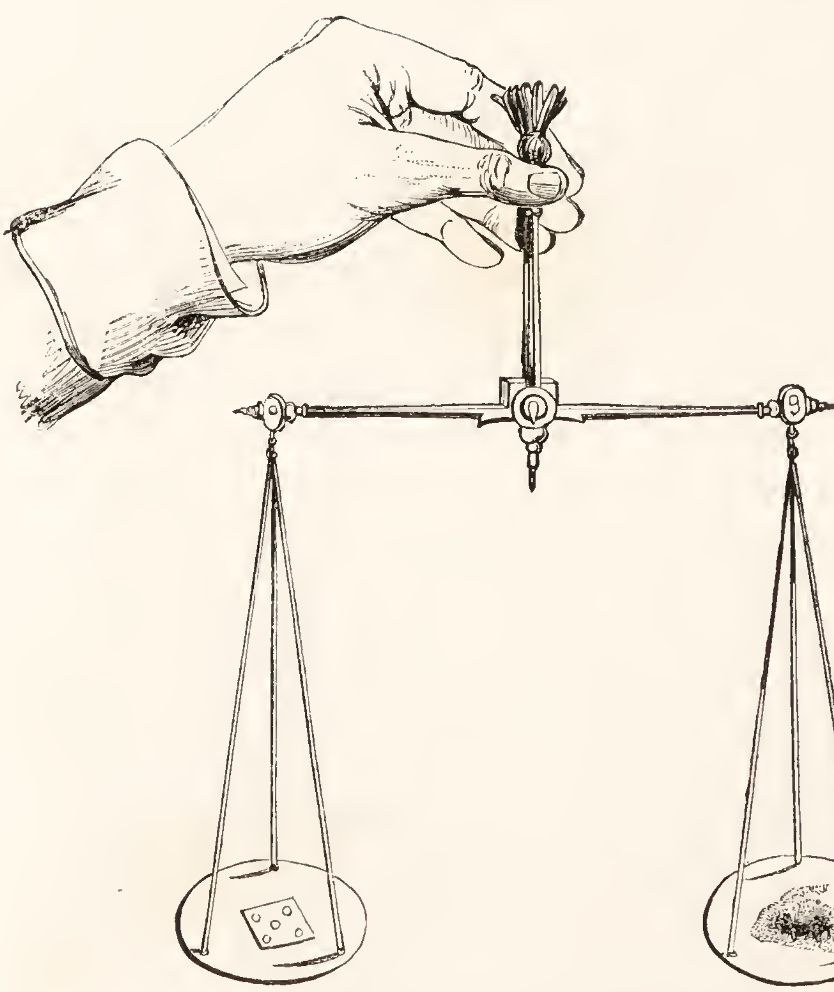
*Fig. 292.*



Glass Syringe.

Weights, from constant wear and occasional exposure to acid vapours, sometimes become incorrect; indeed, it often happens that the drachm and grain weights used for dispensing are incorrect when sold by the manufacturers. These small weights are not examined by the official inspectors, and they appear to be frequently made in a very careless and imperfect manner; they ought, therefore, to be tested, from time to time, by a set of well authenticated weights carefully kept for that purpose.

*Fig. 293.*



Method of Holding the Balance.

In preserving the accuracy of weights, measures, and balances, it is necessary to avoid exposing them to rough treatment.

Delicate balances require to be treated delicately. They must not be handled roughly, nor should they be neglected. They require constant and delicate attention. Those that are only occasionally used should be protected from damp air and acid fumes, by enclosing them in glass cases, or covering them with glass shades, as shewn in figs. 289 and 290.

Weights ought never to be exposed to rough treatment, such as using a weight as a substitute for a hammer.

Glass measures are not liable to be rendered inaccurate by causes such as those above indicated, but copper and other metallic measures are; and it not unfrequently happens that these receive serious injury from blows, for any indentation, thus caused, on the surface of a measure, must alter its capacity.

*Fig.* 294.


Method of Holding the Measure-Glass.

Finally, some attention should be paid to the manipulations of weighing and measuring. The accuracy of the indications afforded by the use of the balance and the measure will depend, in some degree, upon the manner in which the operator handles the instruments.

In performing the process of weighing, there is a certain amount of manual dexterity required, which practice alone can impart. The proper suspension of the dispensing scales from the hand; the preservation of the equilibrium of the beam by resting the pans on a solid surface while the substance to be weighed is being introduced; and the steady, not too lofty, nor too hasty, elevation of the hand, in trying the equilibrium of the loaded pans, contribute not only to the accuracy of the result of the process, but also to the ease and elegance with which it is effected. See fig. 293.

Again, in measuring, it is necessary to acquire a proper and easy method of holding the measure-glass. It should be held in such a manner that the stopper of the bottle from which any liquid is about to be poured into it, may be removed by the same hand; and that, subsequently, the measure can be raised, so that the surface of the liquid shall be level with the eye of the operator, while the measure itself is kept perfectly upright. See fig. 294.

The practised operator, if he be really alive to the importance of strict accuracy in the results of his operations, will acquire dexterity and elegance in the methods of conducting these processes, which result from the best adaptation of every movement for the attainment of the object contemplated.]

## DETERMINATION OF SPECIFIC GRAVITIES.

[The pharmaceutist has frequent occasion to refer to specific gravity, as a distinctive character of bodies, and it is important that he should be able to perform with facility the operations by which this character is determined.

All bodies are assumed to admit of compression and expansion: their solid and impenetrable particles, therefore, are not in absolute contact, the distances varying under different circumstances. *Mass*, expresses the number of material particles contained in a body; and *density* represents the relation of the mass, that is, of the number of particles, or quantity of matter, to the volume, or space which the body occupies. Hence, *density* means comparative mass.

The measure of the gravitating force of a body, expressed with relation to some known standard, which serves as a unit, is the *absolute weight* of the body. The amount of this weight will be in direct proportion to the mass; it has no fixed relation to the volume. *Specific gravity*, on the other hand, expresses the relation of the weight to the volume of the body. A little observation would soon shew that every body occupying a given space, has a weight *specific*, or peculiar to itself. Hence, the comparative weights of equal volumes of different bodies, are called their *specific gravities.*

The figures used for indicating specific gravities, may, with equal propriety, be applied to indicate density; and they are thus frequently employed indifferently, to denote either density or specific gravity.

The process for taking the specific gravity of a body consists in estimating the weight of a given volume of it, as compared with that of an equal volume of some other body, taken as the unit or standard of comparison. *Pure water* is used as the standard of comparison for solids and liquids, and *atmospheric air* for gases.

1. *The specific gravity of a solid substance insoluble in water* is determined by first weighing it in the usual manner, with an accurate balance, suspended in the air, then attaching a slender silken thread to it, and weighing it in water, and finally dividing the weight in air by the difference between the weight in air and the weight in water. Figs. 295 and 296 represent the appropriate

*Fig.* 295.

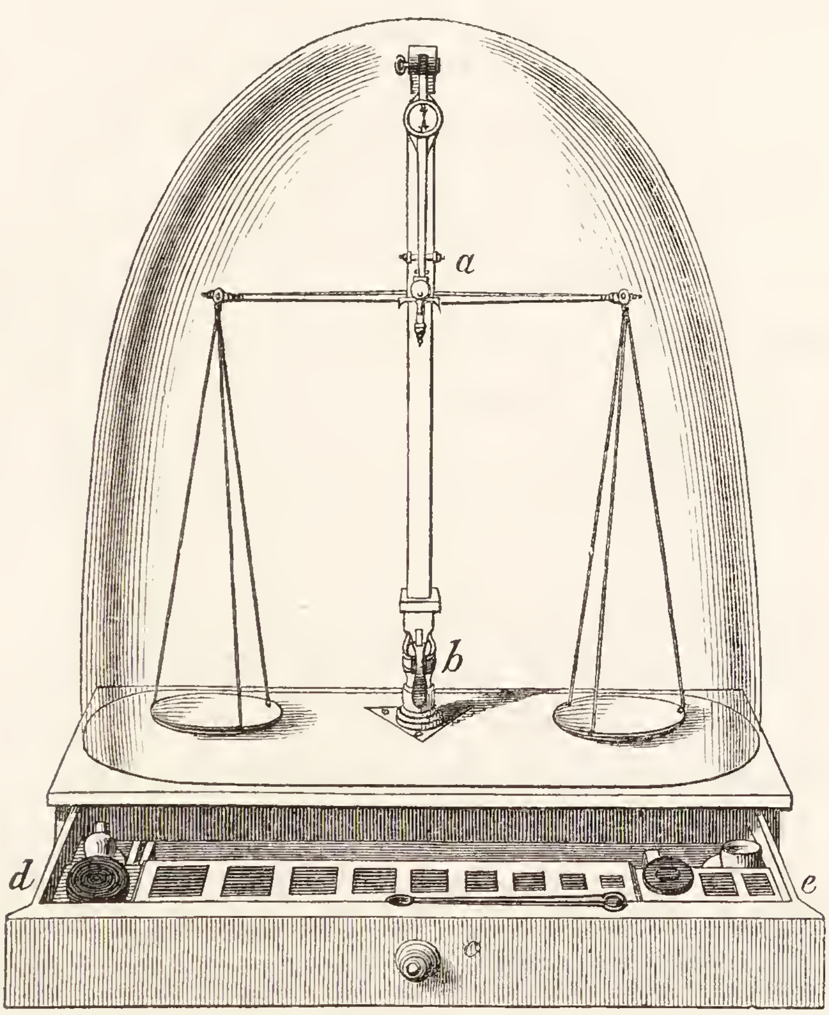



*Fig.* 296.

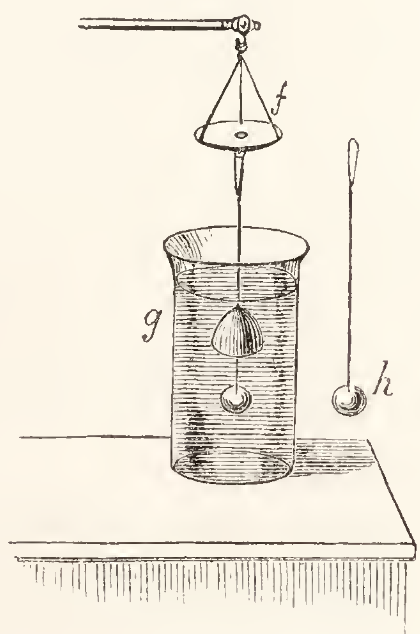



*Fig.* 297.

Apparatus for taking Specific Gravities.

balance and other apparatus for performing the process. The body, the specific gravity of which is to be determined, is weighed in the balance, fig. 295, and its weight carefully noted. One of the pans of the balance is then removed, and a pan, such as *f*, fig. 296, with short strings and a small hook at the bottom of the pan, is substituted for it, and the equilibrium adjusted. The substance under operation is attached to a fine silken thread, a horse-hair, or very thin platinum wire, as shewn at *h*, fig. 296; this is then fixed to the hook at the bottom of the small pan (*f*), and a glass vessel, such as *g*, nearly filled with distilled water, being placed under it, the suspended body (*h*) is immersed in the water, and its weight taken under these circumstances. The object in thus weighing the body in water is, to ascertain the weight of a volume of water equal to that of the body immersed. The process is founded upon the well-known facts, that a solid body, such as a piece of glass or metal, that is impervious to water, on being immersed in that liquid, displaces a volume of water equal to that of the body so immersed; and that the surrounding liquid exercises a pressure upwards, upon such body, equivalent to the weight of the volume of water displaced. Thus the weight of a body weighed as above in water, is equal to the absolute weight of the body, *minus* the weight of an equal volume of water; and, therefore, on deducting the weight of the body in water from its weight in air, the quotient will be the weight of a volume of water equal to that of the body so weighed. We thus obtain, first, the absolute weight of the body, and, secondly, the weight of an equal volume of water. The specific gravity is obtained by dividing the former by the latter.

Thus, a leaden bullet is found to weigh 398 grains in air: when immersed in water, its weight is 362·4 grains, and the difference between these two weights, namely, 35·6 grains, is the weight of the volume of water displaced by the bullet, or of a volume of water equal to that of the bullet. The volume of water being taken as unity, the specific gravity of the bullet is found by the following equation:—

35·6 : 1 : : 398 : 11·176, the specific gravity of the bullet.

2. In taking the specific gravity of *a solid substance lighter than water*, some modification of the process is required, but we have, nevertheless, the same preliminary points to determine: first, the weight of the substance in air: and, secondly, the weight of an equal volume of water. This may be illustrated by describing the method of taking the specific gravity of a piece of wax. The weight of the wax in air is 105·4 grains. On immersing the wax in water, two pressures are exerted—a pressure downwards, equal to the gravity or weight of the wax, and a pressure upwards, equal to the weight of the volume of water displaced by the wax; but the specific gravity of water being greater than that of wax, the upward pressure preponderates, and the wax rises to the surface.

Thus we find that a volume of water equal to that of the wax, weighs as much as the wax, and something more. We must ascertain how much more, and this is done in the following manner: some body heavier than water, and the weight of which in water is known, is attached to the wax, and the two bodies are weighed in water together. A piece of lead may be used for this purpose. The arrangement is represented in fig. 296, where a leaden bullet, attached to a conical piece of wax, and immersed in the water, is shewn. The lead alone weighs 378 grains in water; with the wax attached to it, the weight in water is 372·4 grains, making a difference of 5·6 grains, and this 5·6 grains is equal to the excess of the upward over the downward pressure on the wax when immersed in water. Thus, a volume of water equal to that of the wax weighs 5·6 grains more than the wax, or 105·4 + 5·6 = 111 grains.

Then, 111 : 1 : : 105·4 : 0·949, the specific gravity of the wax.

3. It sometimes happens that the solid substance, the specific gravity of which is to be determined, is *in powder*, or *in several small particles*. In such cases, it is found convenient to proceed as in the following method of taking the specific gravity of calomel.

100 grains of calomel are introduced into a specific gravity-bottle which holds 1000 grains of distilled water; the bottle is now filled up with water, and the weight of the contents is found to be 1083·7 grains; deducting the weight of the calomel (100 grains) from this, the remainder (983·7 grains) will be the weight of the water in the bottle, and the difference (16·3 grains) between this and 1000 grains, the weight of the whole contents of the bottle when filled with distilled water, is the weight of a volume of water equal to the volume of the calomel.

Then 16·3 : 1 : : 100 : 6·03, the specific gravity of the calomel.

*Fig.* 298.

SPECIFIC GRAVITY BUCKET.

If the substance be in several fragments, but not in fine powder, the process may be conducted as follows: After having weighed the fragments in air, the small glass bucket (fig. 298) is suspended from the bottom of the pan *f*, immersed in the water, and the equilibrium adjusted; the fragments are then put into the bucket and thus weighed in water. In this way the two results required for the equation are obtained.

4. In taking *the specific gravity of substances soluble in water*, other modifications of the process are required. Sometimes the substance may be covered with a thin coating of varnish, so as to protect it from the action of the

water. This method answers very well for blue pill, which may be brushed over with a strong tincture of mastic, and then proceeded with as in the case of the lead. In other instances, however, it is necessary to pursue a different course. Thus, any powder that is soluble in water, must have its specific gravity taken, in the first instance, with reference to some liquid in which it is not soluble. Spirit of wine, oil of turpentine, or olive oil, may be used in such cases. The process may be illustrated by describing the method of taking the specific gravity of guano in oil of turpentine. In the first place the specific gravity of the oil of turpentine is ascertained to be 0·874. Then 100 grains of guano are introduced into a specific gravity bottle, as in the case of the calomel; and the bottle being filled up with oil of turpentine, the weight of the contents is found to be 922·7 grains, from which deducting 100 grains, the remainder (822·7 grains) will represent the oil not displaced by the guano, and this deducted from 874 grains, the quantity of oil the bottle is capable of holding, leaves 51·3 grains as the weight of a volume of oil of turpentine equal to that of the guano. Now, 874 : 51·3 :: 1000 : 58·7, the weight of a volume of water equal to that of the guano.

Then 58·7 : 1 :: 100 : 1·7, the specific gravity of the guano.

The methods by which *the specific gravities of liquids* are usually determined, may be divided into two classes:—

1st. Those which consist in filling any suitable vessel with the liquid to be estimated; ascertaining the weight of the contents, and dividing this by the weight of the same volume of water.

2nd. Those which consist in displacing a portion of the liquid, by some solid body floating in it, and estimating the specific gravity according to the weight and volume of the substance immersed, as compared with its immersion in water.

In the first case, the instruments employed are a *specific gravity bottle* and an ordinary *balance.*

In the second case, the instruments used may be comprehended under the general terms of *hydrometers*, or *aräometers.* These, however, are distinguished from each other, for there are many varieties of them, by different names, according to the particular purposes for which they are respectively intended, or from some peculiarity in their construction.

5. *The specific gravity bottle* affords the most accurate means of determining the comparative densities of liquids. It consists usually of a globular bottle (fig. 299) with a flat bottom and a slender neck, which holds exactly 1000 grains of distilled water at a certain fixed temperature. It is very easy at any time to test

the accuracy of one of these bottles by a single experiment, and having ascertained that the bottle is correctly adjusted with regard to distilled water, the indications afforded with any other liquid will be equally trustworthy. Every chemist ought to prepare his own specific gravity bottle for use, and he will then know what degree of confidence can be placed in its indications. Small flasks adapted for the purpose, are made by the glass-blowers, and sold for about a shilling each. One of these flasks is carefully counter-poised in the balance, and 1000 grains of pure distilled water is put into it. The water should fill the globular part of the flask, and extend about two-thirds up the neck.

*Fig.* 299.

SPECIFIC GRAVITY BOTTLE.

The surface of the water in the neck of the flask will be concave, as represented in the drawing, this being caused by the capillary attraction of the glass. The water must now be brought to the temperature of 62° Fahr., and when it is at this temperature a mark is to be made by scratching the glass with a file, indicating the height at which the water stands. It is customary to make two scratches, one opposite the top, and the other opposite the bottom, of the curve formed by the surface of the water, as seen in a horizontal line from the eye of the operator.

The weight, in grains, of the quantity of any liquid filling this bottle to the mark, will indicate its specific gravity. In the use of the specific gravity bottle there are two points which require particular attention;—the *first* is, that the bottle should be perfectly clean and dry before introducing the liquid to be tried; and the *second* is, that the liquid, when the bottle is filled to the proper mark with it, should be exactly at the temperature at which the original adjustment of the bottle with distilled water was made. It is sometimes found difficult to dry a specific gravity bottle quickly, when required to be used for several successive operations; and also to get it perfectly clean when it has been used for oils. In such cases, the desired object may be attained by introducing some clean, dry, and warm sand, free from dust, shaking this out briskly, and repeating the process until the effect is completed. In the absence of sand suitable for the purpose, or in case that method should not succeed, some oil of vitriol may be put into the flask previously containing a few drops of water, so as to cause considerable elevation of temperature, and after bringing the hot acid into contact with every part of the surface of the glass by turning the flask in different directions, continuing the action until all organic matter has been removed, the acid is poured out, and the flask well washed with water. After being washed, it should be drained for a few minutes, and then placed on the sand-bath until it has become hot. A small glass tube, of four or five inches in length, which passes freely through the neck of the flask, is now introduced, and the mouth being applied to the end of the tube, air is drawn into the lungs so as to establish a current and constant change of air in the bottle. In this way it may be cleaned and dried in a few minutes.

With regard to the temperature at which the specific gravity bottle is to be used, it must be borne in mind that the London Pharmacopœia directs specific gravities to be always taken at 62° Fahr., and therefore every English pharmaceutist ought to have his specific gravity bottles adjusted at this temperature, at which, also, he should of course use them. The manufacturers of these instruments, unless they receive express instructions to the contrary, usually adjust them at 60° Fahr.

*Hydrometers*, or *arëometers*, are floating instruments, and their application for the purpose of determining the specific gravities of liquids, depends upon the fact that a body immersed in any liquid sustains a pressure from below upwards, equal to the weight of the volume of liquid displaced by such body.

The use of hydrometers for determining the specific gravities of liquids, has been traced back to a period about 300 years before Christ; an instrument of this kind being described as the invention of Archimedes, the Sicilian mathematician. It subsequently fell into disuse, but was again brought into notice by Basil Valentine.

There are two kinds of hydrometers, which may be taken as types for all the different varieties in regard to construction:—

1st. Those which are always immersed into the liquids to be tried, to the same depth, and to which weights are added to adjust the instrument to the density of any particular liquid. Of this description are Fahrenheit's, Nicholson's, and Guyton de Morveau's hydrometers. These instruments indicate the weight of a given volume of any liquid.

2nd. Those which are always used with the same weight, but which sink into the liquids to be tried, to different depths, according to the densities of the liquids. These usually have graduated scales attached to their stems. Of this description are the common glass hydrometers generally, including those of Baumé, Cartier, Gay Lussac, Twaddle, Zanetti, &c., and the specific gravity beads. These instruments indicate the volume of a given weight of any liquid.

Sikes's and Dicas's hydrometers combine some of the principles of both types, having moveable weights and graduated scales.

Hydrometers may also be divided into two classes, as follows:

1st. Those having a general application for determining the comparative densities of any liquids.

2nd. Those intended for special application, as for estimating the comparative strengths of spirits, or the comparative densities of syrups, oils, &c.

Fahrenheit's, Nicholson's, Guyton de Morveau's, and the common glass hydrometers, including Baumé's, Cartier's, Twaddle's, Zanetti's, and the specific gravity beads, belong to the first class.

Gay Lussac's, Sikes's, and Dicas's hydrometers, the saccharometer, urinometer, elaëometer, and galactometer, belong to the second class.

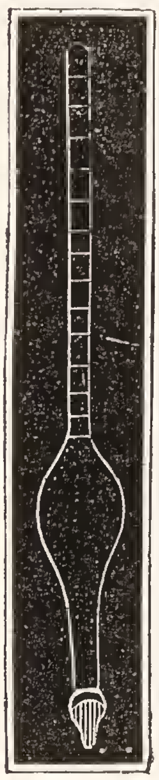
6. *Fahrenheit's hydrometer* consists of two glass bulbs blown on a tube, like a common hydrometer, excepting that the upper bulb is larger, and the stem is terminated at the top in the form of a cup or funnel. The lower bulb is loaded with mercury, but not so as to cause the entire immersion of the instrument, when put into water, without the addition of weights to the cup at the top of the stem. There is a mark about the middle of the stem, which is the point at which the hydrometer is made to float, by putting the requisite weights into the cup.

7. *Nicholson's hydrometer* is a modification of Fahrenheit's. It is made of brass, and consists of a hollow globe, to which a very slender stem, surmounted by a cup, is attached; on the opposite side of the globe there is another cup, fixed in a kind of stirrup and loaded, so that this shall always be the lowest point of the instrument when immersed in any liquid. The form of this instrument therefore differs from that of Fahrenheit's in the lower bulb of the latter being replaced by the loaded cup. There is a mark on the stem indicating the point at which the hydrometer is to be made to float by the proper adjustment of the weights. The weight of the loaded instrument, when sunk to the proper point, is the weight of the volume of liquid displaced by it. It gives, therefore, the relative weights of equal volumes of the liquids into which it is introduced. This instrument is also sometimes called the *Gravimeter;* it is usually made to displace 3000 or 4000 grains of water, and is sensible to the tenth of a grain in this quantity.

This instrument is applicable, also, for taking the specific gravities of solid substances. By placing the solid body in the cup at the top of the stem, and then adjusting the additional weights required to sink the hydrometer, the weight of such solid body in air is ascertained; then, by placing the solid body in the lower cup, immersed in the water, and again adjusting the weights as before, the weight of the body in water is ascertained; and from these the specific gravity is calculated, as in the other cases described.

*Baumé's hydrometers* are used extensively in this country as well as in France, and are applicable for all kinds of liquids. There are two distinct instruments, one for liquids lighter than water, and the other for liquids heavier than water. The latter is, for distinction, called the *acidometer* or *saccharometer* (*pèse-acide* or *pèse-sirop*); the former, the *spirit hydrometer* (*pèse-esprit*).

*Fig.* 300.



Common Hydrometer.

8. *Baumé's acidometer* is made in the form of the common hydrometer, the outline of which is represented in fig. 300. It consists of a glass tube terminated at the lower end by two bulbs, the lowest bulb being much smaller than the other, and intended to contain the ballast with which the instrument is loaded. The scale is marked on a slip of paper, or of ivory, fixed in the tube, and is adjusted in the following manner:—The top of the tube being open, the slip of paper on which the scale is to be marked is put into the stem, and the instrument is then immersed in pure distilled water; quicksilver is now dropped into the lower ball until the instrument sinks so low in the water that only the top of the stem remains above the surface, and a mark is made on the glass denoting exactly the point to which it sinks. The instrument is now taken out of the pure water, and put into a solution of fifteen parts of common salt in eighty-five parts of distilled water, this solution being at the same temperature as the water in which the instrument was previously immersed. The point to which it sinks in this solution is to be marked on the stem as before, and the distance between the two marks being taken with a pair of compasses, and transferred to the slip of paper, the first is made the zero or 0, and the other the 15th degree of the scale. This distance being divided into fifteen equal parts or divisions, each division is called a degree, and the scale is completed by adding as many more degrees as the length of the stem will admit of. This being done, the slip of paper is again introduced into its place, and so fixed that the zero (0) of the scale shall be exactly opposite the first mark made on the glass. The end of the stem is now sealed with the flame of a blow-pipe.

9. *Baumé's spirit hydrometer* is similar in form to the acidometer, but the weight of the instrument and the scale are different. In this case, the hydrometer is first immersed in a solution of ten parts of common salt in ninety parts of water; but it is made to float, so that the greater part of the stem shall be above the surface of the water. This point is marked, and the instrument is then transferred to pure distilled water, when another mark is made. The distance between these marks is made ten degrees of the scale, which are divided with the compasses, and marked on the slip of paper, as in the other case, the floating-point in the solution of salt being made the zero, and the degrees carried upwards from this point.

The temperature at which these instruments were originally adjusted by Baumé, was 10° Reaumur, or 12·5 centigrade; but those made in England are usually adjusted at 60° Fahrenheit. It is sometimes important to be aware of this difference, and to bear in mind that in the London Pharmacopœia specific gravities are directed to be taken at 62°.

10. *Cartier's hydrometer* is much used in France. It is only applicable for liquids lighter than water. This instrument is a modification of Baumé's spirit hydrometer, the form of the instrument being the same, and the same point being taken as the zero of the scale; but the space which in Baumé's scale is divided into 32°, is in Cartier's divided into 30°.

It is becoming the common practice in this country to have the scales of hydrometers marked with the specific gravities intended to be indicated, and this is by far the most convenient kind of hydrometer for general use.

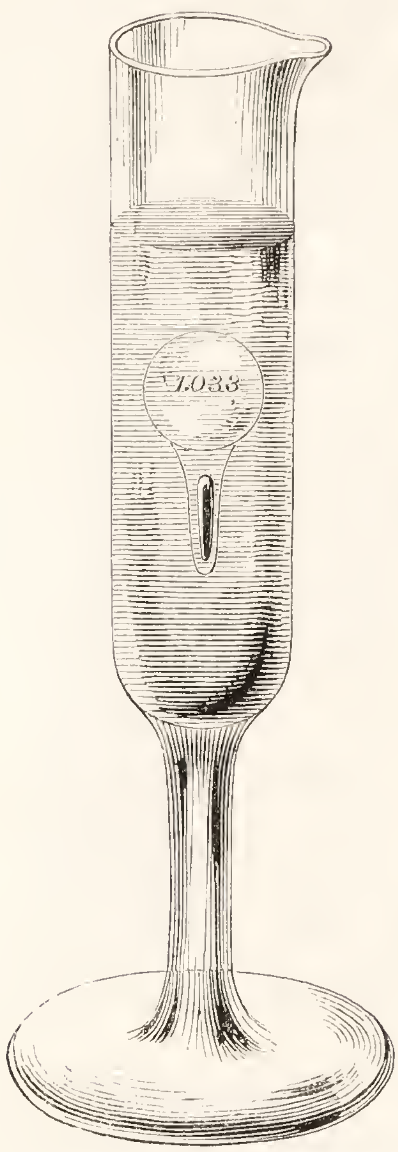
11. *Twaddle's hydrometers* are much used by manufacturers for estimating the strength of saline and other solutions. They are made of glass like the common hydrometers, and are sold in sets of six. Each degree on the scale is equal to 0·005 of specific gravity, so that the specific gravity of a liquid is found with these hydrometers, by multiplying the number of degrees indicated by 5, and adding 1000. Thus, 10° by Twaddle's hydrometer, $\times 5 + 1000 =$ 1·050 specific gravity.

12. *Zanetti's hydrometers*, which are made at Manchester, are also sold in sets of six. With these the specific gravity is got by adding a cypher to the number of degrees indicated.

13. *Specific gravity beads*, sometimes called *Lovi's beads*, are hollow sealed globes of glass, about the size of small pistol-bullets. Each bead is a small hydrometer, intended to indicate one fixed density, by its remaining half-way between the top and bottom of

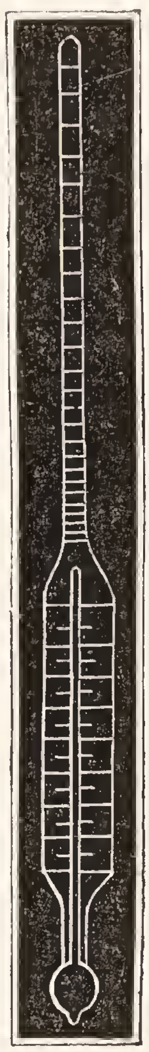
the liquid into which it is introduced, as shewn in fig. 301. These beads are sold in sets, each one being marked with the specific gravity it is to indicate at a certain fixed temperature. They are very useful in making mixtures of any required densities, as, for instance, in making test acids. The bead represented in the drawing, indicates the density of test sulphuric acid, one thousand grain-measures of which will saturate as many grains of alkali as represent the equivalent; for instance, 70 grains of carbonate of potash, 54 grains of carbonate of soda, or 17 grains of ammonia. The test acid is, therefore, readily made, by carefully adding pure oil of vitriol to distilled water, until the bead remains in the mixture, when at a temperature of 60° Fahr., as shewn in the drawing, neither sinking to the bottom, nor rising to the surface. The specific gravity of *test sulphuric acid*, made as above, is 1·033.

*Fig.* 301.




Specific Gravity Bead.

*Fig.* 302.



Gay Lussac's Alcohometer.

14. *Gay Lussac's alcohometer*, fig. 302, is frequently employed in France; it is adapted only for estimating the strength of spirits. The instrument is made like a common glass hydrometer, the scale of which is divided into 100 parts or degrees. The lowest division, marked 0, at the bottom of the scale, denotes the specific gravity of pure water at a temperature of 15° cent., or 59° Fahr., and the highest division, at the top of the scale, the specific gravity of what was considered absolute alcohol at the same temperature, namely, spirit of sp. gr. ·796. The intermediate degrees indicate the number of volumes of such alcohol in 100 volumes of the spirit tried. The instrument is accompanied by a table for correcting the numbers marked on the scale, when it is used at any other temperature than that of 15° cent.; and there is generally a thermometer inserted in the lower part of the instrument, as shewn in the drawing.

15. *Sikes's hydrometer* is used in the collection of our spirit

revenue. It consists of a spherical ball or float, with an upper and a lower stem, made of brass, (*a*, *b*, *c*, fig. 303). The upper stem (*b*) has ten principal divisions, numbered 1, 2, 3, &c., which are each subdivided into five parts. The lower stem (*c*) is made conical, and has a pear-shaped loaded bulb at its lower extremity. There are nine moveable weights (*b*, *b*, *b*, fig. 304), which have the form of circular disks, and numbered 10, 20, 30, and so on to 90. Each of the circular weights is cut into its centre, so that it can be placed on the conical stem (*c*) at the small end, and slid down to the bulb, where it becomes fixed in consequence of the enlargement

*Fig.* 303.

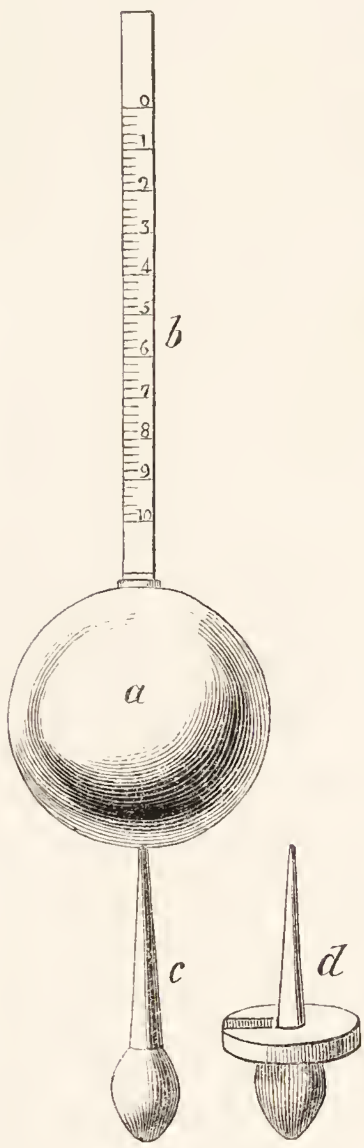
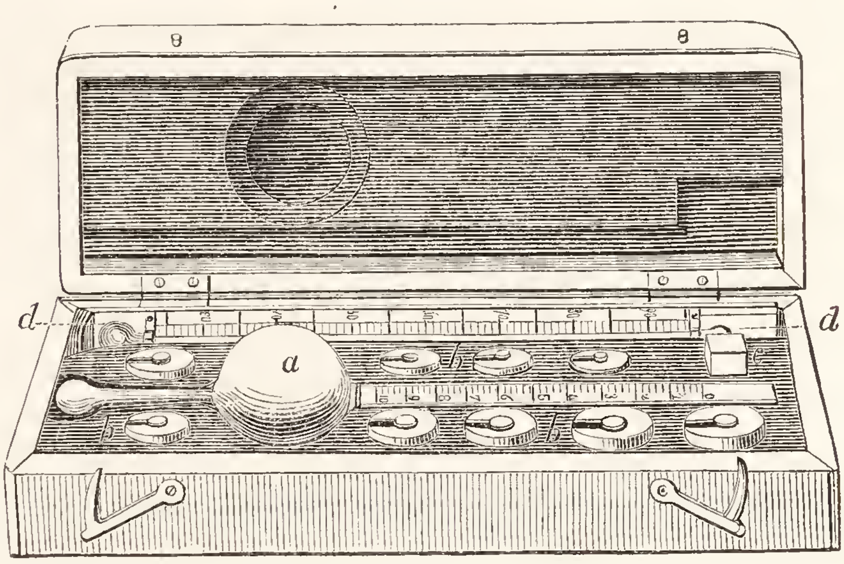



*Fig.* 304.




SIKES'S HYDROMETER.

of the cone, as shewn at *d*. The instrument is adjusted to strong spirit, specific gravity ·825 at 60° Fahr., this being accounted as standard alcohol. In this spirit the instrument floats at the first division, 0 or zero, without a weight. In weaker spirit, having a greater density, the hydrometer will not sink so low, and if the density be much greater, it will be necessary to add one of the weights to cause the entire immersion of the bulb of the instrument. Each weight represents so many principal divisions of the stem as its number indicates; thus the heaviest weight, marked 90, is equivalent to ninety divisions of the stem, and the instrument with this weight added, floats at 0 in distilled water. As each principal division on the stem is divided into five, the instrument has a range of 500 degrees between standard alcohol, sp. gr. ·825, and water.

There is a line on one of the side faces of the stem *b*, near to division 1 of the drawing, at which line the instrument, with the weight 60 attached to it, floats in spirit exactly of the *strength of* *proof* at a temperature of 51° Fahr.; and if the square weight *c* be placed on the top of the stem *b*, the weight 60 still remaining below, the instrument will float at the above line in distilled water of the same temperature. The square weight (*c*) being exactly one-twelfth part of the total weight of the hydrometer and weight 60, the above indication is in conformity with the definition of *proof spirit* given in the act of parliament, "proof spirit to weigh, at 51° temperature, exactly twelve-thirteenth parts of an equal bulk of distilled water."

In using this instrument, it is immersed in the spirit, and pressed down by the hand to 0, till the whole divided part of the stem be wet. The force of the hand required to sink it will be a guide in selecting the proper weight. Having taken one of the circular weights, which is necessary for this purpose, it is slipped on the conical stem. The instrument is again immersed and pressed down as before to 0, and is then allowed to rise and settle at any point of the scale. The eye is then brought to the level of the surface of the spirit, and the part of the stem cut by the surface, *as seen from below*, is marked. The number thus indicated by the stem is added to the number of the weight, and the sum of these, together with the temperature of the spirit, enables the operator to find, by reference to a table which accompanies the instrument, the strength of the spirit tested.

The number thus indicated by the stem is added to the number of the weight employed, and with this sum at the side, and the temperature of the spirits at the top, the strength *per cent.* is found in a table which accompanies the hydrometer. The strength is expressed in numbers denoting the excess or deficiency *per cent.* of proof spirit in any sample, and the number itself, having its decimal point removed two places to the left, becomes a factor, whereby the gauged contents of a cask or vessel of such spirit being multiplied, and the product being added to the gauged contents if over proof, or deducted from it if under proof, the result will be the actual quantity of proof spirit contained in such cask or vessel.

16. *Dicas's hydrometer* is similar in construction to Sikes's, and it is used in a similar manner, with the same result, indicating the relation of the spirit tried to standard proof spirit.

It is the practice in commerce to designate the strength of spirit as so many degrees above or below proof, the government having fixed upon what is called *proof spirit* as the standard in comparison with which the strength of all spirit shall be estimated. The term *proof* is said to have been derived from the ancient practice of trying the strength of spirit by pouring it over gun-powder in a cup, and then setting fire to the spirit; if, when the spirit had burned away, the gunpowder exploded, the spirit was said to be *over proof*; if, on the other hand, the gunpowder failed to ignite, in consequence of the water left from the spirit, it was said to be *under proof.* The weakest spirit capable of firing gunpowder in this way was called *proof spirit;* but it requires a spirit nearly of the strength of what is now called rectified spirit to stand this test. The *standard proof spirit* of the excise is defined by law (56 Geo. III. cap. 140) to be "*that which at a temperature of* 51°, *by Fahrenheit's thermometer, weighs exactly twelve-thirteenth parts of an equal measure of distilled water.*" This will have a specific gravity of ·923 at 51° Fahr., or about ·920° at 60° Fahr. The *standard alcohol* of the excise is spirit, the specific gravity of which is ·825 at 60°. Fahr. By "spirit 60 degrees over proof" is understood a spirit, 100 measures of which, added to 60 measures of water, will form *standard proof spirit*, sp. gr. ·920. By "spirit 10 degrees under proof" is understood a spirit, 100 measures of which, mixed with 10 measures of standard alcohol, sp. gr. ·825, will form *standard proof spirit.*

17. *Saccharometers* are hydrometers intended for determining the density of syrups. They are usually made and graduated in the same manner as Baumé's acedometers, and differ only from these in being made smaller. Fig. 305 represents one of these instruments drawn to its real size; but they are sometimes made larger than this. It floats at 30°, in a solution, the specific gravity of which is 1·26, and this is the density of simple syrup when boiling; therefore, if the instrument floats at 30° in a solution of sugar, when boiling, it is inferred that such solution will be exactly saturated when cold. The scale is sometimes graduated so as to indicate the proportion of sugar in the solution.

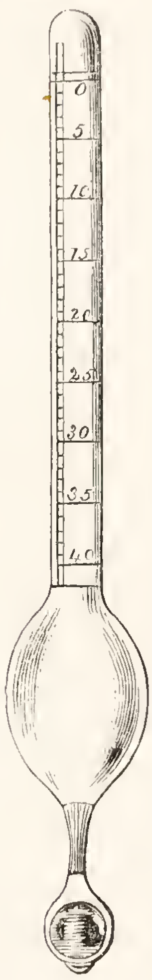
18. The *urinometer* is a small hydrometer, originally suggested by Dr. Prout for estimating the density of urine. The scale is divided into 60 degrees, the zero being the point at which it floats in distilled water. Fig. 306, represents the instrument drawn to its real size.

The numbers on the scale, added to 1000, the assumed specific gravity of water, give the specific gravities at the respective points. Thus, supposing the number cut by the surface of the fluid to be 30, this indicates a specific gravity 1030. Fig. 307 shews the reverse side of the scale. The letters, H. S. on this side signify *healthy standard,* which ranges from 10° to 20° of the scale. The space from 30° to 60° is marked *diabetes,* the urine of diabetic patients having generally a density ranging between these points.

19. The *elaëometer* (fig. 308) of M. Gobley, of Paris, is a very

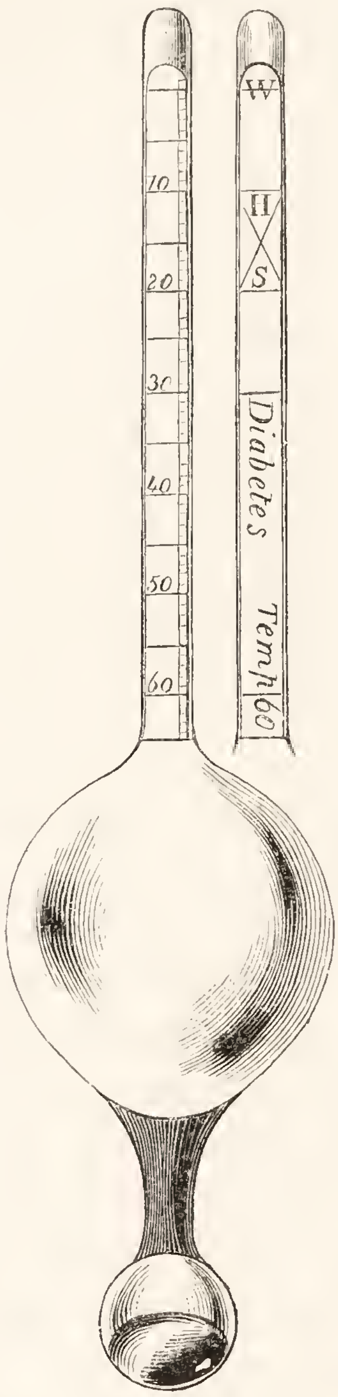
delicate glass hydrometer, intended for testing the purity of olive oil or oil of almonds, by determining their densities. The 0 or zero of the scale, is the point at which the instrument floats in *oil of*

*Fig.* 305.




Saccharometer.

*Fig.* 306. *Fig.* 307.




Urinometer.

*Fig.* 308.

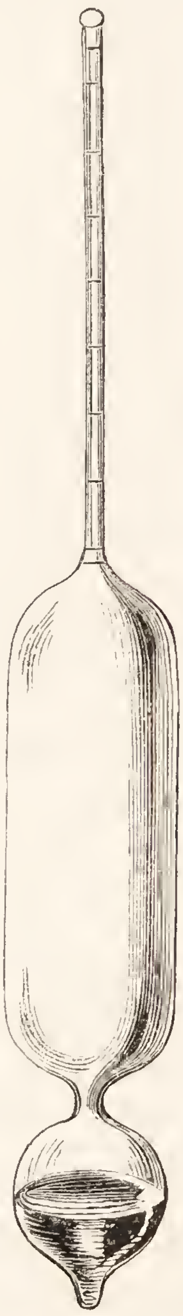
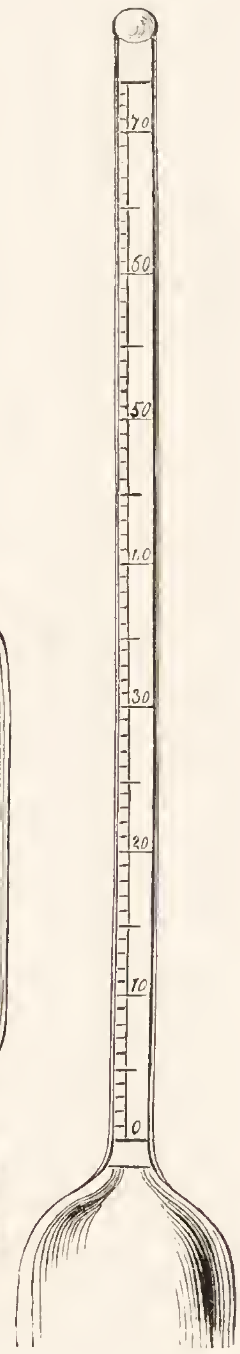


*Fig.* 309.




Elaeometer.

*poppy seeds.* The point at which it floats in *pure olive oil,* is made the 50th degree, and the space between these two points is divided into 50 equal parts and numbered accordingly. It floats at 38 or $38\frac{1}{2}°$ in *pure oil of almonds.* Fig. 309 is drawn to the real size of the scale of the instrument.

20. The *galactometer* is similar in construction to the elaëometer, but is intended for determining the quality of milk. There are two scales which have been attached to the galactometers ; one indicates the different qualities of cow's-milk, according to its density ; the other is intended to distinguish the milk of one animal from that of another animal. These instruments were originally sug-

gested by Cadet de Vaux, and subsequently improved by Dinocourt, 7, Quai St. Michel, Paris, by whom they are made.

21. There are other means besides those above described for taking the specific gravities of liquids. Thus on weighing a solid body, first in air and then in water (as described in process 1), the weight of a volume of water equal to the volume of the solid substance employed, is ascertained ; and if this be repeated, using the same solid body, but immersing it in any other liquid besides water, the weight of an equal volume of such other liquid is determined ; then the latter result divided by the former, will give the specific gravity of the second liquid employed. This method is well adapted for taking the specific gravity of any liquid, where only a small specimen of it is available for the purpose. A small piece of glass, or of platinum, suspended by a hair, may be used as the solid body in such cases. A bit of platinum, of the size of a swan-shot, and half a drachm of liquid, contained in a small test tube, will afford a tolerably accurate result with a good balance. The glass cone (fig. 310) is one of the appendages to the balance (fig. 295), and is intended to be used in the manner above described for taking specific gravities.

*Fig.* 310.

Dr. Mohr describes an arrangement of apparatus, which is shewn in figs. 311, 312, and 313, for determining the densities of small quantities of liquids.

In the first place, the beam and one of the pans of a very good dispensing balance are suspended from a stand, as shewn in fig. 311. One arm of the beam, from the point of suspension to the point from which the pan was originally suspended, is accurately divided into ten equal parts, which are numbered from 1 upwards, commencing from the centre of the beam. In the next place, a small glass tube, of which fig. 312 is the real size, is partly filled with mercury, and its open end is then drawn out in the flame of a blow-pipe and bent so as to form a hook. This tube is suspended by a very slender platinum wire from the end of the graduated arm of the balance, and is counterpoised by weights or a box of sand put into the pan at the opposite extremity. The loaded tube is immersed in distilled water, at the proper temperature, contained in a conical glass, such as that in fig. 311, or a cylindrical glass fixed in a stand, such as fig. 313. A piece of bent copper or brass wire is now loosely suspended from the same hook, to which the platinum wire holding the immersed tube is attached, and the weight of this is accurately adjusted by means of the pincers and file, so as to restore the equilibrium of the balance. This wire will of course represent the weight of the

*Fig.* 311.

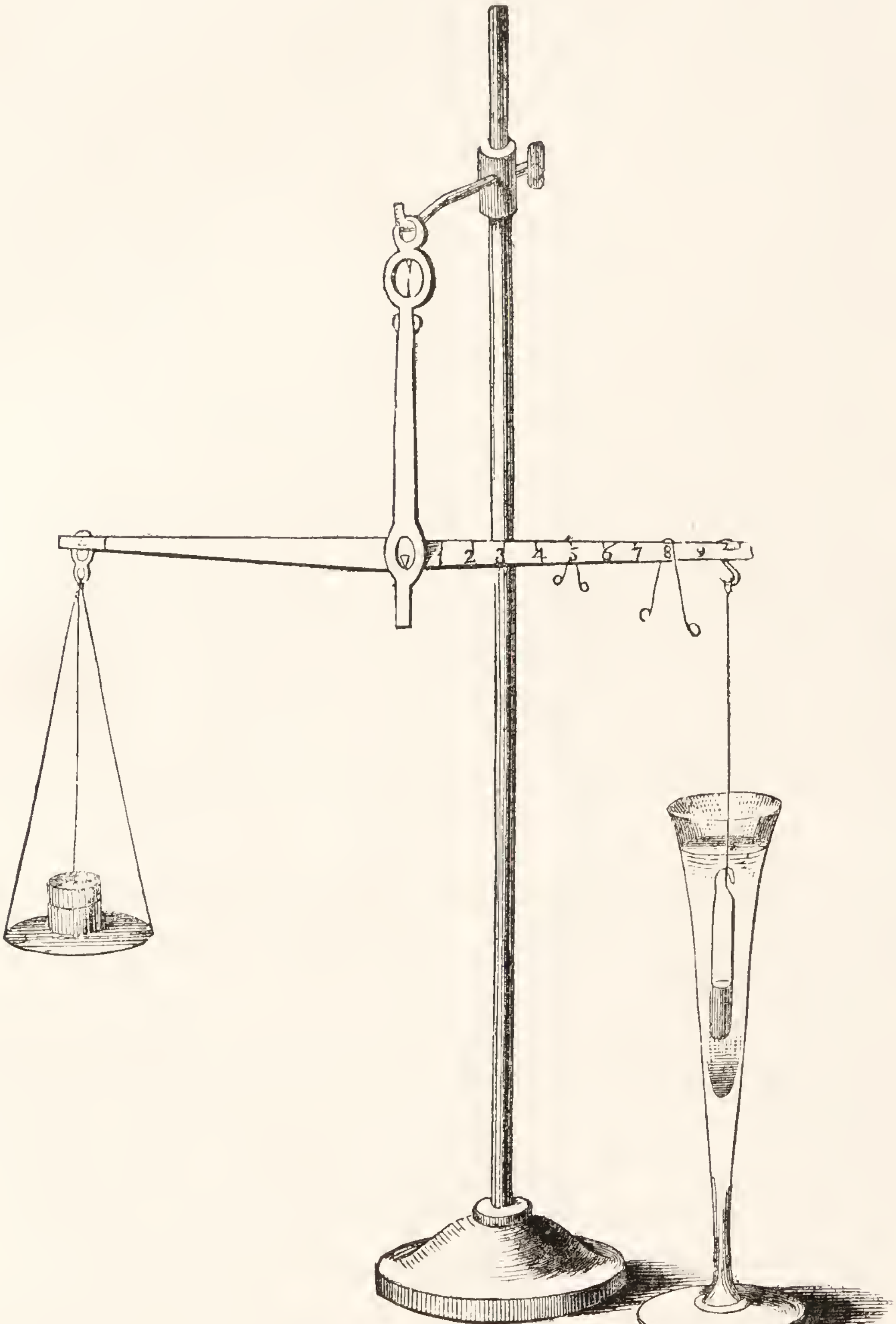
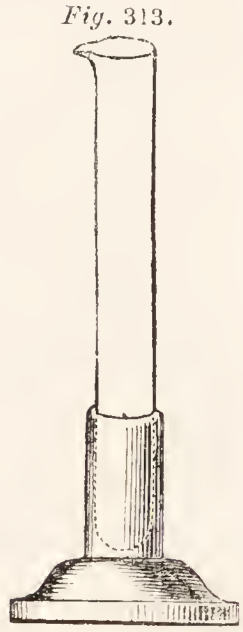


*Fig.* 312.

*Fig.* 313.

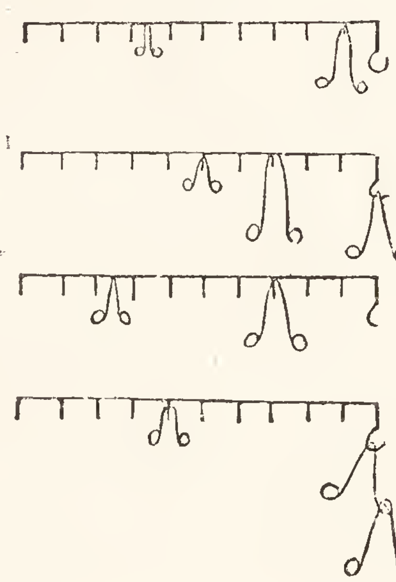


Apparatus for taking Specific Gravities.

water displaced by the immersed tube. When accurately adjusted it is to be bent to the form of those represented as suspended from the graduated arm of the balance. A second wire, of precisely the same weight as the first, and of similar form, is to be prepared; and also a third, which is to be made one-tenth the weight of either of the others. With these three wires all specific gravities up to 2·0 may be determined.

The apparatus is used in the following way:—the liquid to be tested is put into either of the glasses, and the suspended tube being immersed in it, one of the wires is placed on the beam and pushed along it until it is brought to a point at which it restores the equilibrium. If this point should lie between two of the divisions of the beam, as, for instance, between 8 and 9, and if the wire used be one of the heavier kind, it is to be placed at the lower of the two figures, that is at 8, and this will be the first decimal figure in the specific gravity of the liquid; the smaller wire is then put on to the beam and pushed along it until the equilibrium is again established, and the figure opposite which it rests will be the second decimal figure in the specific gravity. In fig. 311, the wires indicate a specific gravity ·850, the larger wire being at 8, and the smaller wire at 5. If the small wire, instead of being immediately over one of the divisions of the beam, should be at a point between two figures, its position must be measured by the eye, and represented by a third decimal figure; thus, if, instead of being at 5, the small wire were midway between 5 and 6, the specific gravity would be ·855. When the larger wire reaches the end of the beam, and is suspended from the hook to which the immersed tube is attached, this will indicate a specific gravity 1·0, or that of water, to which the instrument was adjusted; and the second large wire being now placed on the beam, densities above that of water may be indicated. Fig. 314 represents the method of placing the wires, and in the four cases illustrated the specific gravities which the positions of the wires indicate are expressed in figures placed opposite.

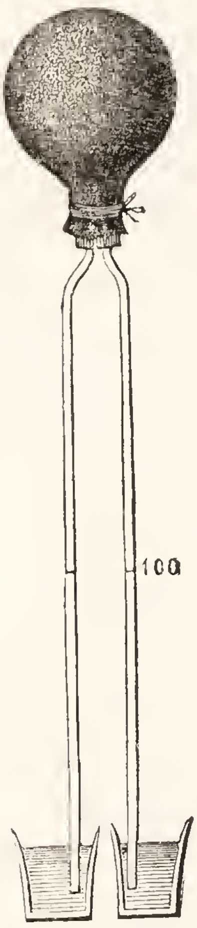
*Fig.* 314.




22. The principle of the syphon has been applied in the construction of an apparatus for determining the specific gravities of liquids. Two glass tubes of equal length are inserted into an Indian-rubber bag, as shewn in fig. 315, or connected by means of a short brass tube, bent twice at right angles, so as to form a syphon. In the space between the two limbs of the syphon is placed a scale divided into 1000 or any number of degrees. A stop-cock is fixed in the brass connecting-piece at the top of the syphon, by which the air can be exhausted, and any liquids into which the lower extremities of the tubes are immersed, made to ascend in the tubes. If one limb of the syphon be immersed in distilled water, and the other in any liquid the specific gravity of which is to be determined, con-

tained in two glasses; and if the air be exhausted by first collapsing the Indian-rubber bag and then allowing it to expand, or by applying the mouth or a syringe to the tube if the other form of apparatus be adopted, so that the liquids, or at least one of them, shall rise nearly to the top of the syphon, the length of the columns thus sustained by the pressure of the external atmosphere, will be in inverse proportion to the specific gravities of the liquids. Then, water being taken as unity, the specific gravity of any other liquid in relation to it is easily ascertained. Thus, if water stands at 240° in one limb of the syphon, and oil of vitriol at 131° in the other, we ascertain the specific gravity of the oil of vitriol by the inverse rule of proportion, as follows:—

*Fig.* 315.




Specific Gravity Syphon.

131 : 1 :: 240 : 1·845, the specific gravity of the oil of vitriol.

*The specific gravities of gases and vapours* are expressed with reference to atmospheric air as unity. As in the cases of solids and liquids, it is necessary to ascertain, first, the weight of a given volume of the gas or vapour under examination; and secondly, the weight of an equal volume of the substance to which it is to be compared,—in this case atmospheric air. These processes are rarely required to be performed by the pharmaceutist, and therefore will not be described here.]

## THE STOPPERING OF GLASS BOTTLES.

It not unfrequently occurs that glass stoppers do not fit perfectly into the mouths of the bottles to which they belong. The best method of trying the fitting of a stopper is to press it down lightly with the point of one of the fingers while it is pushed laterally in different directions. If it moves in any direction, when thus treated, it must be considered as badly fitting, and unsuited for the preservation of volatile substances, or such as are readily oxidized or otherwise injured by exposure to the air. Even when liquids will not pass, the stoppering may admit of an interchange of the internal and external air, and this interchange is greatly promoted by the variations which are constantly occurring in the expansion or contraction caused by heat or barometric pressure.

Too much care cannot be taken to ensure well-fitting stoppers for, at least, those substances which are most liable to change. If any are found to be defective, means should be adopted for remedying the evil.

Badly-fitting stoppers may be rendered air-tight by regrinding them. This is effected by first mixing sand or emery with water; then dipping the stopper into this, and placing it in the neck of the bottle, moving it laterally to and fro, with a gentle pressure, and slightly withdrawing the stopper from time to time to admit fresh portions of sand or emery. After grinding thus for some time, the stopper and the mouth of the bottle should be washed, and the fitting of the stopper tried in the manner already described. When the stopper is found to fit in firmly without shaking in any direction, the grinding may be finished off with a little fine emery powder and oil.

In this way, not only may badly-fitting stoppers be made to fit air-tight into the bottles for which they were intended, but bottles not previously stoppered may have stoppers ground in to fit them. It is necessary in selecting a stopper to be thus fitted to a bottle, that due regard should be paid to the form of the neck of the bottle, for stoppers which do not agree in shape with the neck of the bottle can hardly be made to fit properly without the use of a lathe. If the neck of the bottle be more conical than the stopper, as shewn in fig. 316, or if the stopper be more conical than the neck of the bottle, as shewn in fig. 317, in either case it will be difficult, if not impossible, to make them fit well by mere hand-grinding.

*Fig.* 316.

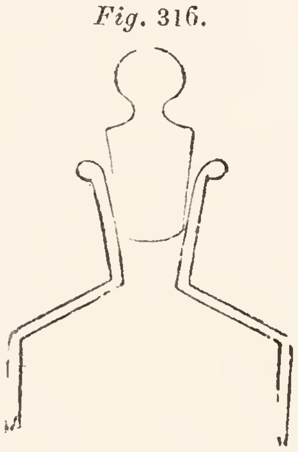


*Fig.* 317.

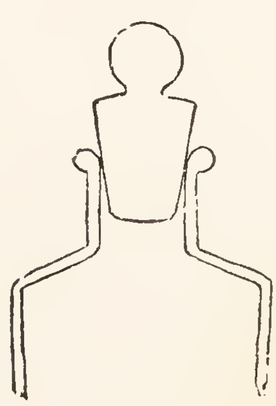
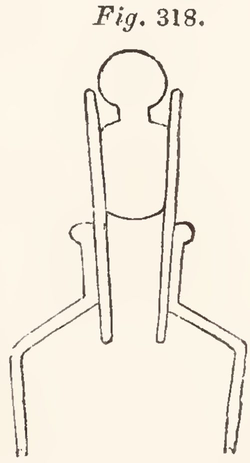


*Fig.* 318.



Stoppering Bottles.

When long-continued grinding is required, a piece of conical copper tube should be used in the process, with which both stopper and neck may be ground at the same time. The conical tube is made of a piece of sheet copper, bent and soldered to the proper form and size, and afterwards turned in the lathe so that the inner and outer surfaces may be perfectly smooth. This cone is used as represented in fig. 318, the stopper being placed within it, and the neck of the bottle on the outside. Copper answers the purpose better than any other metal, as the sand becomes imbedded in it, and thus forms a good grinding surface.

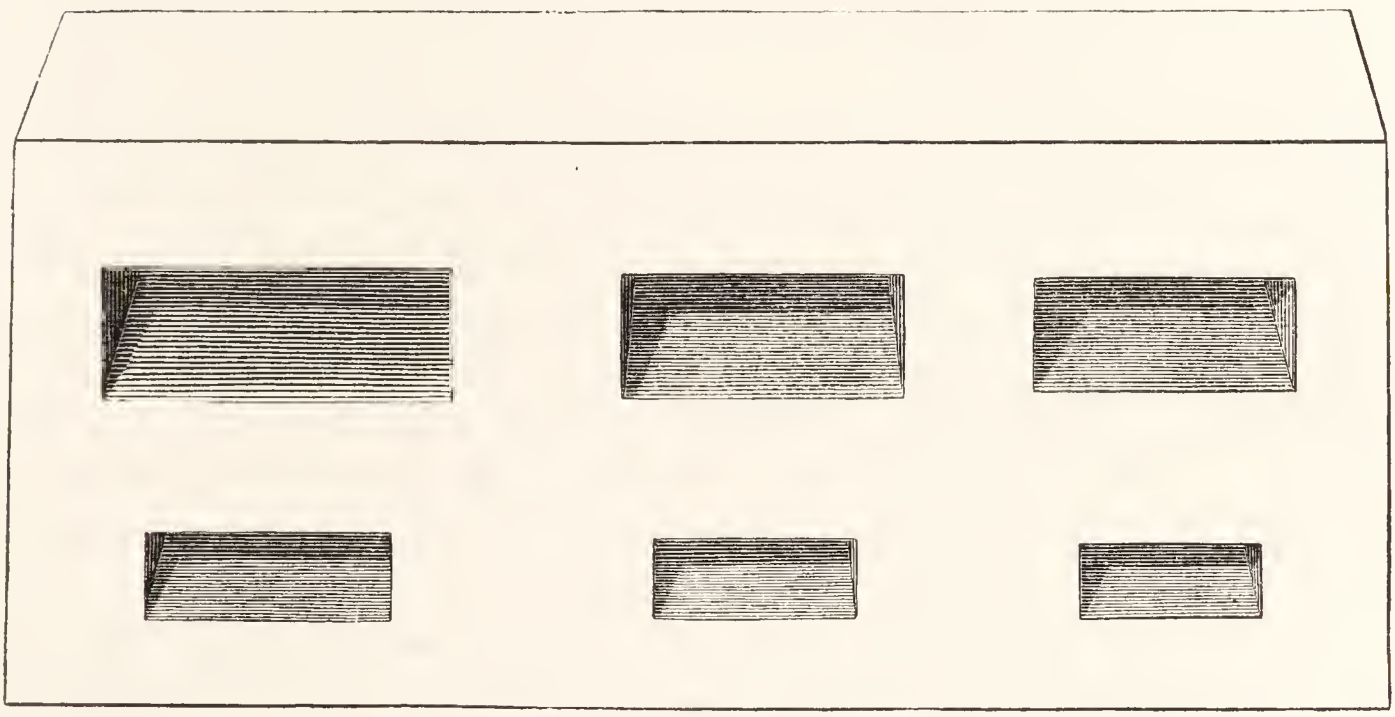
## REMOVAL OF FIXED STOPPERS.

[The adhesion of glass stoppers to the necks of bottles, from which they become immoveable by the mere force of the hand, is a frequent source of annoyance to the pharmaceutist. There are several causes which give rise to the fixing of glass stoppers. Sometimes it is occasioned by the deposition of resinous or other adhesive matter between the stopper and the neck of the bottle, which, hardening there, forms a kind of cement; and sometimes salts are crystallised around the stopper, either in consequence of the evaporation of a solvent, or from the sublimation of the salt itself. In some cases the pressure of the atmosphere, occasioned by contraction of the gaseous contents of the bottle, is the cause of the stopper becoming fixed; and this may either continue to operate directly in preventing the removal of the stopper, or having, by the force of the pressure, brought the stopper into very close contact with the neck, the adhesion may be thereby increased, and may then continue after the original cause has ceased to exist.

From these or other causes, glass stoppers are frequently found to be fixed, and the skill and ingenuity of the pharmaceutist are taxed for the means of extracting them. In some establishments, the extraction of the stoppers of smelling-bottles is, of itself, an operation of almost daily occurrence. The means of effecting the extraction must depend on the cause of adhesion, and on other circumstances connected with it, such as the size, form, thickness, &c., of the bottle, and also of the stopper.

If the bottle and its stopper be of sufficient capacity and strength it is customary in the first instance to attempt the extraction by grasping the bottle firmly in one hand, and with the other hand pushing the stopper laterally, in different directions, at the same time pulling it upwards. Should this method fail, the following may be tried. Hold the stopper between the fore-finger and thumb of the left hand, and press it upwards, while the other fingers rest on the shoulder or lip of the bottle, and then, holding a pellet-knife in the other hand by its flexible blade, strike the stopper in a lateral and slightly ascending direction with the wooden handle of the knife. The blows thus inflicted, the force of which must depend on the strength of the stopper, and size of the bottle, should be repeated for some time, with the object of producing a vibratory motion in the bottle. Stoppers may frequently be extracted by this method with great facility, but it cannot well be applied to bottles of less capacity than half a pint or a pint. Sometimes a lever is used, which, fitting on to the stopper of the bottle, enables the operator to use more force than could otherwise be applied for overcoming adhesion. The lever consists of a piece of wood, fig. 319, in which there are several oblong holes of different sizes,

*Fig.* 319.



Lever for Removal of Fixed Stoppers.

into one of which the head of the stopper is to be put, a cloth being interposed between them, if this will make them fit better. The greatest possible care and judgment are necessary in the use of the lever, as the stopper may be very easily broken off by the force thus applied. Indeed, the cases are few in which this method can be safely resorted to, and there are probably many more stoppers broken than extracted by its adoption.

If none of the foregoing means prove effectual for the extraction of the stopper, the cause of adhesion ought to be considered. Should it be found that resinous or other matter soluble in spirit is the cause of the evil, it may be well to try the effect of placing a little alcohol in the groove between the stopper and the lip of the bottle, allowing time for this to be absorbed, and then repeating some of the methods previously described; or should the deposition of salt or other matter soluble in water, be the probable cause, a little water may be substituted for the alcohol.

More energetic measures may yet be found necessary, and, as a last resource, one or other of the following means should be adopted.

The application of the flame of a spirit lamp to the neck of the bottle, constitutes one of the best and most uniformly successful methods. The immediate object in this case is, by the application of heat, to cause the expansion of the neck of the bottle, which will thus relax its grasp of the stopper, and allow the latter to be withdrawn. Some judgment is necessary in the application of the heat. The whole of that part of the neck of the bottle which surrounds the stopper should be heated as uniformly as possible, without allowing the heat to be communicated to the stopper. The flame of the lamp should, therefore, be made to play over the part indicated, while the bottle is constantly turned so as to equalize the effect, and from time to time the extraction of the stopper should be attempted with the hand. The length of time required to produce the effect will depend on the size and thickness of the neck of the bottle. Should the bottle contain an inflammable liquid, the application of a flame may be unsafe, and in such case, a piece of cloth dipped into hot water may be wrapped around the part to be heated, and the heat maintained for the required period by pouring more hot water over it. This method of applying the heat, through the medium of hot water, is, indeed, under all circumstances, the safest way of conducting the operation.

But the above process, although very generally successful, if dexterously managed, in those cases where the size and form of the neck of the bottle admit of the application of heat to that part, without, at the same time, heating the stopper, is, nevertheless, inapplicable in a great many instances, and especially in those of smelling-bottles, and of bottles generally of small size. In these cases the following will be found to be the best mode of proceeding.

*Fig.* 320.

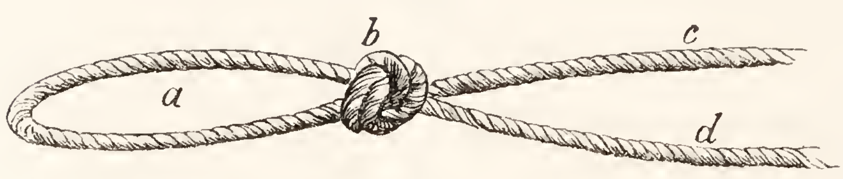
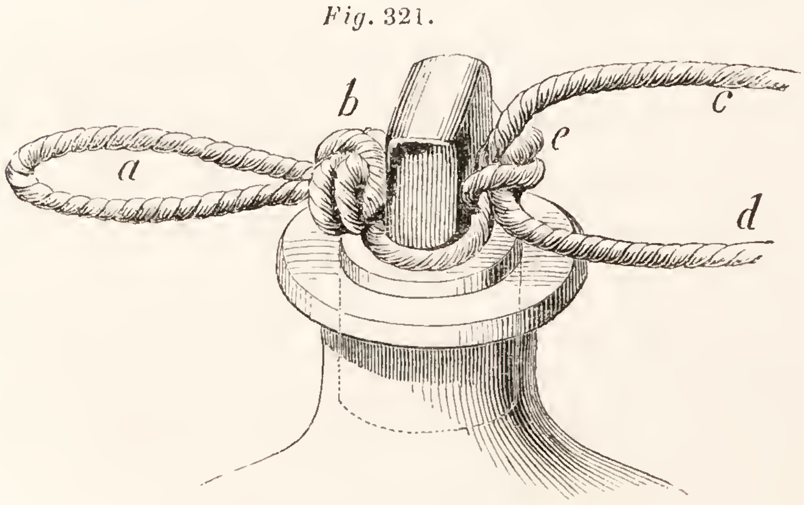


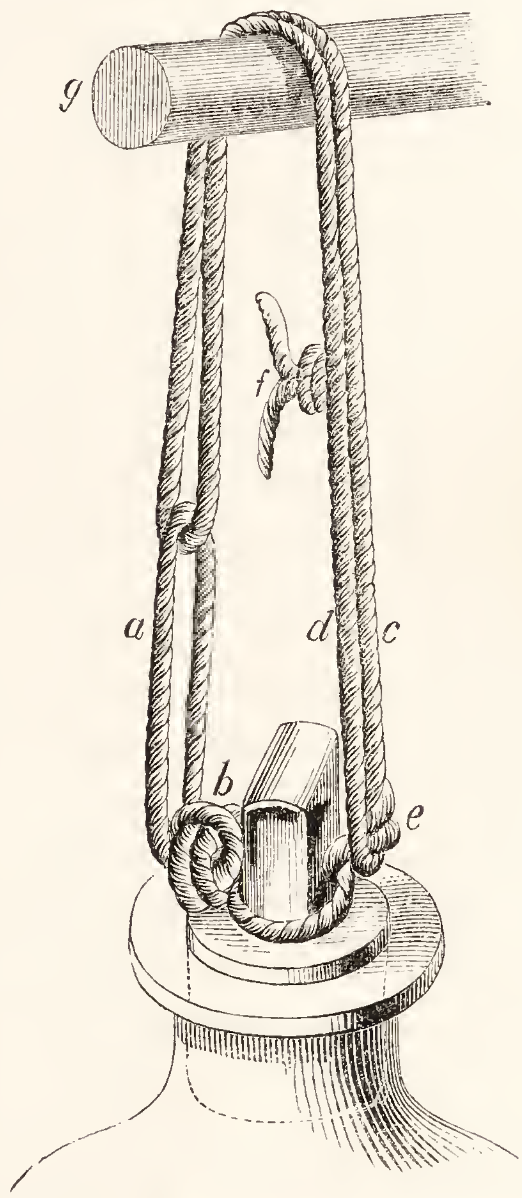

*Fig.* 321.




Extraction of Fixed Stoppers.

In the first place, a strong cord, between three and four feet in length, is selected, which is to be tied to the stopper of the bottle. The cord is doubled, and tied in a knot near to the doubled end, as represented in fig. 320. This being done, the knot (*b*) is placed against one side of the stopper, and the ends (*c*, *d*) being carried along the groove to the opposite side, are tied there, as represented in fig. 321. The end (*d*) of the cord is now passed through the loop (*a*), and the two ends being brought together, are tied as represented at (*f*) fig. 322. The cord being thus secured to the stopper, the bottle is, in the next place, to be suspended as shewn in fig. 322, by placing the cord over an horizontal bar of sufficient strength and firmness to bear a powerful jerk. It must be so adjusted that the cords on each side of the stopper shall be of equal length, and the weight of the bottle will then ensure its maintaining a vertical position. An assistant places his hand over the part of the cord in contact with the horizontal bar to prevent it from slipping to either side, and the operator, having wrapped a cloth around the neck and shoulder of the bottle, and grasped this part with his two hands, raises the bottle a few inches, and then pulls it down with a jerk. This operation is repeated, commencing with slight force, and increasing the power with each successive jerk, until the extraction of the stopper is effected. If care be taken to maintain the vertical position of the bottle, and of the direction of the jerk, there will be little danger of breaking the stopper. I have found this a more effectual method of extracting the stoppers of smelling-bottles, and of small bottles generally, than any other that I am acquainted with.]

*Fig.* 322.




EXTRACTION OF FIXED STOPPERS.

### DESICCATION OF BOTTLES, FLASKS, ETC.

The pharmaceutist has frequent occasion for drying glass vessels expeditiously. The bottles into which oils, syrups, and some other substances are put, should always be made perfectly dry, after washing them, before they are used for the purposes intended. Vessels having only one orifice, and that a contracted one, do not readily part with their moisture, unless a particular arrangement be adopted for promoting desiccation. Many days or even weeks would elapse before a bottle, which has been just rinsed with water, would become perfectly dry if it were merely exposed in a dry room at the mean temperature of the atmosphere. To ensure rapid desiccation a current of warm air should be made to pass through the vessel.

The best method of proceeding is, to warm the vessel, by placing it on a sand-bath, or in some other warm situation, and then to blow into it with a bellows. The warm air loaded with moisture, is displaced by a current of comparatively dry air, which becoming heated from contact with the vessel, is capable of taking up and carrying away some of the moisture which remains. By operating in this way, and repeating the application of heat and the blowing as often as is necessary, complete desiccation may be very speedily effected. It is necessary, however, to observe that the vessel not only appears to be dry while it is warm, but that this continues to be the case after it has cooled; for moisture which the air holds in solution when warm is sometimes deposited again as the temperature falls.

In the absence of a suitable bellows a glass tube and the human lungs might be used with similar effect, although in this case the desiccation would not be so rapid. The tube should be long enough to reach to the bottom of the vessel, while it projects some inches above the orifice. After heating the vessel as previously described, the tube is introduced, and the operator, having exhausted his lungs, applies his mouth to the end of the tube and makes a long inspiration. The moist air of the vessel is thus drawn into the lungs, and dry air from without enters to supply its place. The process is repeated in this way until the vessel is completely dried.

Tubes, when sealed at one end, are dried in the manner above described. If they be open at each end the desiccation is much more easily and quickly effected. It is then only necessary to hold them in an oblique position over the flame of a lamp or other source of heat. A current of air will thus be determined upwards which will soon carry off the moisture.

## ON TYING KNOTS.

There is some art involved even in the tying of a string, and inconvenience is not unfrequently occasioned by a badly constructed knot. The common method of tying a knot, for securing the ends of a string, is sufficiently well known; but there are a variety of circumstances under which knots of different kinds are required, and the best methods of making these are not so uniformly understood.

[In some cases it is more important to be able to fasten the string expeditiously than very securely; in other cases the tightness of the compression is the object principally aimed at; in others, again, close compression, secure fastening, and the means of subsequently tightening the knot, are desired.

*The capping-knot.*—In capping bottles, it is sometimes advantageous to adopt a more easy and expeditious mode of fastening the string than by making a common knot. This is especially the case in capping draughts, and small vials generally, for as both hands are necessarily occupied in making the common knot, there is some difficulty in keeping a small vial in a suitable position during the operation. The *capping knot* is both easily and expeditiously made. The vial is held in the left hand, and the end (*a*, fig. 323) of the string

*Fig.* 323.

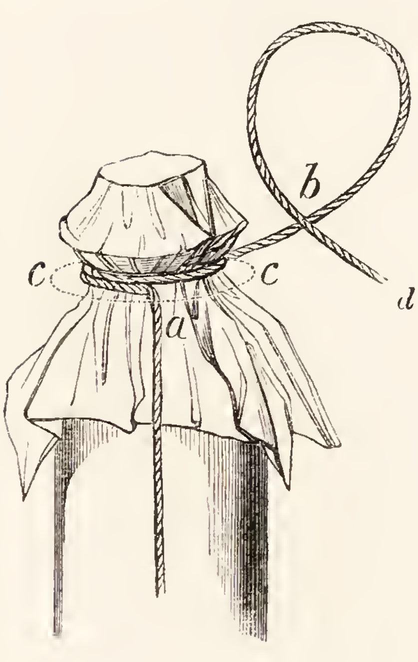



*Fig.* 324.

THE CAPPING KNOT.

is placed under the thumb, while, with the other hand, the string is carried twice round the neck of the bottle; it is then formed into a loop, as represented in fig. 323, and this loop, being held at (*b*) between the thumb and fore-finger, is thrown over the top of the bottle and brought to the position of the dotted line (*c c*), so as to pass over and compress the end (*a*) of the string; finally, the end (*d*) of the string is pulled so as to form a knot, which is sufficiently secure for the purpose intended. Fig. 324, shews the method of holding the vial and string in making this knot. Vials may be capped in this way in half the time that would be occupied if the common knot were made. But the *capping knot* can only be used advantageously in capping bottles which have short necks and projecting lips, such as the smaller description of vials have. Green-glass moulded bottles of six ounces capacity and upwards require to have the caps tied on with a more secure knot.

*The binding knot.*—In fitting together glass-tubes with India-rubber connecters, it is generally found necessary to bind the latter with a silken or other cord, so as to render the juncture air-tight. In doing this, it is difficult to secure the ends of the cord with a common knot, without at the same time relaxing the tightness of the compression. *The binding knot* affords a ready method of forming a perfectly tight and secure ligature. It is made in the following way. The end of the string is doubled, and laid on the tube as shewn in fig. 325, *d* being the short end, and *c* the long end of the string. The tube being held in the left hand, the thumb of that hand is laid over the loop (*a*), so as to retain it in the position represented, while *c* is carried round the tube several times, and, finally, is passed through the end of the loop (*a*) as shewn in fig. 326. The end (*c*) being held tightly in this position, the other end (*d*) of the string is pulled so as to reduce the loop (*a*) until it clasps (*c*) and securely fixes it. The ends (*c* and *d*) are now cut off, leaving the ligature as represented in fig. 327.]

*Fig.* 325.

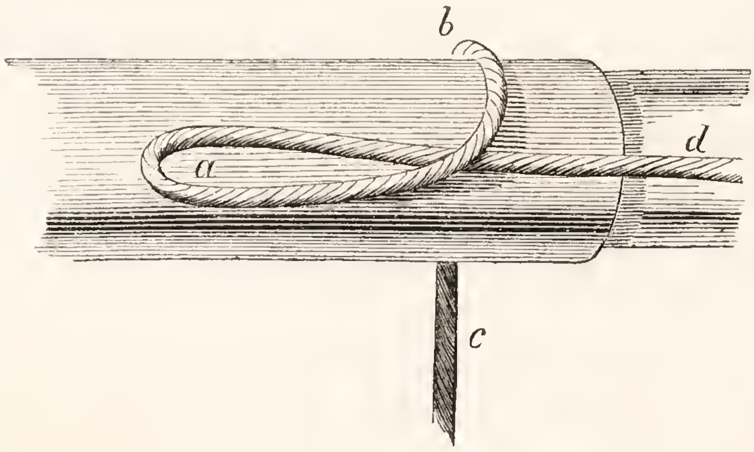



*Fig.* 326.

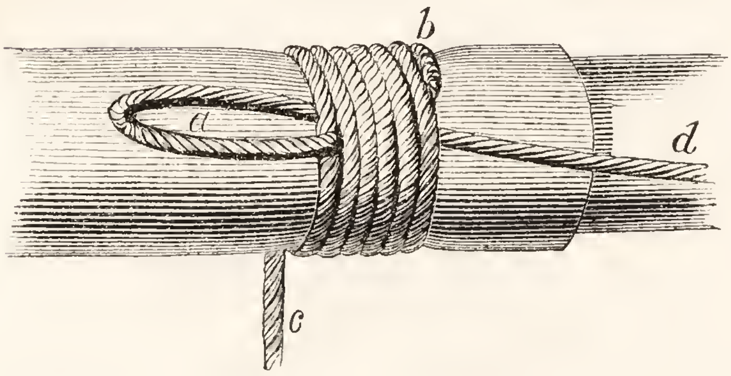
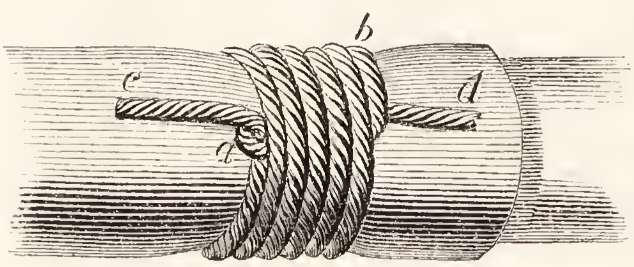



*Fig.* 327.




The Binding Knot.

*The pyrotechnical knot.*—This knot is used for the same purpose as that last described. In making it two loops are formed as shewn in fig. 328; these are brought opposite each other, as in fig.

329, *b* being placed in front of *a* ; they are then slipped over the tube, as in fig. 330, and the two ends of the string pulled. When the coils are brought close to each other and made tight by drawing

*Fig.* 328.

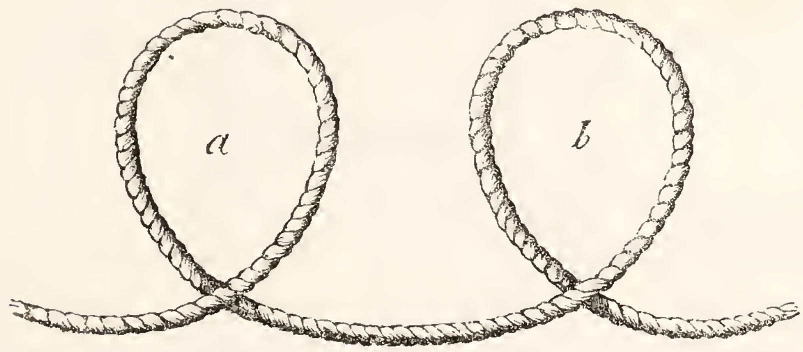



*Fig* 329.

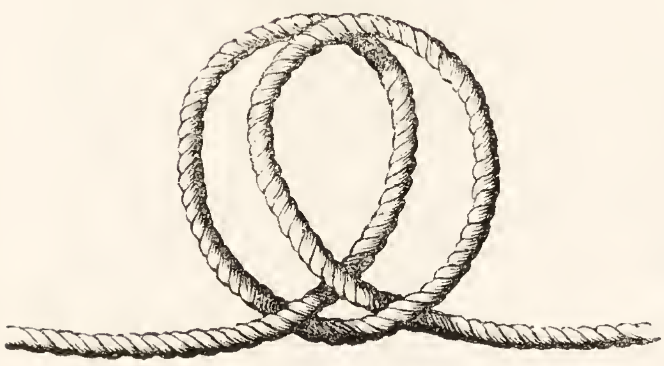
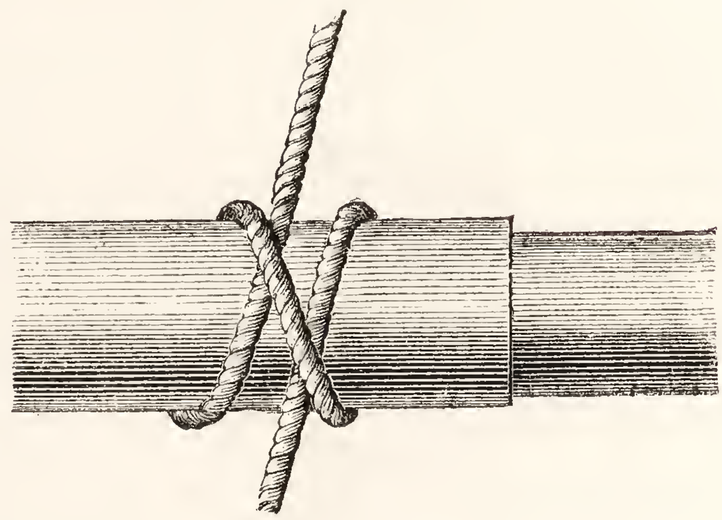


*Fig.* 330.

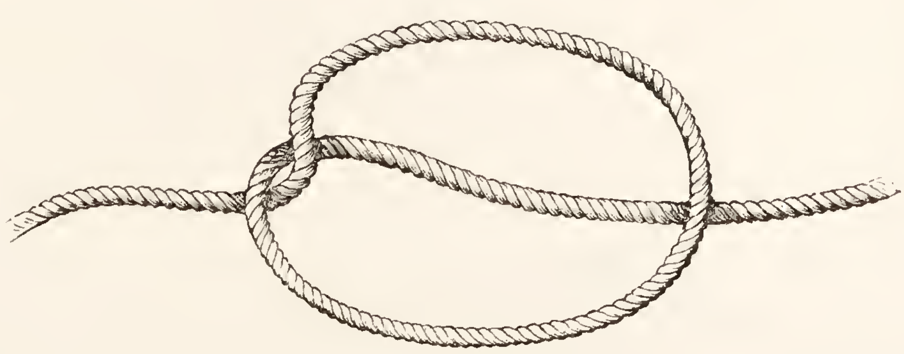


THE PYROTECHNICAL KNOT.

the ends in opposite directions, a pretty secure knot is produced. Sky-rockets are tied in this way, and hence the name. A few coils of the string forms a good ligature for an Indian-rubber connecter ; and it has these advantages that it may be tightened at any time by pulling the ends, and also, that it is easily untied, without cutting the cord, by merely pulling each ligature away from that next to it.

*The Beer Knot.*—The corks of bottles are sometimes fastened

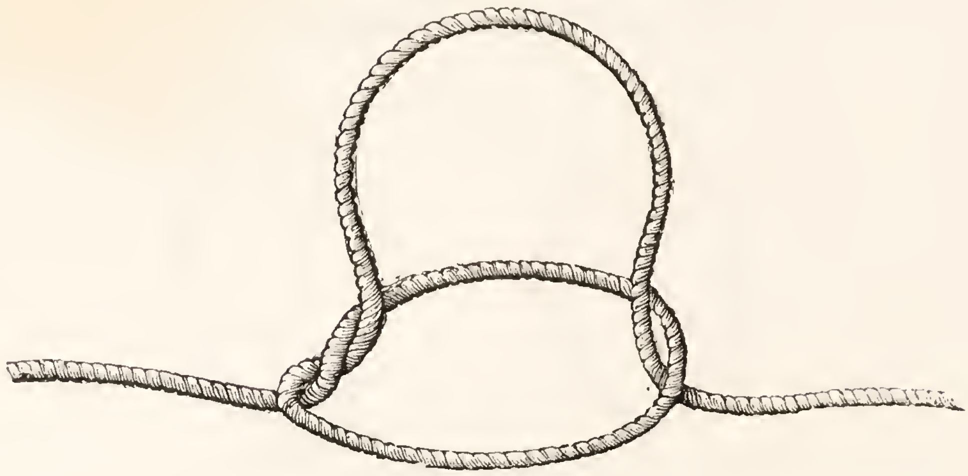
*Fig.* 331.



THE BEER KNOT.

down with string, which is tied in what is called a *beer knot*. The name is probably derived from the application of this knot in tying down ginger-beer. It is thus made:—First, the loop, fig. 331, is

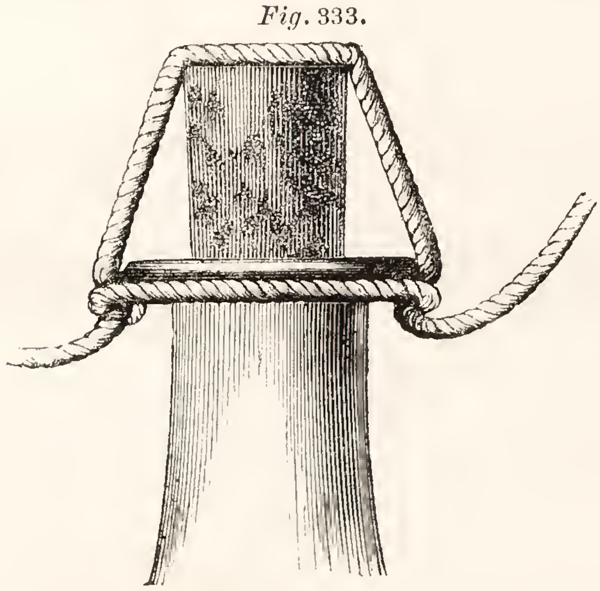
*Fig.* 332.



THE BEER KNOT.

formed; then the part of the string which passes across the loop is turned up, as in fig. 332. This is placed over the cork of the bottle, and by dexterously pulling the two ends, the loop is made tight beneath the lip of the bottle, while the string which crossed the loop passes over the top of the cork, as represented in fig. 333; the ends are then tied at the top.

*Fig.* 333.



THE BEER KNOT.

*The champagne knot* is also used for fastening down the corks of bottles. It is a more secure knot than the beer-knot. A loop, such as fig. 334, is first formed; then the end (*m*) is turned into

*Fig* 334.

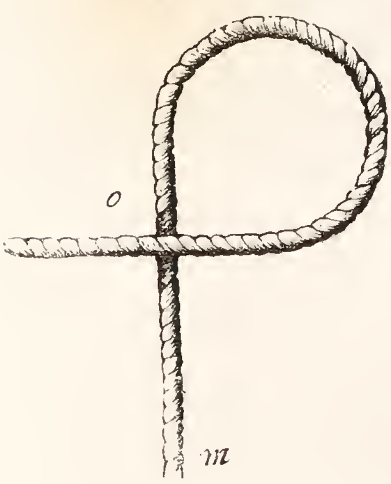
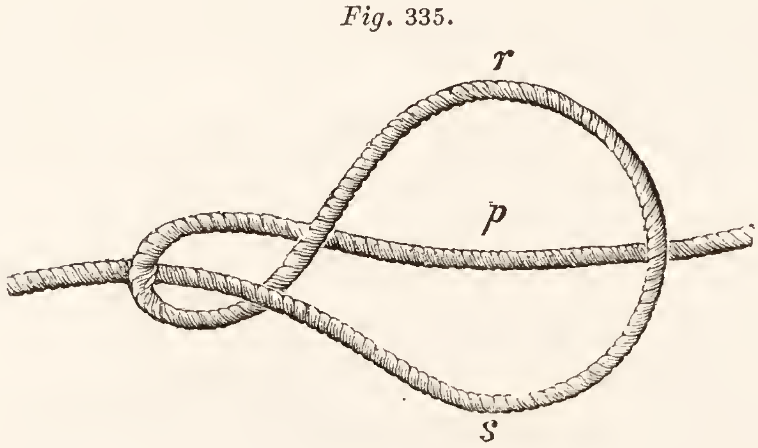



*Fig.* 335.




THE CHAMPAGNE KNOT.

the angle (*o*) and carried behind or beneath the loop, as in fig. 335. The part *p* is drawn through the loop, as in fig. 336, and in this state it is placed over the neck of the bottle immediately under the lip, *p* being on one side, and *r s* on the other side. The two ends are then pulled so that, the knot being tight around the neck

*Fig.* 336.

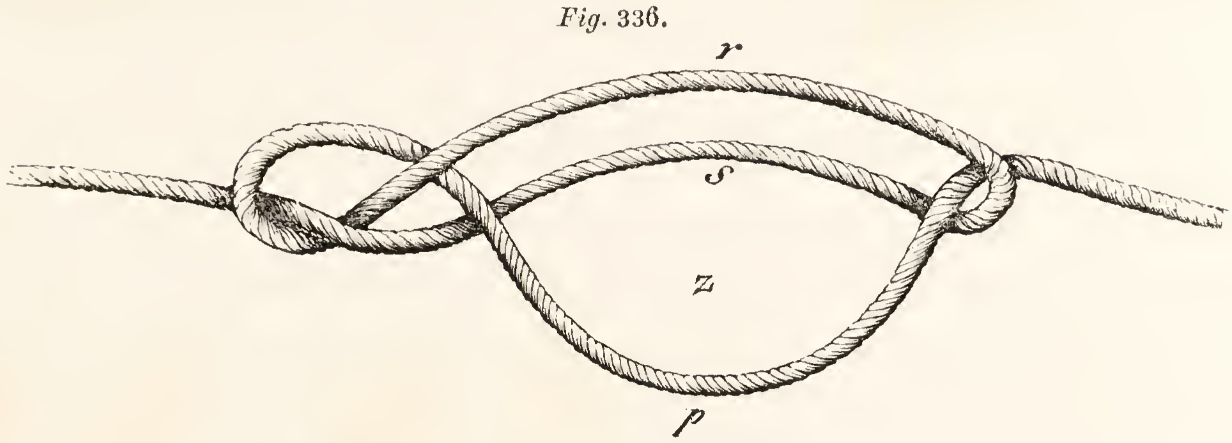



*Fig.* 337.

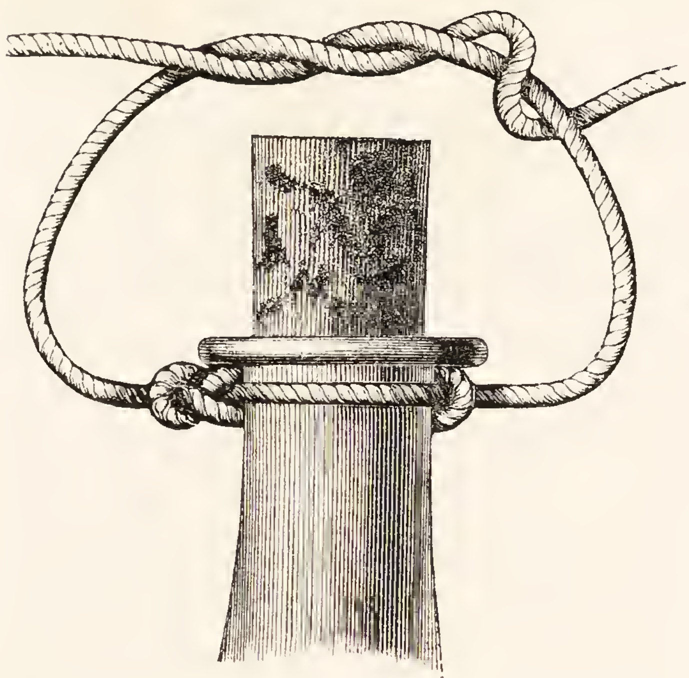
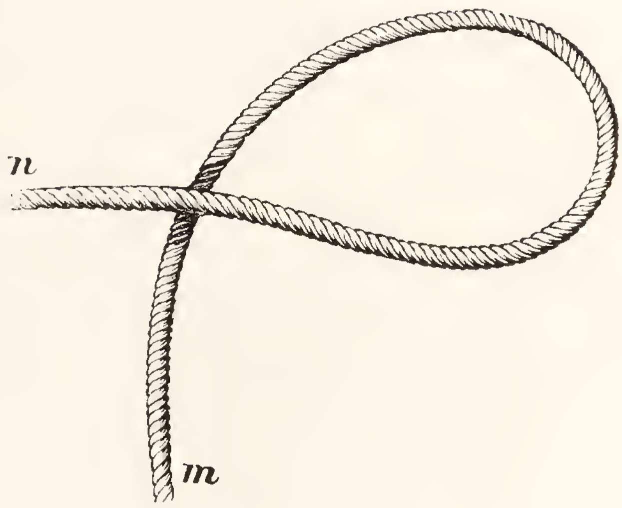


*Fig.* 338.




of the bottle, the free ends shall be opposite each other, and these are turned up over the cork, twice twisted, and finally tied in a common knot, as shewn in fig. 337.

*Fig.* 339.

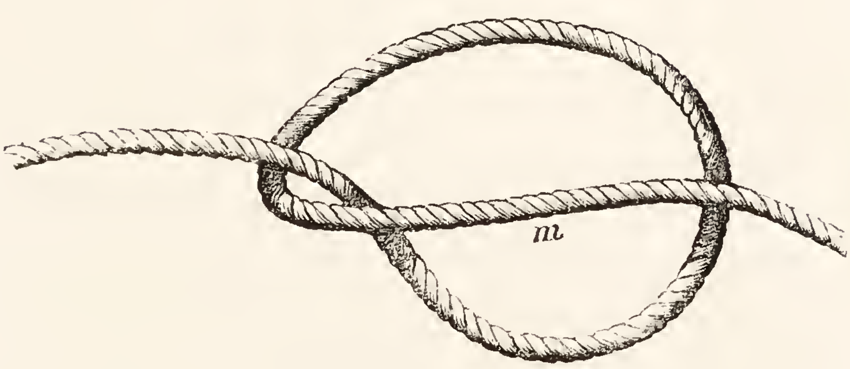
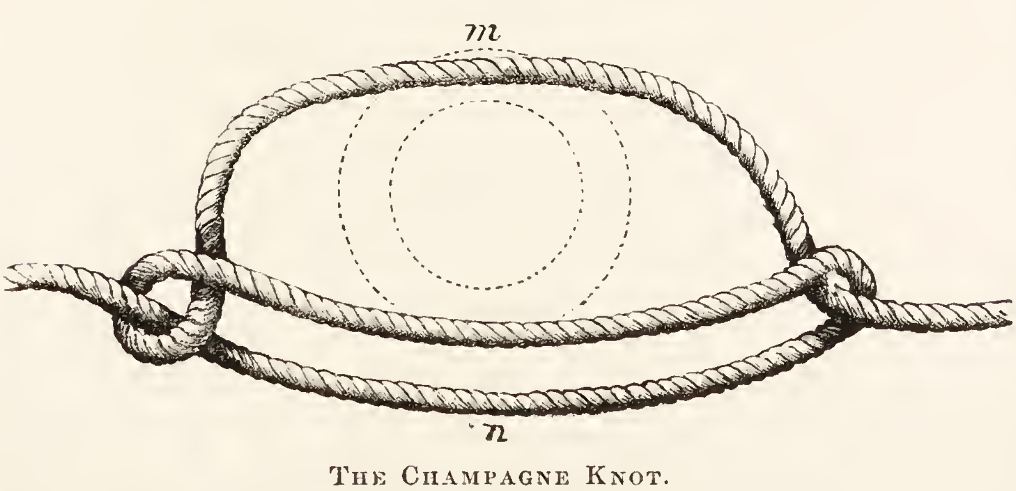



*Fig.* 340.




The Champagne Knot.

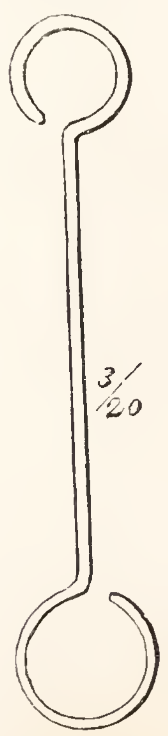
There is another more simple, but less secure, method of making the champagne knot, as follows:—the loop (fig. 338) is first formed, then (*m*) is carried across the loop in front, as in fig. 339, and being brought out on the other side (fig. 340), it is thus slipped over the neck of the bottle and tied as in the other case.

### CUTTING, DRILLING, AND BENDING GLASS, &C.

There are several operations connected with the modification or construction of glass vessels and apparatus, which the pharmaceutist has frequent occasion to perform. Among these are the operations of cutting, drilling, and bending glass.

*In cutting glass* the method to be adopted will depend on the form, size, and thickness of the part to be cut. If it be cylindrical and tolerably thick, the iron ring (fig. 341) may be used. This instrument consists of a round iron rod, the two ends of which are bent so as to form two circles of different sizes. It is used in the following manner:—The ring which most nearly fits to the cylindrical glass to be cut is put into the fire until it has become red-hot; it is then placed around the glass where the separation is desired, and kept there for a few minutes; on removing it a few drops of water are allowed to fall on the heated part, when it will instantly split in two. The principal objection to this mode of operating is that, for its complete success, it is necessary that the iron ring should very nearly fit to the part to be cut. If the ring be much larger than the glass, it must be made to approach alternately on every side, and as the heating is never so uniformly effected in this way as it would be otherwise, the fracture will sometimes be irregular. With a suitable ring the operation may be well and expeditiously effected, and it is particularly applicable for cutting off the ends of the necks of retorts or of flasks.

*Fig.* 341.




Iron Ring for Cutting Glass.

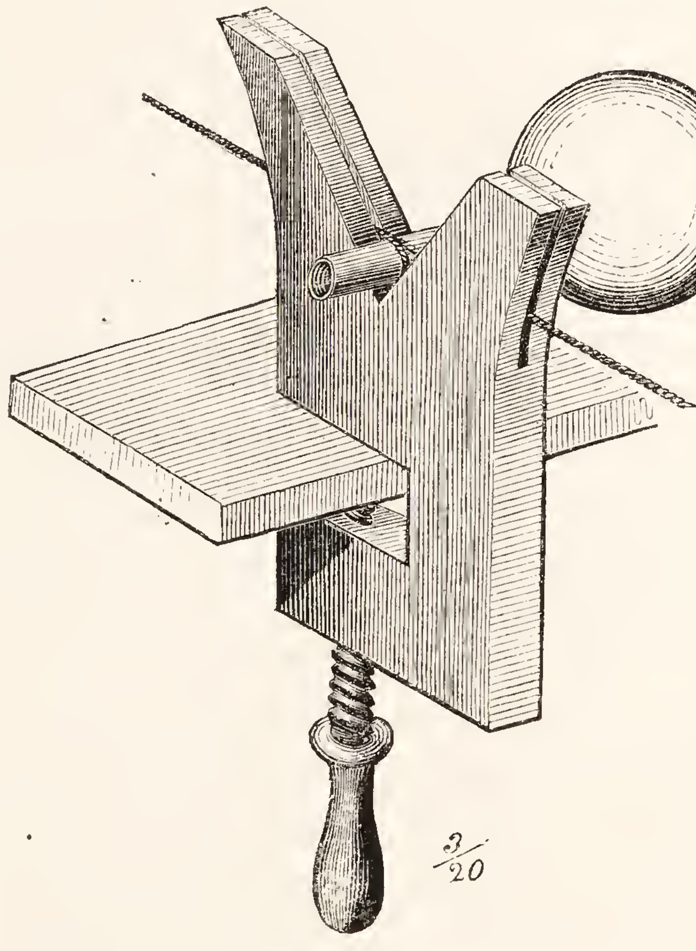
A method is sometimes adopted, which consists in tying a thread of lamp-cotton, dipped in oil of turpentine or in sulphur, around the part where the fracture is required, then igniting the thread, and when the flame has heated the glass, dropping a little water on to it. This method seldom succeeds well, as the flame heats too wide and unequal a surface.

Another and much better method of effecting the same object is, to heat the glass by the friction of a string passed around it, and drawn to and fro with great rapidity. In doing this it is necessary to have some means for confining the string to the exact part required to be cut.

[One method of confining the string is to bind a thick cord, in the manner represented in fig. 327, around the glass, on each side of the part to be cut, leaving a groove just wide enough for the string by which the friction is effected, to run in. One end of this string is to be fastened to some firm object, and a single coil being carried round the glass in the groove, the other end is to be held in the hand of the operator or of an assistant. The glass is now to be drawn alternately towards each end of the string, increasing the velocity of the motion to the greatest extent practicable, and continuing the friction for two or three minutes ; it is then to be plunged into a vessel containing cold water, when the fracture will instantly occur.]

Fig. 342, represents a good arrangement for confining the string. In this case a piece of board is used, in which there is an angular notch, giving it somewhat the form of a boot-jack. This board is fixed to a table, while the notch receives the cylindrical glass to be cut, as shewn in the drawing. There is a groove or slit in the board extending as far as the notch, through which the string passes. The glass, having a coil of the string around it, is kept in a fixed position in the angle of the notch while two assistants draw the ends of the string alternately in opposite directions. The friction is thus confined within the narrowest possible limits. If the operator can hold the glass in his left hand, he may draw one end of the string with his right hand while an assistant draws the other end. It is necessary to avoid the application of any grease to the cord or to the glass during this operation, as the friction would be thereby diminished.

*Fig.* 342.



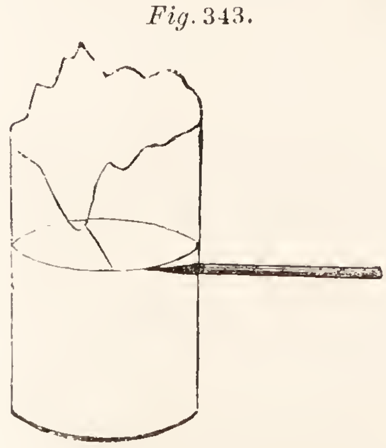

ARRANGEMENT FOR CUTTING GLASS.

If the size, form, or thickness of the glass be such as to prevent the successful application of the foregoing methods of operating, the ignited pastil, or charcoal point, might be advantageously used.

*Pastils* are prepared expressly for cutting glass, being made of a composition somewhat analogous to that of the common fumigating pastils, which is rolled out into pointed sticks. Gahn has given the following formula for these pastils. Dissolve $2\frac{1}{2}$ ounces of gum arabic, and $\frac{1}{2}$ ounce of tragacanth, in $5\frac{1}{2}$ ounces of water. Dissolve $\frac{1}{4}$ ounce of styrax, and $\frac{1}{4}$ ounce benzoin in $1\frac{1}{2}$ ounce of spirit. Mix the two solutions with $3\frac{1}{2}$ ounces of powdered charcoal, or as much as is sufficient to form a tough paste. This is formed into sticks about the size of a black-lead pencil, which are subsequently dried. I have found the following more simple formula to answer equally well. Reduce half an ounce of powdered tragacanth to an elastic mucilage with a sufficient quantity of water, allowing them to macerate together for about an hour; then add a quarter of an ounce of benzoin dissolved in spirit; rub them together in a mortar, and mix in as much powdered charcoal as will form a tenacious paste. Before rolling the mass into sticks it should be well pounded, and made rather soft, otherwise it will crack, or the sticks will become hollow in the centre, in which case they will not burn to a point.

In using the pastil for cutting glass the usual method of operating is, to lead a crack, previously commenced, in the direction in which the fracture is required. If the vessel to be cut has already a crack, a line should be drawn beneath it, with chalk or ink, and carried round the vessel. The pastil is now to be ignited at the point, and the incandescent part applied to the end of the crack and slowly moved in an oblique direction towards the line, so that it may pass into the marked course at an angle of about forty-five degrees. The crack will follow the burning point as it is thus made to pass over the surface of the glass, and may be carried round the vessel in the direction required. Should there be no previous crack, a scratch is first made with a file in a slanting direction, and on applying the burning pastil to this a crack will be formed which may be led in the manner already described. Fig. 343 represents the way in which this is done. It is generally safer to commence the crack from the upper edge of the vessel than from any point below it.

*Fig.* 343.



CUTTING GLASS WITH A CHARCOAL POINT.

Badly annealed glass, and vessels which are not circular, cannot be cut in this way with any certainty; but if the glass be tolerably thick and well annealed the crack will often be as straight and smooth as if cut with a diamond.

The sharp angles of the cut edge should be taken off with a file wetted with oil of turpentine; and should there happen to be any inequalities in the surface formed by the fracture, these may be removed either by the file or by rubbing the part over the surface of a sand-stone.

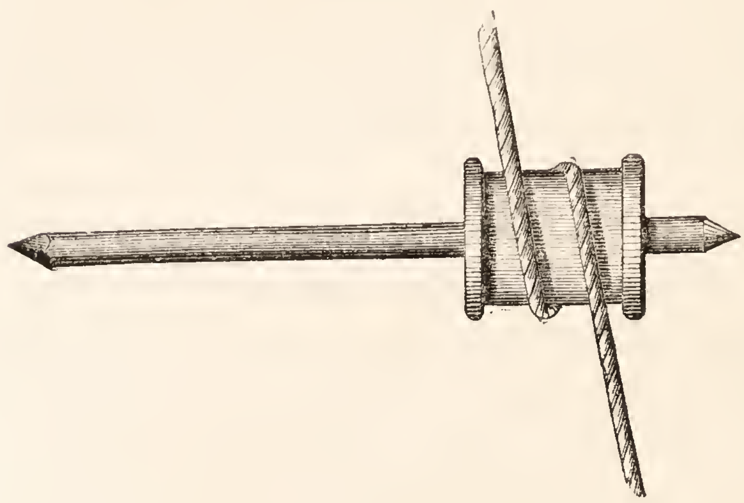
[The file is often used alone, for cutting glass, especially glass-tubes, which are most conveniently cut in this way. A scratch is made on one side of the tube at the part to be cut, and the tube being then held in the two hands of the operator on each side of the scratch, it is gently strained in a lateral direction, while at the same time it is pulled longitudinally.]

*The boring or drilling of glass* is an operation not very frequently required to be performed, yet it is well to understand how it is done. Round holes are cut into glass vessels with copper cylinders, which are about two inches and a half in length, and of any required width up to three quarters of an inch in diameter. These cylinders are made of sheet copper, about one line in thickness. They are fixed upon a block in the turning lathe, where the sides and edge are made smooth and fit for cutting. A circular piece of paste-board is cut to the size of the interior of the cylinder, so that it should fit in loosely, and this is fastened with paste or glue over the spot where the hole is to be cut in the glass. This paper disk is intended for guiding the cylinder and preventing it from slipping about, while it makes the first incision. A stand must now be provided for the glass, so that the part to be drilled shall be exactly opposite the copper cylinder. These arrangements being made, a rather thick mixture of emery powder and oil is applied to the edge of the cylinder, and the glass being placed against it the lathe is put into motion. A circular groove is thus speedily cut around the circumference of the paste-board patch, over which the cylinder is placed, and by which it is retained in its proper place. The glass should be occasionally withdrawn a little from the cutting instrument and again made to approach it, and the supply of emery from time to time renewed. It is necessary towards the end of the operation to be careful that the cylinder when it has cut the groove completely through the glass should not be pressed forward so as to break the vessel. The pressure should be cautiously adjusted by the hand, until the piece breaks out, and the cylinder should then be instantly withdrawn. Under these circumstances, there will generally be a rough projecting rim on the inner edge of the cut surface, from which the cut piece has fallen, and this will prevent the cylinder from passing in. This projecting edge is to be ground off with a file.

In this way round holes may be cut into the sides of thick bottles, so that stop-cocks or tubes may be inserted through perforated corks.

When holes of smaller diameter are required to be made, the operation is performed with a common drill and bow-string, such as fig. 344. The surface of the glass should be broken at the spot where the hole is to be made, with the end of a sharp file or with a scratching diamond; and the point of the drill, previously wetted with oil of turpentine, is then placed upon the spot and worked with the bow. It is essential that the part should be kept constantly wetted with the turpentine, which has a peculiar efficacy in promoting the abrasion of the glass, and at the same time the protection of the steel instrument. The efficacy of the turpentine will be increased if it be slightly resinified by exposure to the air, or even if it be thickened by dissolving a little common resin, or camphor in it. In all cases where glass has to be cut with a steel instrument oil of turpentine should be used.

*Fig.* 344.



Drill for Boring Glass.

*The bending of glass tubes* is an operation of constant occurrence in connexion with the fitting up of apparatus.

The first point claiming attention in reference to this operation is the selection of suitable tubes. The glass of which the tubes are made should be easily fusible, so that they may admit of being bent, drawn out, or sealed, in the flame of a lamp. It is important that the thickness of the glass should bear a certain relation to the size of the tube, for if it be too thin the tube will collapse at the bend, and, moreover, when passed through a cork it will not admit of the necessary compression to render the juncture air-tight, without some danger of the tube being broken. A tube, the external diameter of which is five lines, should have a thickness of glass of about three fourths of a line, as fig. 345. This is a very suitable size for conveying gases. Tubes of smaller diameter, such as fig. 346, which is four lines in diameter, and half a line in thickness of glass, are used for small apparatus. If tubes of larger diameter are used the thickness of the glass should be in proportion. Fig. 347

*Fig.* 345.

*Fig.* 346.

*Fig.* 347.

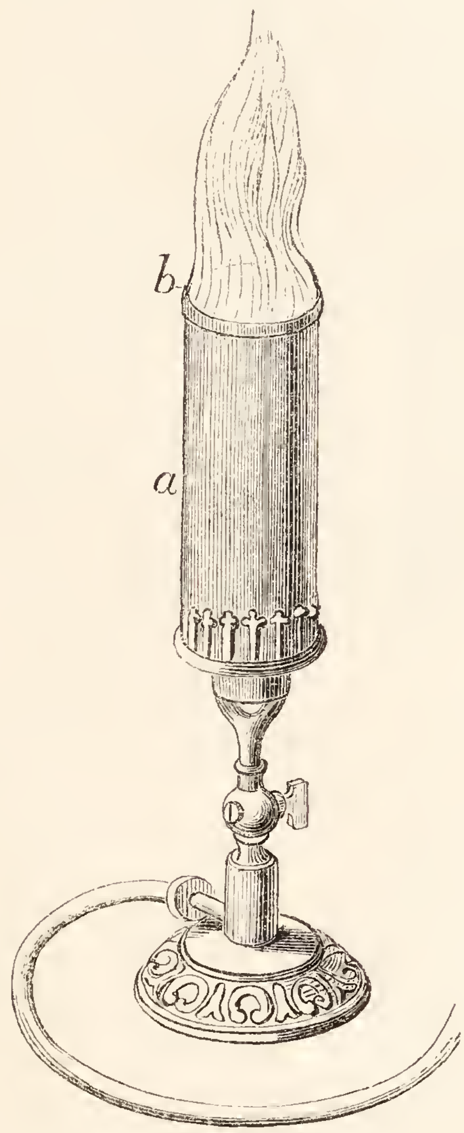
represents a size seven lines in diameter and one line in thickness, which is suitable for the distillation of ethereal and other liquids, the vapours of which require free means of escape.

A tube suitable for its intended application having been selected, the bending is effected with the aid of the flame of a lamp.

[The flame of a *common argand gas-burner* may be used with a short copper chimney, the height of the chimney being such that the flame extends about an inch above the top of it.

*The solid gas-flame* (fig. 348) is very suitable for bending glass-tubes, especially if they be large and thick. The arrangement by which this flame is produced is similar to that of the mixed gas-furnace, figs. 1 and 3, page 4. It consists of a common gas-burner, over which is placed a copper cylinder (*a*), with a wire gauze top (*b*). The gas is allowed to escape from the burner, and, mixing with atmospheric air in the copper cylinder, the combustible mixture issues through the wire gauze at the top, and burns there with a solid pale blue flame, from which there is no deposition of charcoal.]

*Fig.* 348.

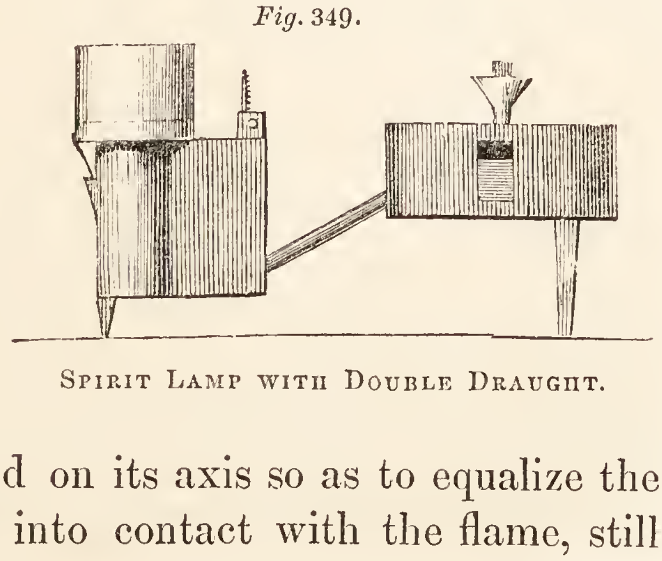



Solid Gas-Flame.

In the absence of gas, a *spirit-lamp with double draught* (fig. 349) will be found fully efficient for the purpose required.

The lamp having been prepared [the part of the tube which is required to be bent should be marked with a piece of chalk], and the tube should then be held over or introduced into the flame. If the glass be thick, the part at which the bend is to be made, and extending for an inch or two on each side of it, should be gradually warmed by holding it above the flame, and moving it to and fro, while at the same time it is turned on its axis so as to equalize the effect. It may then be brought into contact with the flame, still

*Fig.* 349.



Spirit Lamp with Double Draught.

continuing to move it as before. When slight indications of softening are perceived, which the hand of an experienced operator will readily discover, one end of the heated part is to be kept in the flame, the tube being merely turned on its axis, and not moved to and fro, until it admits of being bent with a slight force, the rotating motion is then stopped while a slight curvature is given to this part ; the tube is then moved so as to bring another heated portion into the flame, which in like manner is slightly curved ; and this is continued until the curve extends to an equal distance on each side of the chalk-mark, and until the two limbs of the bent tube form the required angle. [It will be found convenient to have some object in front of the operator to assist the eye in determining the required angle. The bars of a window may be conveniently used for this purpose when a right angle is required, the bent tube being held before the eye and brought opposite to, or parallel with, two intersecting bars. In making the bend while the heated part of the tube is in the flame, the ends should always be turned upwards, and not in any other direction.]

By proceeding as above described, a uniform curve may be formed, such as fig. 350, which represents a good bend, while fig. 351 represents a badly-formed curve, such as inexperienced operators generally produce.

*Fig.* 350.

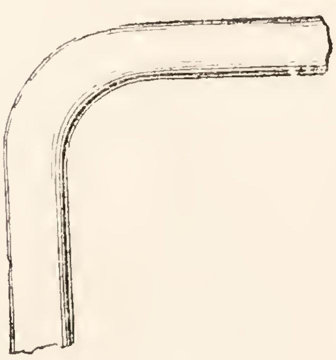
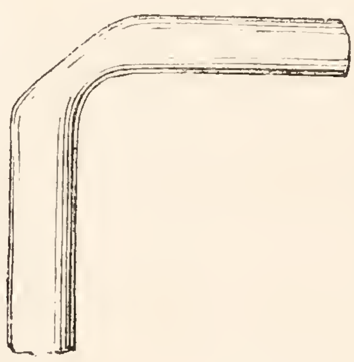


*Fig.* 351.

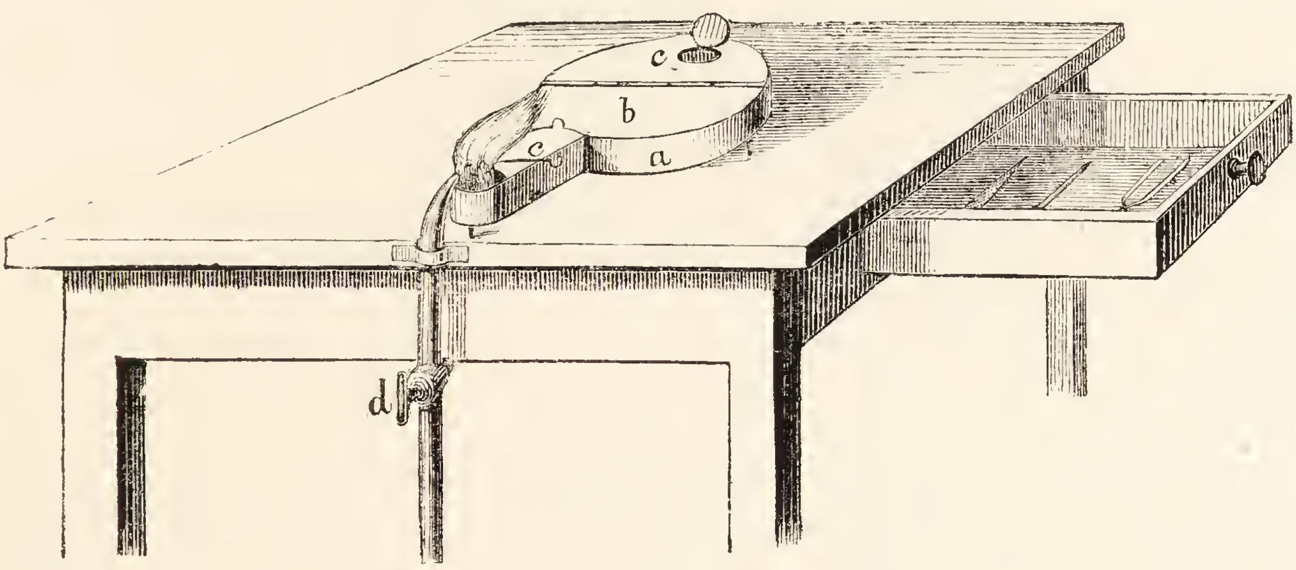


Bent Tubes.

To get a good curve, it is desirable that the heat should not be confined to one point, and that the glass should not be softened more than is necessary to admit of its being bent. A large flame, and especially the solid gas flame, fig. 348, will be best adapted for producing the effect required. If the heat be too much confined to one spot, and the glass be much softened, the tube will collapse in bending, as shewn in fig. 351, a result which should always be avoided if possible. It is necessary, however, in addition to the precautions already mentioned, that the glass should have a certain thickness in proportion to the diameter of the tube, equal, or nearly so, to that indicated in figs. 345, 346, 347. If the tube be large and the glass thin, it will be very difficult, if not impossible, to prevent it from flattening on the outer side of the curve, and not only will the glass, when thus bent, be very likely to crack, but the tube will be contracted at this part. When it is important to avoid the collapsing of a tube, which, from the thinness of the glass or some other cause, will not admit of a good curve being formed in the manner above described, the best method of proceeding will be, to seal one end of the tube, and then, after bending it, and while the glass is still soft, to blow into it from the other end. The increased elasticity of the air, caused by blowing, will force out the compressed part of the tube and restore its cylindrical form to it. This is the method usually adopted by the glass-blowers.

There are some operations on glass tubes, in performing which, a stronger heat than that of a common lamp is required, and in these cases the blow-pipe is employed. Thus, for instance, in drawing out, and hermetically sealing glass tubes, excepting in the case of small tubes, it is necessary to have the intense heat of the blow-pipe. Fig. 352 represents the usual arrangement of the glass-

*Fig. 352.*

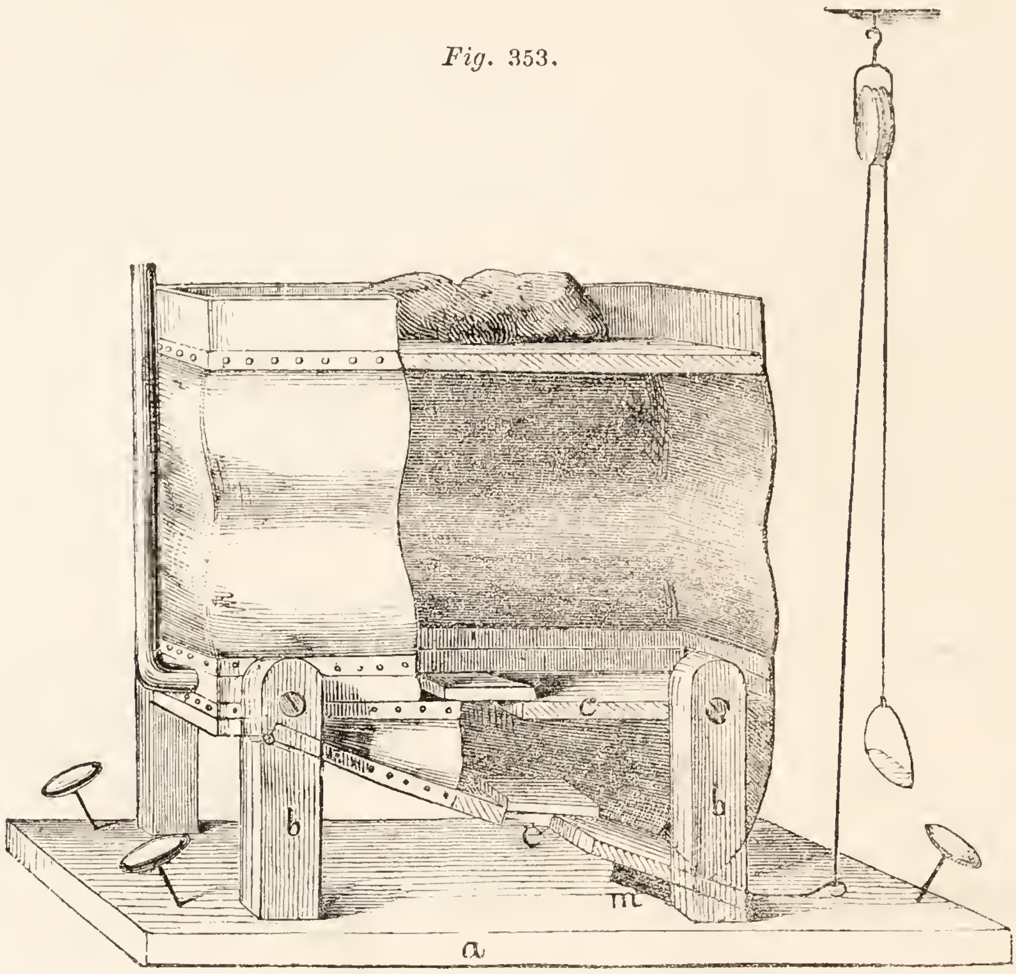



Glass-Blower's Blow-Pipe.

blower's blow-pipe. The lamp (*a b c*) stands on a table, in front of which the pipe (*d*) conveys the compressed air from a bellows. The glass-blowers generally prefer the flame of an oil-lamp to that of a gas-lamp. The bellows, fig. 353, stands beneath the table, and is worked by the foot of the operator placed in a stirrup. The best method of constructing the bellows has been already described at page 125.

*In drawing out glass tubes*, the part to be operated upon is first warmed by holding it over the flame ; it is then heated strongly by directing the flame upon it, while the tube is constantly turned, so that it may be equally softened on every side. When it is found to admit of extension, it is drawn out to the required extent. If the object be to get an extension of tube with a uniform but contracted diameter, the softening should be effected through a part of the tube two or three inches in length, and it should be drawn out slowly and steadily before it has become very soft. If, on the other hand, it be desired to have a gradual contraction, the part softened may be shorter, the softening should be carried further, and the drawing effected more rapidly.

*Fig.* 353.




BELLOWS FOR BLOW-PIPE.

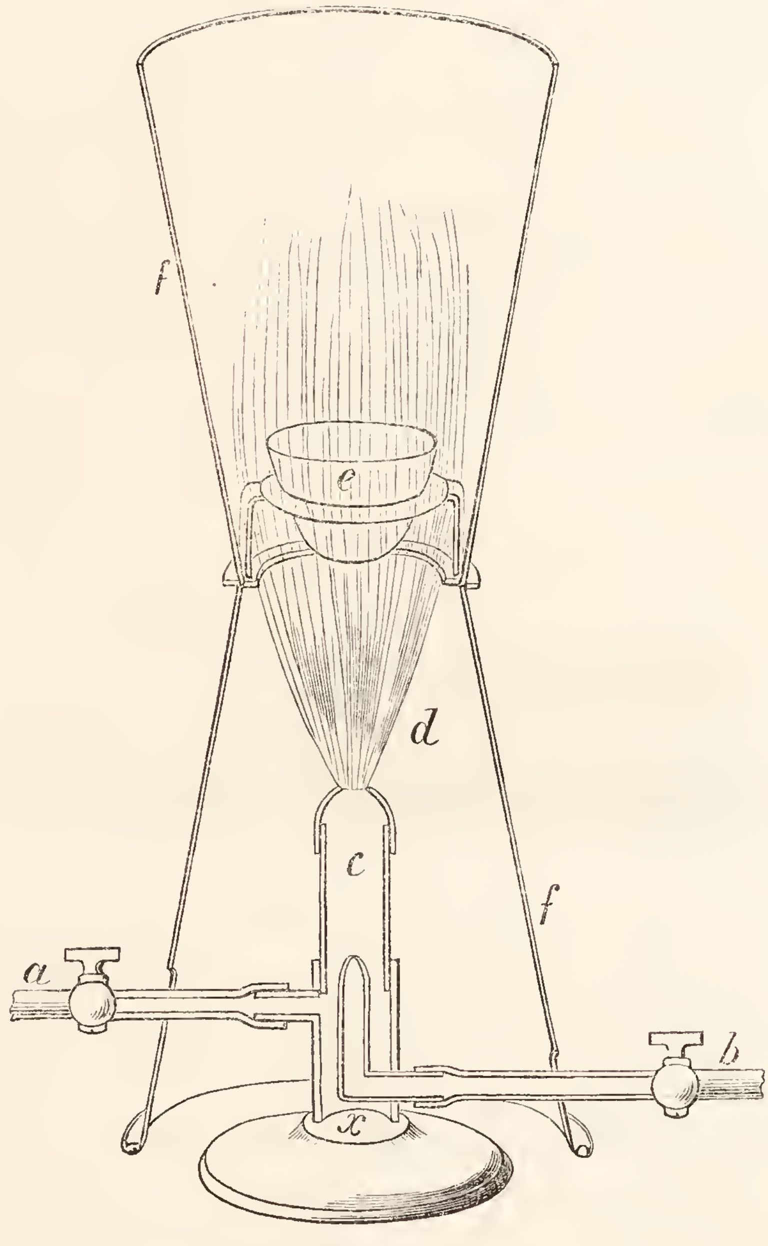
As the drawing out of the tube makes the glass thinner, it is sometimes desirable to thicken the softened part before extending it. This is done by pressing the two ends towards each other, while the softened part is in the flame.

*The sealing of glass tubes* is effected in a somewhat similar manner to that last described. The part intended to be sealed is first drawn out. If the sealing is to be effected at the end of a tube, another tube of about equal diameter is put into the flame with it, and when sufficiently softened these are to be united together by fusion, then rapidly drawn out, and the fine point at which the two parts separate, put into the hottest part of the flame until it fuses into a globule. When the sealed end is required to be suddenly contracted, the softened part of the tube should be short; it should be much softened before drawing it out; and the part to be sealed should be kept steadily in the flame while the extending part is drawn away from it.

For producing a round and smooth bottom, such as that of a test-tube, after sealing the tube as above described, the sealed point is again softened in the flame, and a piece of thin tube being united to it by fusion, the point is drawn away. The sealed end is then uniformly softened and air blown in from the open end, while the tube is rapidly turned round. In this way, only softening rather more of the tube, a bulb may be blown at the sealed end.

[In performing operations on glass tubes, when a strong heat is required, *the gas-blow-pipe*, fig. 354, may be used advantageously. Blow-pipesconstructed on this principle have for many years been used at Birmingham in brazing large vessels. The form represented in the drawing is that which I have adopted, and found suitable for chemical purposes. To a circular stand ($x$) is fixed a brass cylinder ($c$), which is slightly contracted at the top or mouth. A pipe charged with common coal gas, and furnished with a stopcock ($a$), enters this cylinder on one side; and a pipe ($b$), connected with a good double bellows, enters on the opposite side, and terminates with a small orifice in the centre of the cylinder. This pipe also has a stop-cock.

*Fig.* 354.



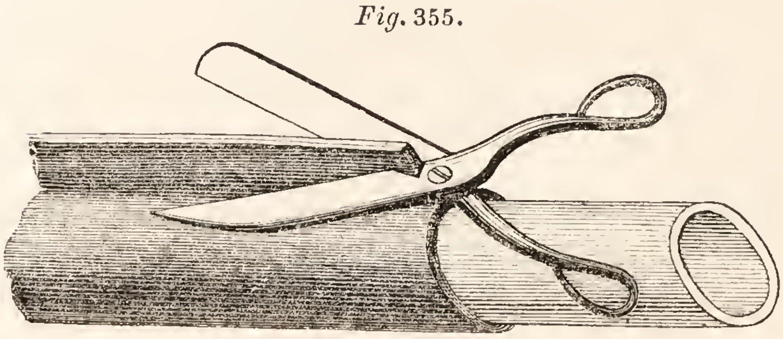

THE GAS-BLOW-PIPE.

In using this blow-pipe, the gas is turned on at $a$, and ignited at the mouth ($d$) of the cylinder. The stop-cock ($b$) is then opened, and a blast of air forced into the centre of the cylinder by the bellows. This air mixing with the gas forms a combustible mixture which issues at the orifice, under pressure, and forms a spreading flame, the heat of which is very intense. The proper proportions of gas and air are adjusted by the stop-cocks, so as to afford a pale blue flame from which there is no deposition of carbon. I am accustomed to use a furnace ($f\ f$) for confining the heat, and applying it to a crucible as represented in the figure. This furnace, of which the drawing represents a section, consists of two conical cylinders united at their smaller ends. It is placed over the blow-pipe, two apertures being provided for the tubes *a* and *b*. There is a rim projecting inwards at the part where the two cones are joined, which serves to receive a stand for a crucible, as shewn in the drawing.]

### THE CONNECTING AND LUTING OF APPARATUS.

When tubes are required to be connected, the union is usually and best effected by means of Indian-rubber connectors. These are made from a piece of sheet Indian-rubber, such as is now commonly met with in commerce. A slip of this substance, being previously warmed so as to render it perfectly pliant and elastic, is placed around the tube as shewn in fig. 355, and the ends are then cut off close to the tube with a pair of clean scissors. The scissors should be sharp, and previously warmed, and should be sufficiently long to admit of the ends of the Indian-rubber being removed by a single cut. In the figure the scissors have been purposely drawn to a considerably reduced scale, while the tube is represented of its real size. The newly cut surfaces of the caoutchouc immediately adhere, wholly or in part, and the adhesion is perfected by pressing the surfaces together with the thumb nails. The connecter is thus formed over the tube, from which it may be removed by passing some water between them so as to wet the surface of the glass. The connecter may sometimes be made, as above described, over the ends of the two tubes which are intended to be connected, and it will then only require to be secured in its place, and the connexion rendered air-tight, by means of the binding-knot or pyrotechnical knot, applied over each tube.

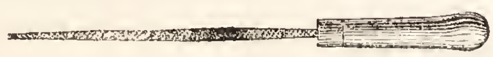
*Fig.* 355.



[Connecters of common Indian-rubber cannot be used for confining the vapours of essential oils and ethers, nor indeed any hot vapours. In these cases, the vulcanized Indian-rubber will be found to be much more serviceable. Tubes of various sizes and any length, made of vulcanized Indian-rubber, are sold by Messrs. Mackintosh, the patentees, and they may be economically and advantageously substituted, in all cases, for those made of common Indian-rubber.]

Tubes are attached to the mouths of bottles, flasks, and other vessels, by means of perforated corks. Formerly the corks were perforated for this purpose with a red-hot iron, but this method was found to be inconvenient, and was superseded by the use of the round file, such as fig. 356, the cork being first pierced by a thin file, and the hole subsequently enlarged to the required extent by using files of larger size.

*Fig.* 356.



The most convenient, and in every respect the best method of perforating corks, consists in the use of the *cork-borers*, which I originally invented for that purpose. They consist of cylinders of tin-plate, about six inches in length, and varying in diameter to suit the different sized tubes. A wooden handle is fitted to one end of the cylinder, as shewn in fig. 358, which greatly facilitates its use. There should be a set of these cylinders of such sizes that, without the handles, they may fit loosely one within another, the smallest being about a quarter of an inch in diameter. The cutting edge of the cylinder is sharpened with a small half-round file. It is found convenient to have a gauge (fig. 357), which has a series of notches corresponding with the diameters of the borers and marked with corresponding numbers, so that by fitting the tube to one of the notches, a suitable borer may be at once selected.

*Fig.* 357.

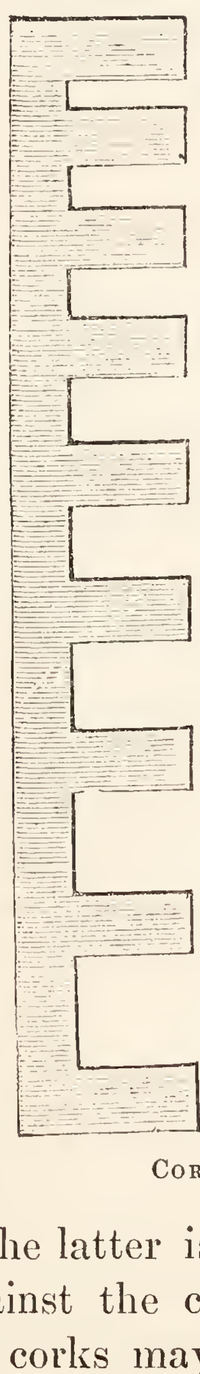
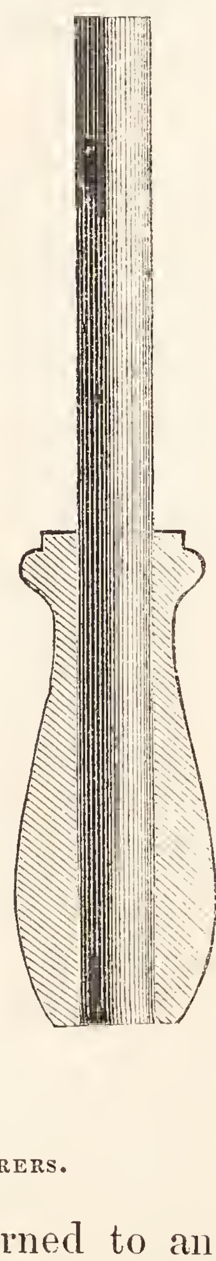


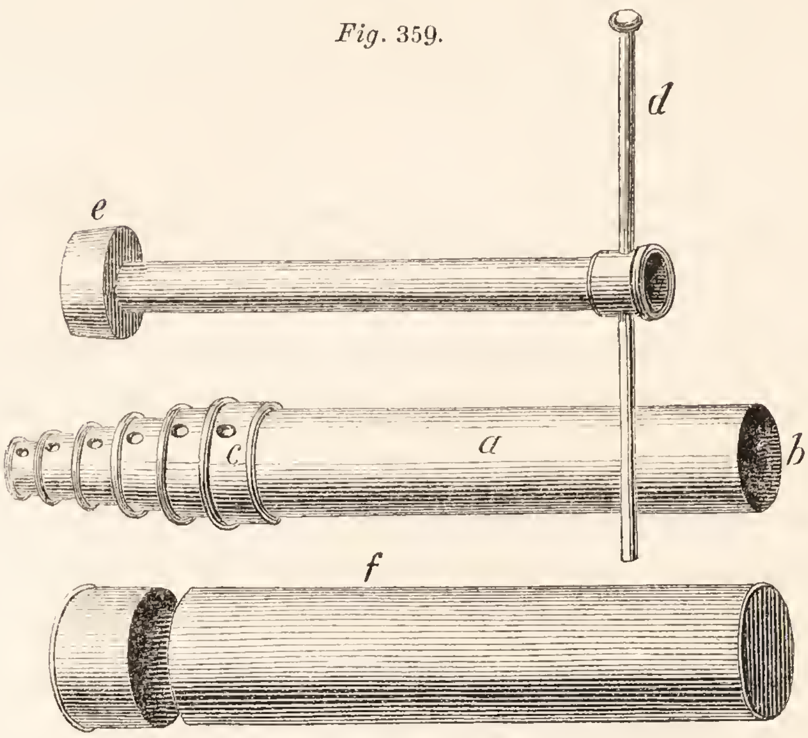
*Fig.* 358.



CORK-BORERS.

The method of using the cork-borers is very simple. A little oil being rubbed over the inner and outer surface of the cylinder, the cutting-edge is placed upon the cork in the proper place, and in the direction in which the tube is intended to pass. The cutting is effected by holding the cork in one hand and the borer in the other, while the latter is turned to and fro, and at the same time pressed against the cork until it has passed through. With a little practice corks may be cut in this way, so as to have a perfectly smooth cut surface. If none of the borers should be of exactly the right size for the tube, that one nearest in size, but smaller than the tube, must be used, and the hole subsequently enlarged with a round file.

*Fig.* 359.




CORK-BORERS.

[In this country cork-borers are usually made of brass. Fig. 359 represents a set of borers such as I am accustomed to use. The cylinder (*a*) is made of rather thin drawn brass tubing, to one end of which, at *c*, a short piece of a thicker tube is soldered, and through this there are two holes on opposite sides of the cylinder, for the reception of the iron rod (*d*). The set consists of twelve borers of different sizes, six of which are shewn in the drawing. These fit one within another, and are kept in the tin case (*f*), the rod (*d*) being put within the smallest cylinder. In the drawing they are represented as having been partly drawn out to shew the succession of sizes, and the rod (*d*) is represented in the position in which it is placed in one of the borers when used in perforating a cork (*e*).]

The corks by which connexions are made should never be left in the mouths of bottles, or other vessels, when the apparatus is not in use, as the long-continued compression to which they would thus be exposed would destroy their elasticity, so that after some time they would cease to fit tightly into the openings they originally stopped. After using the apparatus, therefore, the corks should be taken out or loosened, before putting them away for subsequent employment.

If the opening into which the cork is fitted be large it will be difficult to get a cork that will, alone, form a perfectly air-tight connexion. The compression to which a large cork is submitted, when inserted in the mouth of a vessel, is not sufficient to close up the pores which always exist to a greater or less extent. In these cases it is necessary to use some kind of luting.

[If no heat be employed in the process to which the apparatus is to be applied, a little grease will form a suitable luting. Lard, which has been mixed with about one-twentieth part of its weight of white-wax, so as to give it a stiff and tenacious consistence, will be found a most useful luting for rendering cork connexions air-tight. It should be well rubbed into the pores and over the surface of the cork, and made to fill up every open space at the points of connexion between the cork and the glass. If, however, the apparatus is intended to be used for processes in which heat is applied, a different kind of luting will be necessary. A paste made of linseed-meal, or almond-meal, and water, is the most common and generally useful luting. It may be applied, either alone, or with a piece of moist bladder tied over it, as represented in fig. 360. A mixture of chalk and linseed oil, also forms a good luting, which becomes very hard and impervious to vapours after it has stood for a day or two.

*Fig.* 360.

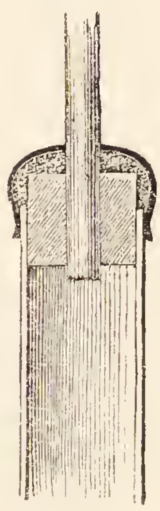


*Fig.* 361.

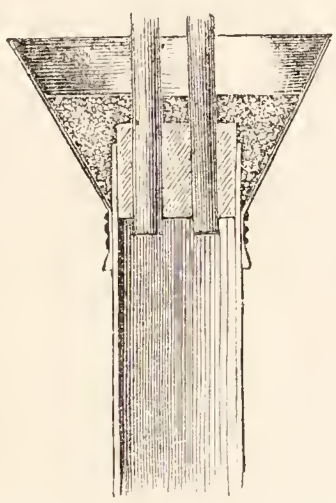


*Fig.* 362.

*Fig.* 363.

Tube Connexions.

When there are two or more tubes inserted through the same cork, it is sometimes difficult to apply a stiff luting so as to form a neat and air-tight union. In such cases, plaster of Paris may be used advantageously in the following manner. A coil of paper is tied around the larger tube or mouth of the vessel, as shewn in fig. 361, and the plaster of Paris, mixed with water to the consistence of cream, is then poured in so as to surround the inserted tubes. When the plaster has hardened, the paper is removed, and the luting scraped with a knife until reduced to a suitable form.

A solution of sealing-wax in spirit or naphtha is frequently applied as a kind of varnish to the surface of corks, when used for connecting apparatus. It constitutes the most elegant method of rendering the cork air-tight, but does not always supersede the necessity for the application of other luting to the points of contact between the cork and other parts of the apparatus. The solution of sealing-wax is, also, sometimes inapplicable, in consequence of its requiring some time to harden after it has been applied. There are some cases in which sealing-wax may be used advantageously without a solvent, the wax being ignited and allowed to drop, in the melted state, on to the cork, and surrounding parts of the apparatus, where it is spread as smoothly as possible by the still burning end of the stick, or by the subsequent use of a hot iron. This method of luting will be found to resist the escape of very penetrating vapours, such as ammonia, which it is difficult to confine with other kinds of luting, and in the generation of which much heat is not applied.

For confining acid vapours, a mixture of pipe-clay and linseed oil, beaten into a tenacious paste in a mortar, should be used. Pipe-clay made into a paste with a concentrated solution of sulphate of soda is also sometimes used.

When much pressure has to be overcome, but no heat is applied, as for instance, in passing sulphuretted hydrogen through a solution into which the gas is conveyed to a considerable depth, I have found a stiff and tenacious clay to form the best luting.]

The connexion of a small tube to one of larger diameter is sometimes effected by means of the neck of an Indian-rubber bottle, as shewn in figs. 362 and 363.

[Connexions of a more permanent kind than those above described are usually made by the manufacturers of apparatus. The pharmaceutical operator will, however, frequently find it convenient to be able to repair or reconstruct a joint which has become defective.

Fig. 364 represents the union of a glass-tube to one of brass, such as occurs in the water-index of the boiler, fig. 4, page 5. The glass-tube is here inserted into the brass-socket and secured with cement. The best kind of cement to use in these cases is a mixture of ground white-lead with a portion of red-lead made into a tenacious paste with a little boiled-oil. This soon hardens, and then forms a perfectly tight joint, which is unaffected by high temperatures.]

Fig. 365 represents another method of connecting a glass-tube to one of metal. The metallic-tube (*a*) has a broad flanch, in which there are four screw-holes. Over this flanch three circular disks of pasteboard are placed, each of which has a hole cut in its centre with a cork-borer, so as to fit tightly over the glass-tube, whose end is inserted into the metallic-tube. A disk of metal (*c c*) is then placed over the pasteboard and screwed down tightly. No cement is used in this case, and yet the union will be perfectly water-tight, even when applied to a steam-boiler, where some pressure is employed.

*Fig.* 364.

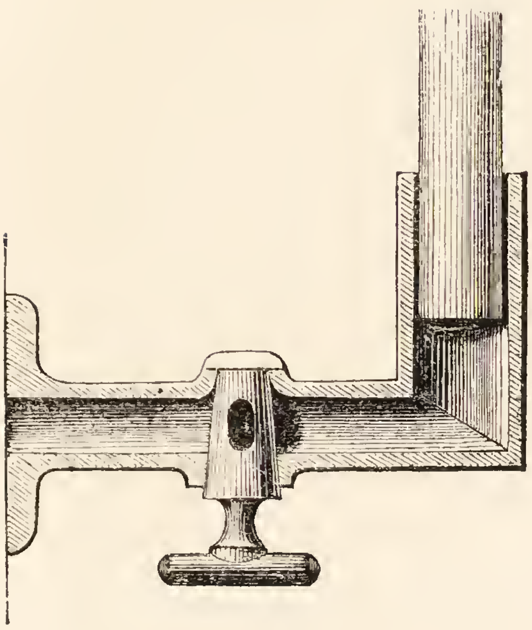


*Fig.* 365.

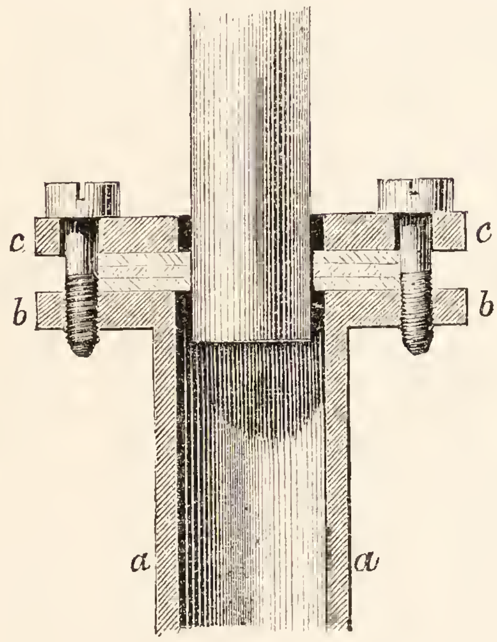
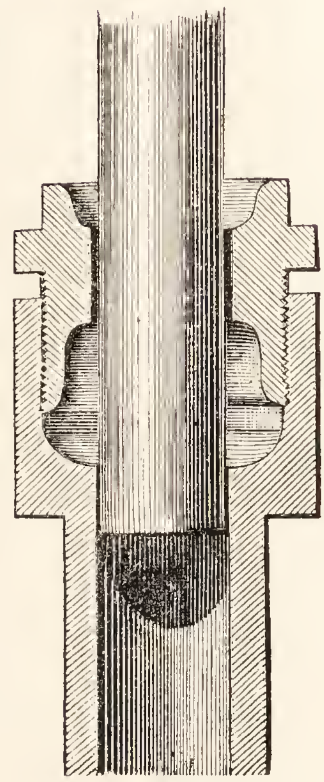



*Fig.* 366.



Figs. 366, 367, 368, and 369, represent other methods of connecting tubes. In fig. 366 the connexion is made air-tight by means of a stuffing-box. In fig. 367 two disks of pasteboard surround and closely embrace the glass-tube, and these are secured in their place by an overlapping screw (*b c*), which screws on to the metallic-tube (*a*). Figs. 368 and 369 represent methods of connecting two metallic tubes.

*Fig.* 367.

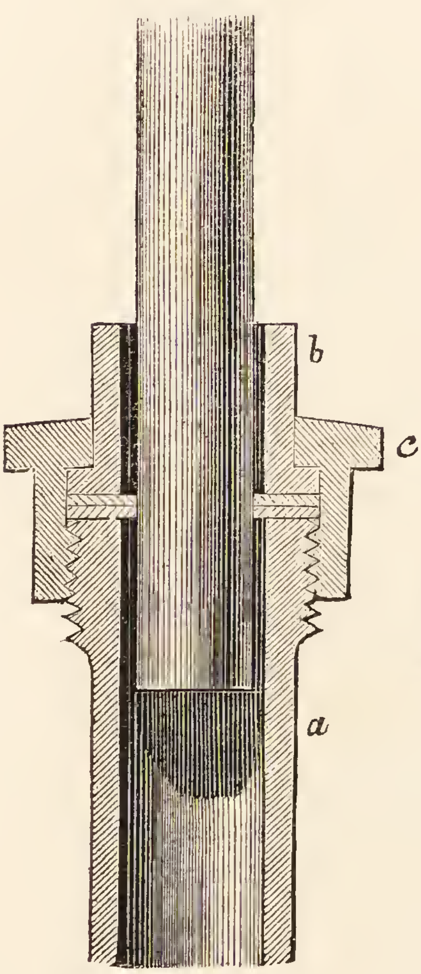



*Fig.* 368.

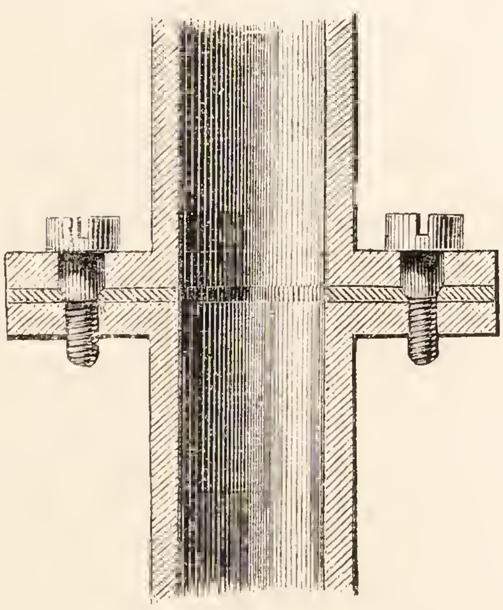
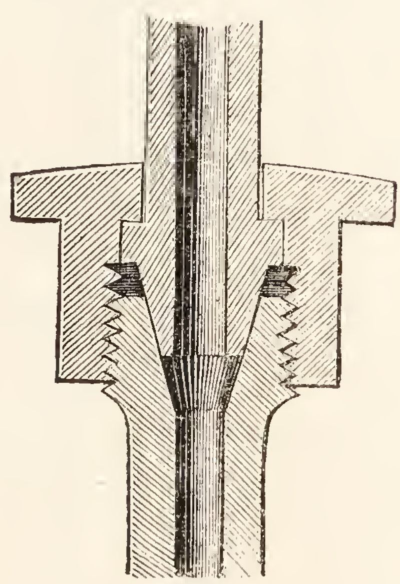


*Fig.* 369.



TUBE CONNEXIONS.

## COATING OF GLASS AND PORCELAIN VESSELS WITH COPPER.

At the exposition of works of art and manufacture in Paris, in the summer of 1844, there were exhibited glass and porcelain vessels of different kinds coated with copper. The metallic coating was perfectly smooth and of uniform thickness, and the adhesion appeared to be perfect in every part. Among the vessels thus coated were flasks, retorts, receivers, evaporating dishes, &c. It was evident that the copper must have been deposited on these vessels by electricity, and that it rendered them much less liable to breakage, either from sudden changes of temperature or from other causes, than they otherwise would be.

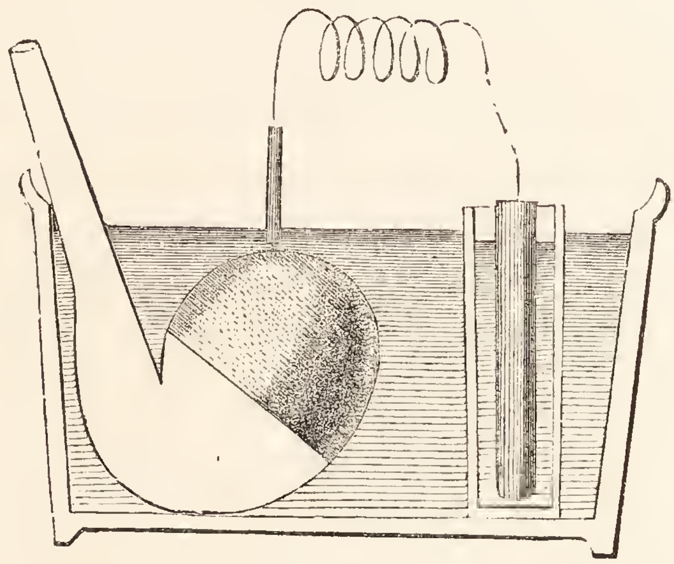
After my return home, having brought some of the coated vessels as patterns, I made several experiments, with the view of ascertaining the best method of effecting this useful application of the electrotype process.

The first step in the process must of course be to cover the surface of the vessel with some substance capable of conducting electricity. In my early experiments I put a thin coating of copal-varnish over the part on which the copper was intended to be deposited, and while this was yet adhesive it was covered with thin leaves of Dutch-metal. A conducting surface being formed in this way, and the varnish allowed to dry, the vessel was filled with water and immersed in a solution of sulphate of copper, such as is generally used for electrotyping, contained in a large earthen pan. In the same pan was placed a porous earthen vessel filled with diluted sulphuric acid, and containing a zinc cylinder, from which a copper wire was made to communicate with the conducting surface of the vessel to be coated. The part of the wire that passed through the solution of copper was isolated by enclosing it with sealing-wax in a glass tube. With this simple arrangement a sufficient deposit of copper was obtained in three or four days, care being taken from day to day to turn the vessel under operation so as to present a new surface towards the zinc cylinder, as the copper is always deposited more rapidly on the parts facing the zinc than on any others. Fig. 370 represents the whole arrangement.

In subsequent experiments I found that metallic bronze-powder brushed over a thin coating of varnish forms the best conducting surface on which to deposit the copper.

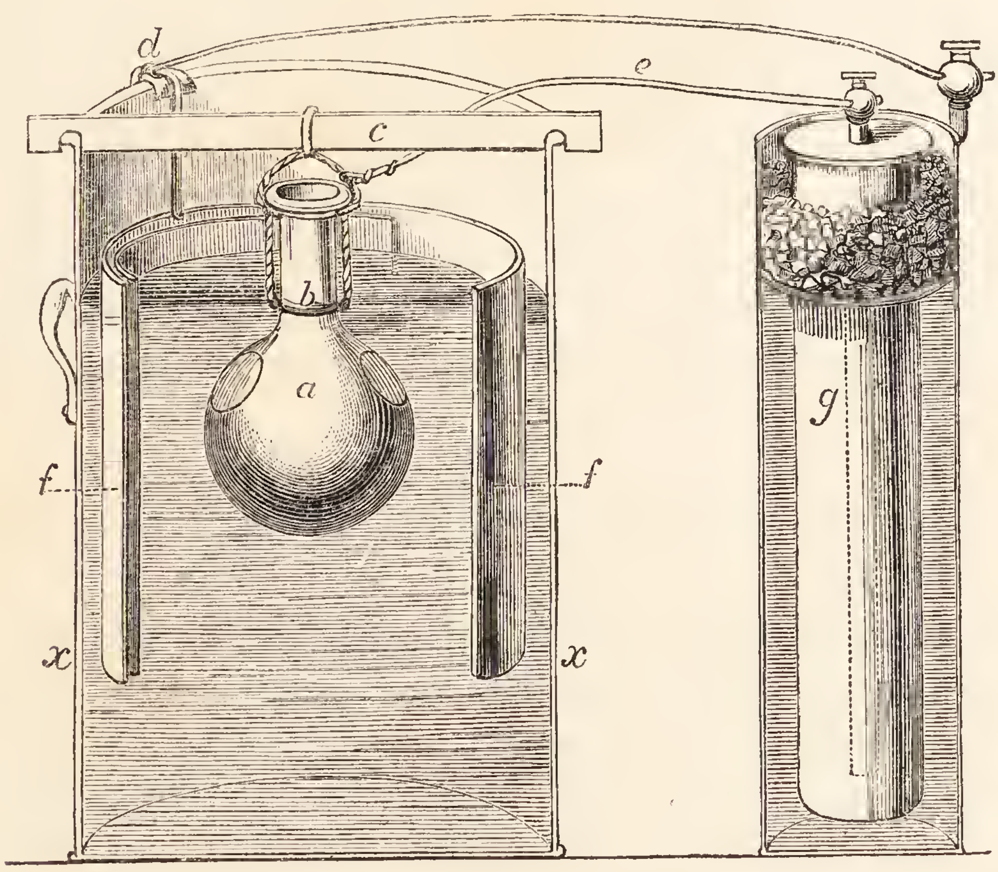
[My experience in the use and preparation of vessels coated with copper dates from the same period as that of Dr. Mohr. I brought several coated glass-vessels from Paris in 1844, some of which have been in use ever since. I have not, however, found that so simple an arrangement as that described by Dr. Mohr, for depositing the copper, afforded satisfactory results. The arrangement which I have found to answer best is that represented in fig. 371. A thin coating of fat varnish (not spirit-varnish) is, in the first place, applied with a camel's-hair brush, over the part of the vessel on which the metal is intended to be deposited, leaving two or three uncovered circular spaces, as shewn on the flask (*a*) in the drawing. When the varnish has become nearly dry, but is still sticky, some bronze-powder is brushed over it with a thick camel's-hair brush. A perfectly bright and uniform metallic surface is thus produced

*Fig.* 370.



Coating of Vessels with Copper.

*Fig.* 371.




Coating of Vessels with Copper.

over the varnished part. A copper wire is, in the next place, twisted around the neck of the flask at the point (*b*) at which the bronzed surface commences, and in contact with it. This copper wire is carried up on each side of the neck of the flask, and again secured immediately below the projecting rim or lip, from whence it is formed into a loop over the mouth of the vessel. The flask, thus prepared, is filled with water, and a sufficient quantity of shots put into it to make it sink in the solution of copper. The solution consists of two parts of a saturated solution of sulphate of copper, and one part of a saturated solution of sulphate of soda to which as much sulphate of copper as it is capable of dissolving has been subsequently added. This solution is put into a large copper vessel (*x x*), across the top of which is placed a bar of wood (*c*), from which the flask is suspended. A sheet of copper, coiled into a circular form (*f f*) is also immersed in the solution so as to surround the flask, and a copper wire (*d*) connects this with the positive pole of a constant battery, while the flask is at the same time connected with the negative pole by the wire (*e*). The battery (*g*) is a large Daniel's battery of the usual kind. With this arrangement the copper will be deposited of sufficient thickness in about two days.

There are several advantages in the use of glass-vessels thus coated with copper. They are rendered less liable to be broken than they otherwise would be: when exposed to the flame of a lamp the heat is more equally distributed over the surface of the vessel, and condensation is prevented in the upper part of the globe when used for distillation. I have not found any indications of a separation of the metal from the glass, even after long use. I am informed, however, that they do not answer for the distillation of liquids which boil at a very high temperature. On applying them for the distillation of oil of vitriol, it has been found that the copper speedily becomes oxidized, and the coating thus destroyed.]

### PREPARATION OF WAXED-PAPER.

Tissue-paper is most advantageously employed for making waxed-paper. It absorbs but little wax, and when prepared has an elegant appearance, and is easily moulded to the mouth of the gallipot or other vessel to which it may be applied. In accordance with its name, waxed-paper should be prepared with wax, but practically it is frequently made by impregnating the paper with stearine, and sometimes with oil. Stearine appears to answer nearly as well as wax.

Waxed-paper is prepared in the following way. A plate of iron, the upper surface of which is quite clean, is placed over a furnace until it has become warm. On the iron-plate a sheet of stout paper is laid, and over this the tissue-paper. A piece of wax or stearine is now placed in the centre of the paper, and as it melts it is spread out in all directions with a suitable instrument, while the paper is, at the same time, moved so as to bring the different parts alternately over the centre or hottest part of the furnace. The complete and equal distribution of the wax over the whole of the paper requires the exertion of some force. The rubber or instrument by which the wax is spread, should be so constructed that while it presents a soft surface it shall not be too absorbent. I am accustomed to make the rubber by first rolling a slip of paper into a cylinder, covering this with tin-foil, and finally surrounding the tin-foil with a double layer of linen. The tin-foil prevents the absorption of the wax by the paper.

An iron plate answers better than one of any other metal for supporting the paper, especially when stearine or stearic acid is used. Copper or brass would be acted upon by the fatty acid, and a colour would thus be imparted to the paper.

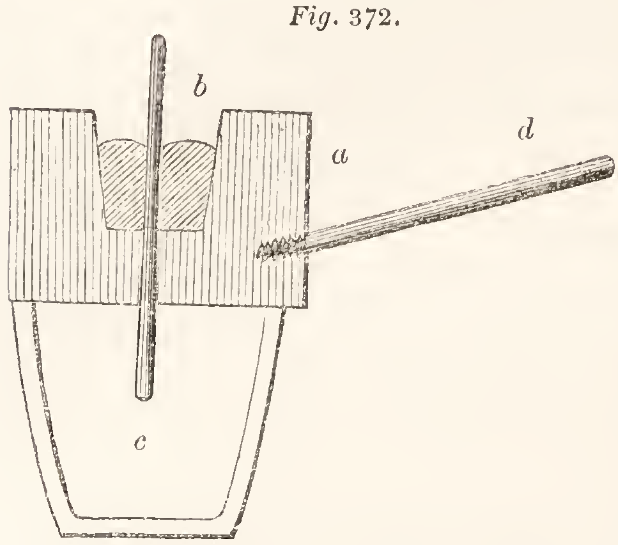
[Waxed-paper may also be prepared by holding a sheet of paper by the four corners in front of an open fire until it becomes hot enough to melt a piece of wax when rubbed over it. In doing it thus, the operator requires assistance. It may be done with one assistant, who holds the two corners of one end of the sheet of paper, while the operator himself holds the paper with his left hand midway between the two opposite corners, and then, holding in the other hand a cake of white-wax which has been cut across its centre, so as to present the straight edge to the surface of the paper, this is rubbed quickly over every part until a thin film of wax has been uniformly imparted.]

## THE CASTING OF ZINC, POTASH, AND LUNAR CAUSTIC.

*Zinc* is sometimes cast in cylinders for using in Döberiener's lamps. The clippings of sheet zinc, which may be purchased at the zinc workers', are economically used for this purpose. The mould for casting the zinc is sometimes made of thin pasteboard, or even of thick paper, rolled up so as to form a hollow cylinder of the required size, and then bound on the outside with string. This cylinder is placed upright in a vessel of sand, and a round stick is fixed in the centre of it, the lower end of the stick being inserted into the sand. The zinc should be melted with the least possible amount of heat, and poured into the mould. If the metal be made too hot it will burn the paper.

I have adopted a much more convenient, and generally better, method than the above, for casting these cylinders. Fig. 372, (*a*) represents the mould, which is made of cast-iron. It is of a cylindrical form, three or four inches in diameter, and of the required depth. There is a round hole (*b*) in the centre, of the size of the intended cylinder. The diameter of this hole is rather less at the bottom than at the top. There is also a small hole passing from the centre of the latter through the bottom of the mould, and through this an iron rod (*c*), which slightly tapers towards the top, is passed from below upwards, and temporarily fixed, as shewn in the drawing, by striking it with a hammer. A handle (*d*) is attached to the side of the mould.

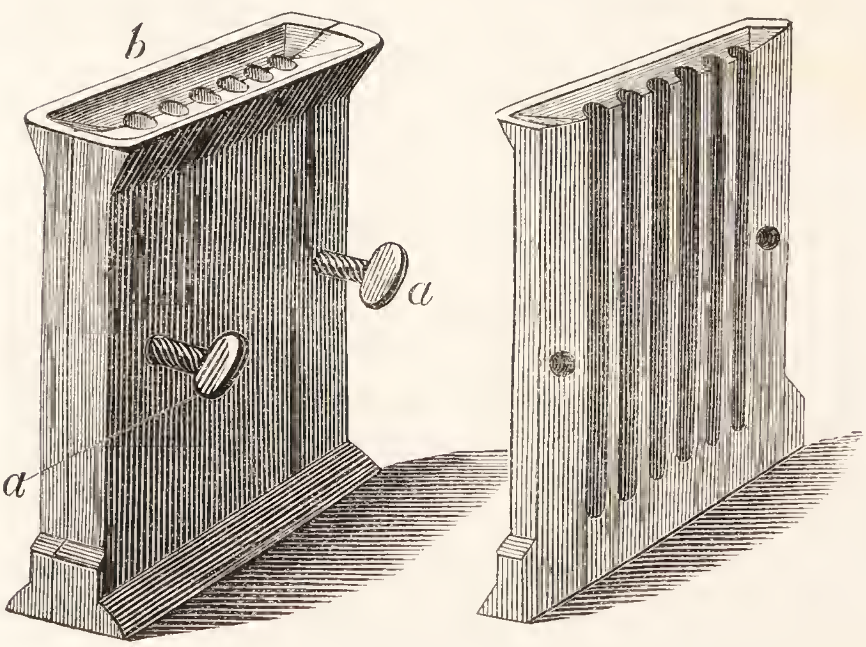
*Fig.* 372.




MOULD FOR CASTING ZINC CYLINDERS.

The rod (*c*) being fixed in its place, the mould is placed over the mouth of an empty crucible, or on any other suitable stand, and the melted zinc is poured into it at *b*. As soon as it has become solid, and sufficiently cooled, the rod is knocked out, and the mould being then turned over with the bottom upwards, and struck gently with a hammer, the zinc cylinder falls out. The rod is now again put into its place, and another casting made. Thirty or forty cylinders may be thus cast in a few hours.

*Fig.* 373. *Fig.* 374.




MOULD FOR CASTING HYDRATE OF POTASSA, AND LUNAR CAUSTIC.

[*Hydrate of potassa* and *lunar caustic* are cast into small cylindrical sticks, and are used in this form by surgeons. Fig. 373 represents the kind of mould used for casting them. The mould is made either of iron or of brass. Iron should always be used for casting potash; but the moulds for casting lunar caustic are generally made of brass or gun-metal. The mould consists of two metallic plates (*b*), fig. 373, which are grooved, as represented in fig. 374. These plates are joined together by the screws (*a a*) and the substance to be cast is poured, in the melted state, into the cavity at the top, and allowed to run into the grooves. When it has hardened, the mould is unscrewed, the two plates taken asunder, and the cylinders removed from the grooves.]

## CLOSED OPERATING CHAMBER OR CLOSET.

There are so many operations in the laboratory in which noxious vapours are evolved, that it is always desirable, if it can be so arranged, to have a chamber or closet communicating with the chimney, and having a glazed door in front by which the escape of vapours into the apartment may be prevented. A closet of this description is represented in fig. 375. It should be fixed against a chimney, into which all vapours evolved in it may be conducted through an opening provided for the purpose near the top of the closet. It should also be so situated that sufficient light may enter through the glazed door in front. The closet from which the drawing, fig. 375, has been made, is constructed in the following manner.

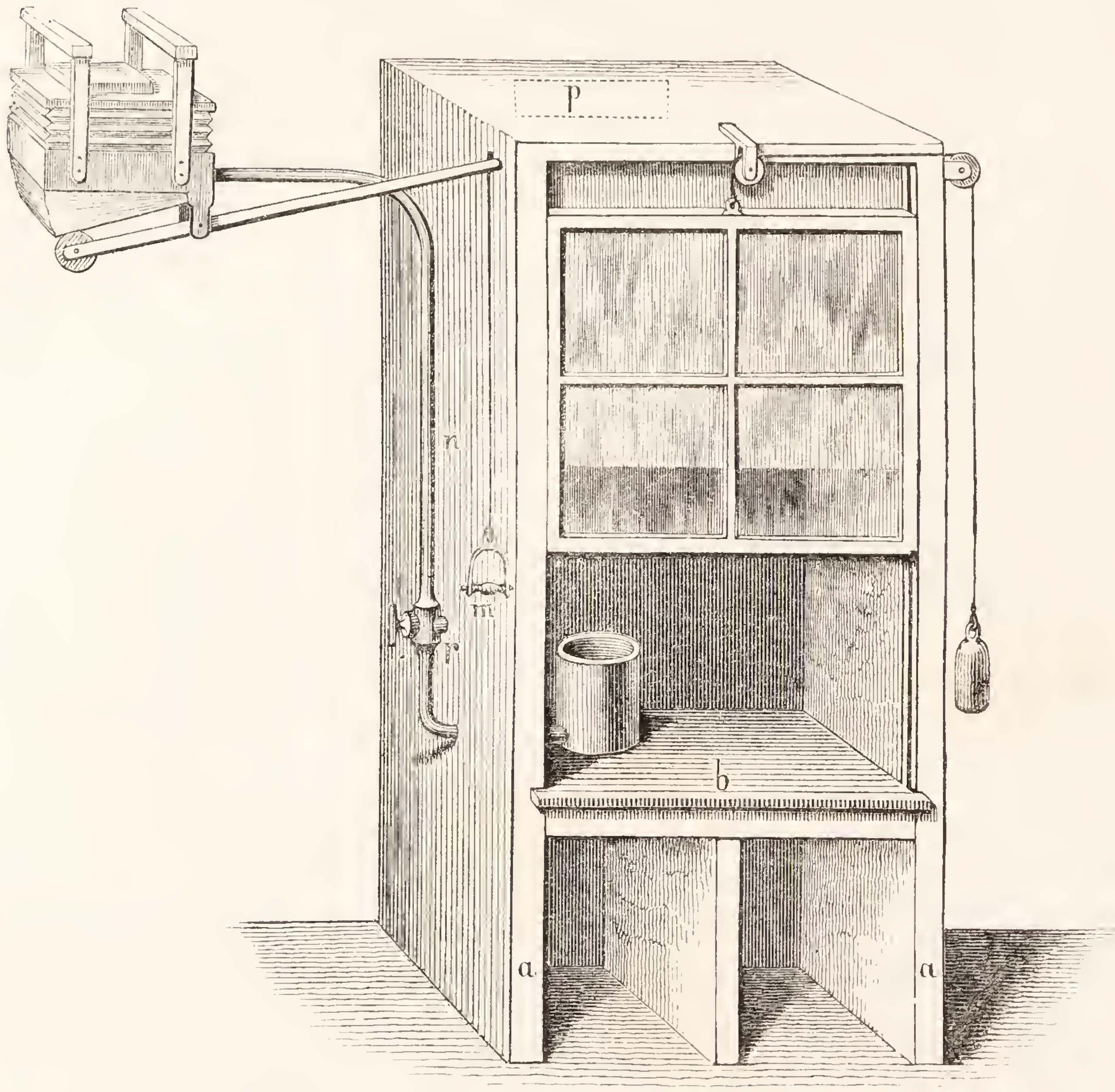
Two thin brick walls (*a a*) are run up to form the sides of the closet. These are about three feet and a half distant from each other, and they project about twenty-seven inches from the wall of the room. The operating table (*b*) is fixed at a height of thirty-two inches from the ground, and consists of a cast-iron plate resting on a stone slab. The iron plate is made to slide in a groove on each side, so that it may be easily removed and replaced at any time, without otherwise disturbing the closet. The height of the table is so arranged that a dish or other vessel, placed on a small furnace within the closet, shall be in such a position as to admit of the contents being closely observed by the operator.

The space between the operating table (*b*) and the ceiling is enclosed, partly by a brick wall, and partly by a glass door. The upper half is bricked in the same way as the sides of the closet, the brickwork being supported on a strong iron bar. The lower half is enclosed with a glazed sash, running in a frame like a common window-sash, and counterbalanced by a weight.

The space below the operating table is divided into two compartments by a wall. Fuel is kept in one of these compartments, and apparatus in the other.

A double-acting bellows is fixed near the ceiling, and the rope and stirrup (*m*) by which this is worked hangs on the left hand side of the closet. The pipe (*n*) of the bellows enters the closet through the wall at such a height above the operating table that it may enter the air-pipe of one of the furnaces, figs. 109, 110, or 111.

*Fig.* 375.




Closed Operating Chamber or Closet.

The obvious advantages resulting from the use of this closet, in a variety of operations in which noxious vapours are evolved, will amply compensate for the expense of its erection.

# THE DISPENSING OF MEDICINES.

The extemporaneous admixture and preparation of medicines from the prescriptions of medical men, and the supply or administration of remedial agents to the public, constitutes the primary objects, and most ostensible duties of the pharmaceutist. All other operations are performed in anticipation of those connected with the dispensing of medicines.

The duties of the dispenser are of a very important nature, and for their due discharge a certain combination of qualities is required in the individual who undertakes them. With some degree of physical strength and agility, he should combine a quick perception, sound judgment, and firmness of resolution. He should maintain a constant and lively attention to every operation, however trifling, with which he may be occupied, and evince, both by night and by day, a readiness to fulfil his duty in serving others, even at the sacrifice of his own convenience and pleasure.

The art of dispensing is generally learnt from practical demonstration, and this indeed, is the only method of acquiring expertness in the various manipulations which the art involves. It is not, therefore, contemplated in the observations which will be offered here, to supersede the necessity for practical instruction, but merely to give the results of many years' observation, with the view of supplying some facts to the less experienced, and of inducing a habit of observation and reflection with reference to the most apparently simple phenomena.

The operations of dispensing are carried on at the counter appropriated to that purpose, either in front and within view of the customers, or behind a screen which intercepts the view. The construction of the dispensing counter, without the screen, has been described elsewhere. The screen, which usually consists of a curtain, or of a wooden erection, on the front edge of the counter, and extending to about the height of a man's shoulder, or not quite so high, is generally adopted in the north of Germany. There is much difference of opinion with regard to the supposed advantage of this arrangement. As much, probably, might be said against it as in its favour. To the dispenser, it may be more agreeable to carry on his operations behind the screen, where he is not exposed to the scrutinizing eye of the patients, who might otherwise be watching his fruitless attempts at effecting the combination of some rebellious constituents of a pill-mass, or criticising the accuracy with which he divides out a powder into the separate doses. But on the other hand, an accomplished dispenser should be capable of evincing his skill by adroitly overcoming difficulties; and the stimulus which the observation of the customer affords to the cultivation of habitual expertness and careful attention, is one of the advantages of the unscreened counter.

The existence of the screen will naturally excite in the mind of the customer a suspicion that something is being done with which the operator is anxious that he should not become acquainted; and it is also calculated to induce carelessness on the part of the operator, which would probably become habitual. Under such circumstances, the dispenser may be sometimes seen in his dressing-gown and slippers,—a habit which cannot be too strongly condemned. He should every morning make his appearance, from the commencement of the hours of business, neatly, but not expensively dressed. Before his customers, and indeed at all times, while engaged in the operations of dispensing, he should be careful to observe the greatest possible cleanliness, and to avoid everything that would be calculated to excite feelings of disgust.

The dispenser who licks the lip of the syrup-bottle, after pouring out what he requires;—who removes any foreign body from a mixture by putting his finger into it, or puts a cork between his teeth to soften it and make it fit the mouth of a bottle, might be compared to an ill-bred person, who, at meal-time, drinks from the decanter, helps himself to salt with his fingers, or cuts bread from the loaf with a knife which has just been in his mouth. He who prepares the dose for the sickly, and often fastidious patient, should be especially careful that he add no extraneous repulsiveness to that which, of necessity, belongs to the prescribed remedy.

## MEANS FOR PRESERVING CLEANLINESS.

The means by which cleanliness is preserved, should be amply provided in the dispensary. The most important of these means is water. *A sink with water laid on*, in a convenient situation, for the use of those engaged in dispensing, is indispensable. If there should not be a water-cistern on the premises, from which a supply might be conveyed to the sink by a pipe, it will be necessary to provide a vessel for this purpose. It is desirable that the cistern should not be at a great height above the stop-cock at which the water is drawn, as the force of the current would in that case be so great as to cause much splashing of the water in using it for washing a measure-glass or other vessel. The size of the tap should also be such that it may pass into the mouth of a bottle.

*A good sponge* is another requisite. It should have a string attached to it, by which it is hung from a nail in some suitable place. The sponge is used for wiping up any water, or substances soluble in water, that might be spilled on the counter. It is kept in a moist state, so that it will readily absorb any liquid, and it should always be washed and squeezed before being returned to its place after use. Care should be taken, however, that the sponge is never used for wiping any kind of grease, as this would render it subsequently useless, until it be well cleaned with soap or carbonate of soda and hot water.

*Two towels, or cloths*, will also be required, which should be of different degrees of fineness. These may be kept in a drawer, but must be ready of access. Many dispensers appear to be ignorant of the proper use of the towel. The finer towel ought to be used only for wiping clean water off the bottles, measures, or other objects which have been wetted, or which require delicate cleaning. The coarser towel may be employed for removing dust from the counter, or for other similar purposes. But it should be borne in mind that whatever dirt is removed from an object with the towel, may become attached to the next object to which the towel is applied. The practice so commonly adopted, of wiping up all kinds of dirt with the towel, seems to indicate a great want of discernment or reflection in the operator, for such conduct, after two or three repetitions of it, only increases his difficulties by rendering the towel of no further use. Powders, or anything more than a sprinkling of dust, should be always removed with a dusting-brush, or the coarse towel should be used in such a way as to remove the dust from the object without holding it in its texture. Syrups, mixtures, extracts, and all substances of this kind, which are soluble in water, should be removed with the wet sponge, and the place then wiped dry with the towel. All greasy substances should be carefully removed with blotting-paper, saw-dust, or a piece of tow. A little attention to these points will save a great deal of inconvenience and trouble, and will greatly facilitate the maintenance of cleanliness.

## AIDS TO DISPENSING.

[There are several preparations which may be made for the purpose of aiding or expediting the operations of dispensing. If by adopting such means, the properties of the medicines are not altered, while the pharmaceutist is enabled with greater facility to dispense them, no possible objection can be urged against the practice. Indeed, in some cases, there is decided advantage, independently of the saving of time, in having the requirements of prescriptions met by anticipation, and operations which are ordered extemporaneously, performed during leisure hours, when greater attention can be devoted to them.

Thus, for instance, many salts which are frequently ordered in prescriptions, are advantageously kept in fine powder, in which state they will more readily dissolve in any fluid. In this way the use of a mortar, which otherwise would be required, may be dispensed with, in effecting solution. It is important, however, that due care should be taken to ascertain that the salt, when powdered, has the same composition as the crystals, or, at least, that there is some known and definite relation between them. Efflorescent salts, such as carbonate of soda, and sulphate of soda, would lose a portion of their water of crystallization in being powdered, unless the process were conducted with special precautions. Sesquicarbonate of ammonia would also be likely to undergo some change. These salts, even if ascertained to be unaltered in composition when first reduced to powder, would be more likely to undergo change from exposure to the air in this state than they would if the crystals were unbroken. Moreover, it would be more difficult to detect the occurrence of change by the eye, in the case of the powder, than it would be in that of the properly crystallized salt. But there are many salts, such as salammoniac, nitrate of potash, alum, and sulphate of magnesia, which are not subject to the changes indicated from mere exposure to the air. It would be necessary, of course, carefully to distinguish between salts powdered with their water of crystallization, and those, such as alum and sulphate of magnesia, which are sometimes rendered anhydrous before being powdered.

Again, there are some salts which may be very conveniently kept in solution for use in dispensing. Of this class, are sulphate of magnesia, salammoniac, and carbonate of potash. It is desirable, unless there be some obvious reason for doing otherwise, to make such solutions of uniform strength; and the strength should be such as to admit of easy calculation in determining the quantity of solution that shall contain a specified quantity of the salt. As the solution would be always apportioned by measurement (in England), while the salt is ordered by weight, the weight of the latter should bear a simple relation to the volume of the former. The most convenient proportions will be those in which fʒiv of the solution shall contain ʒi of the salt. A solution of this kind is made by dissolving ℥v, troy-weight, of the salt in water, and making the solution to measure f℥xx. Solutions thus made, of the salts above-named, will be of such strength that there will be no chance of any portion of the salt being deposited in cold weather, while, at the same time, calculations will be easily made. The labels of the bottles should indicate the strength of the solutions.

There are some salts which are not unfrequently ordered in prescriptions, but which, nevertheless, cannot be kept in solution in consequence of their undergoing decomposition. Emetic tartar (potassio-tartrate of antimony) is a salt of this kind, and indeed most salts which contain organic acids belong to the same class.

Salts, the solubility of which varies much with differences of temperature, cannot often be conveniently kept in solution, unless much diluted, as the strength of the solution would be liable to variation from the deposition of crystals in cold weather. This is the case with sulphate of soda and nitrate of potash, which, although very soluble at temperatures above 60° or 70°, are very much less soluble at low temperatures.

There are other substances which may be kept in solution, such as manna, extract of liquorice, and gum ammoniacum. The pharmaceutist will, of course, be guided in his selection of those which it will be most desirable to keep thus prepared, by the common requirements of the locality in which he is situated. The practice of a neighbouring physician may render a preparation useful in a particular place, while there would be no demand for it in a different locality.

In some places, *Griffiths's Mixture* (the *Mistura Ferri composita* of the Pharmacopœia), is very frequently ordered in prescriptions, and as some time is occupied in properly preparing this mixture, it may, in such case, be kept partly prepared beforehand, by which means the operation of dispensing it will be greatly expedited. The emulsion of myrrh, carefully made from picked pieces of the gum-resin, which, when broken, present an opaque and milky appearance in the centre, and to which all the ingredients, excepting the sulphate of iron, have been added, may be kept in a stoppered bottle for several weeks without undergoing any change, and the mixture will be at any time completed by adding to a portion of it the proper quantity of sulphate of iron.

*Aromatic confection* is sometimes kept mixed with water, so that fʒij of it shall contain ʒj of the confection. This mixture requires to be shaken up in the bottle in which it is kept, so that the ingredients may be held in suspension when a portion of it is poured out. It should not be long kept thus mixed, as it is liable to undergo fermentive decomposition, especially in warm weather.

Some *extracts* and *pill-masses* may be conveniently kept, for use in dispensing, in a state different from that in which they are ordered in the Pharmacopœia. Thus, it is often found advantageous to have *compound extract of colocynth* in the form of powder, as well as in the soft state. *Extract of jalap* is also kept in powder. The pharmaceutist should always prepare these powders himself. The greatest possible care and attention are required to avoid injuring the qualities of the extracts in the desiccation to which they are submitted. An accurate determination must also be made of the relation in weight which the powder bears to the extract in its original state, and this relation should be specified on the label of the bottle in which it is kept.

*Plummer's pill* (*Pilulæ hydrargyri chloridi compositæ* of the Pharmacopœia), is frequently kept in powder, one of the ingredients, namely, the treacle, being omitted; by which means the strength is increased one-fifth. The object in adopting this method of keeping the pill, is to obviate the inconvenience often experienced, when it is kept for some time in the form pill-mass, made with treacle, from its becoming hard and intractable. In using the powder the difference in strength must be taken into account, and the treacle or other excipient added.

*The concentrated infusions* constitute important, perhaps the most important, aids to dispensing. These preparations have come into very general use, and in many establishments they are always substituted for the infusions made according to the instructions of the college. It is very questionable whether the practice of using concentrated infusions in dispensing medicines can be justified, excepting under particular circumstances. Some concentrated infusions, which I have met with in commerce, certainly afford, when diluted, very near approximations in all their sensible qualities, to the infusions made in the ordinary way, but others have been found to be of a very different character, and to be greatly deficient in strength, or in the properties peculiar to the infusions they represent. In all cases, where circumstances will admit, I think, the use of concentrated infusions ought to be avoided, at least, until they are sanctioned by the college. Every pharmaceutist should, however, be provided with the means of supplying the best substitute for a properly and recently made infusion in a case of emergency.

When the dispensing-counter has a boarded screen in front of the dispenser, a very useful aid to his operations may be afforded by having a set of small bottles, containing those substances which are most frequently ordered in prescriptions, arranged on shelves against the screen.]

## INFUSIONS AND DECOCTIONS.

[The preparation of infusions and decoctions is a very troublesome, yet necessary part of the operations connected with the dispensing department. Much difficulty and inconvenience are frequently experienced, especially in houses where there is not much dispensing, in providing a supply of these preparations, at the times and in the quantities suited to the daily requirements of the business. In consequence of their proneness to undergo change, they cannot be kept, under ordinary conditions, for more than a day or two, especially in warm weather. They ought, therefore, to be made on the day on which they are used in dispensing, otherwise they may be sent out in a state of incipient decomposition. If they be not prepared in anticipation of the requirements of the day, much inconvenient delay will often be occasioned in supplying medicines that are ordered; and if they are prepared every morning in readiness, there will often be much waste in consequence of the uncertainty of the demand.

It is not customary to keep decoctions ready made, excepting, occasionally, decoction of bark, or any particular one which local or temporary circumstances may call into unusual requisition. It is also very rarely found necessary to keep the whole of the infusions in readiness, but their use is much more general than that of the decoctions, and some of them, such as the infusions of senna and roses, are in daily use in most localities.

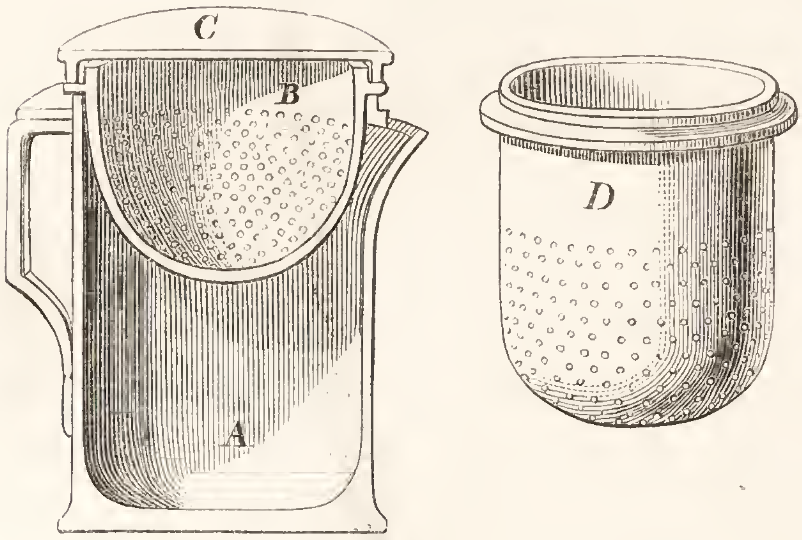
The nature and extent of the business will indicate the amount of daily preparation required in reference to the supply of infusions and decoctions; and, in accordance with this, means for preparing them must be provided.

The pharmaceutical stove, described at page 5, if kept in daily operation, will afford efficient accommodation, as far as regards the supply of boiling-water and of heat.

The infusion-pot, fig. 376, which has been described at page 39, is the vessel best suited for making infusions in; and a flat-bottomed saucepan, such as fig. 377, may be conveniently used for boiling decoctions. A saucepan of this kind may be placed on the hot plate of the pharmaceutical stove, where two or three of them may be kept boiling at the same time.

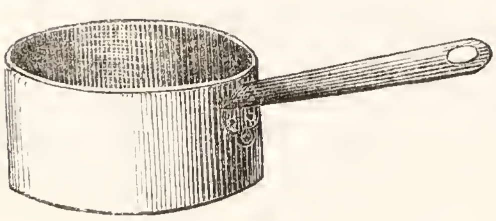
Those infusions which are intended to be kept ready, should be prepared the first thing every morning. The infusion-pot (fig. 376) serves for making the infusion in, for straining it when made, and subsequently for keeping the strained liquid in. There should be a separate pot for each infusion, and there is a flat projection immediately over the handle which is intended to bear the name. The ingredients are put into the perforated dish (*b*) — if they are very bulky a deeper dish, such as *d*, is employed—and the requisite quantity of water is poured over them. When they have stood for the specified time, the perforated dish containing the solid ingredients is removed, and the clear liquor which remains will then be ready for use. The great facility with which the infusion is thus strained, without even the necessity for a second vessel to put the strained liquor into, constitutes one of the strongest recommendations to the adoption of this infusion-pot. It is not an unfrequent practice to leave infusions in the vessels in which they are made, in contact with the solid ingredients, for a much longer time than that specified in the Pharmacopœia. Sometimes the infusion is strained from the vessel in which it is made, from time to time, when wanted, by which means a continued cold maceration is maintained until the whole has been used, or a fresh set of ingredients are put under operation. This practice is very objectionable, as the infusions, especially some of them, assume a very altered character from prolonged contact with the solid ingredients.

*Fig.* 376.




Infusion Pot.

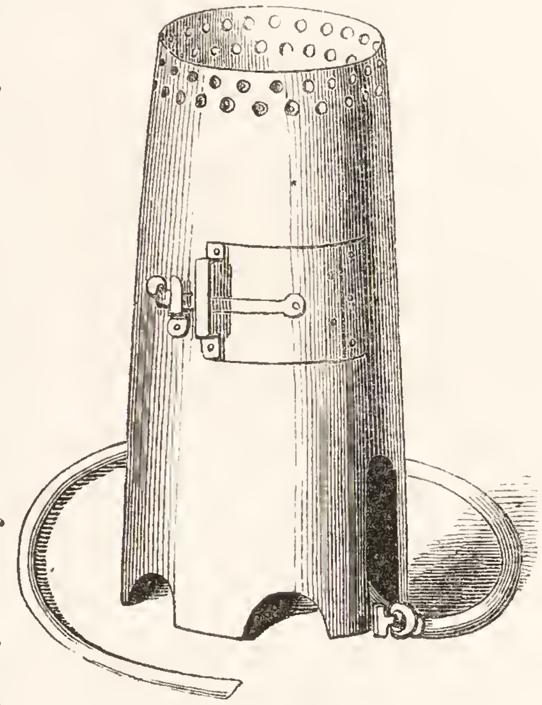
*Fig.* 377.



Decoction Saucepan.

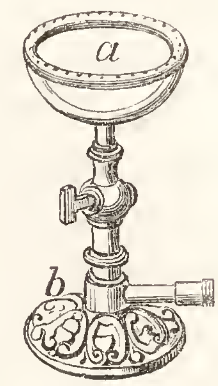
The gas-furnace (fig. 378), with the burner (fig. 379), may be sometimes more conveniently used than the stove, for making decoctions. This method of operating possesses many advantages, and no other means need be provided wherever there is a constant supply of gas during the day as well as night. It is economical, in as much as it obviates the necessity for keeping a fire throughout the day, which might not otherwise be required ; and the gas can be lighted in a moment when wanted, and extinguished when done with. Even if a stove be employed as the common daily source of heat for these operations, it will be desirable to have a gas-furnace which can be used at night, if there should happen to be occasion for it.

*Fig.* 378.



Gas Furnace.

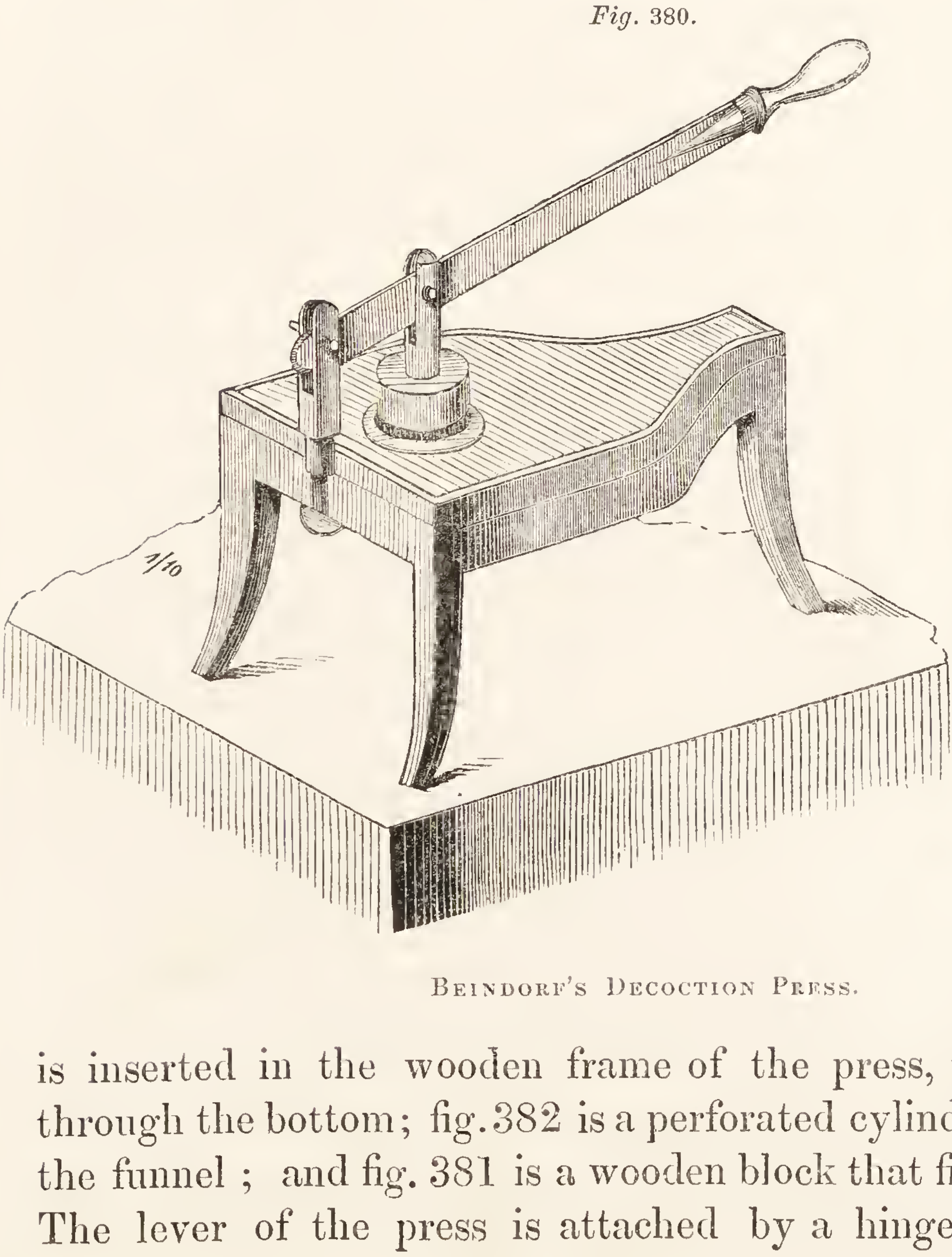
*Fig.* 379.




Gas Burner.

Dr. Möhr describes an apparatus for straining decoctions, which is called *Beindorf's decoction press.* It is represented, entire, in fig. 380, and parts of it in figs. 381, 382, and 383. The object in using this press is to facilitate the straining and pressing of a hot decoction. Fig. 383 is an iron or tinned copper funnel, which

*Fig.* 380.



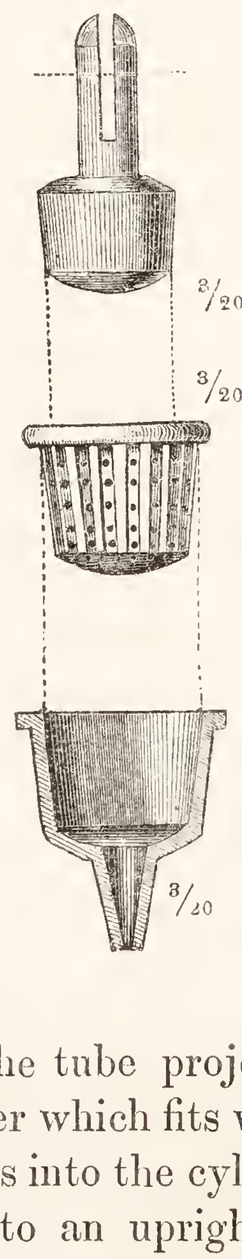




*Fig.* 381.

*Fig.* 382.

*Fig.* 383.

Beindorf's Decoction Press.

is inserted in the wooden frame of the press, the tube projecting through the bottom; fig. 382 is a perforated cylinder which fits within the funnel ; and fig. 381 is a wooden block that fits into the cylinder. The lever of the press is attached by a hinge to an upright bar forming the fulcrum, which turns in a socket, so that when the block (fig. 381) is fixed to the lever, as shewn in fig. 380, this may be turned from the mouth of the funnel to admit of the introduction or removal of the ingredients to be pressed, and again brought over the cylinder when pressure is required. A straining-cloth is first put into the cylinder, and a vessel placed beneath the frame to receive the strained liquor; the decoction is then poured in, and pressure applied by means of the lever and attached block.

The foregoing arrangements, for the preparation of infusions and decoctions would fully meet the requirements of a good dispensing business, and with such provisions the only difficulty and inconvenience likely to be felt would be those contingent upon the uncertainty of the demand for the preparations in question, and the constant attention required in maintaining an adequate supply of them. Much more difficulty, however, is experienced by those who have very little dispensing business. In these cases the demand for infusions is often insufficient to induce the daily preparation of any of them in anticipation of their being required; yet they are occasionally called for; and if a customer, who has previously had his medicine dispensed elsewhere, without delay, is told that the preparation of it will occupy several hours, he sometimes becomes mistrustful of the dispenser, or impatient of the delay. This is a frequent source of annoyance to the pharmaceutist, and has been one reason for the adoption, so generally, of the concentrated infusions in place of those made according to the Pharmacopœia.

Mr. Alsop has suggested a good method of preserving infusions, which might be very advantageously adopted by those who have not a sufficient demand for them to make it worth while to prepare them daily. The infusion is introduced into bottles provided with well-ground stoppers, and which are filled to the brim. If the infusion was not hot when put into the bottles, it must be subsequently made so by plunging the bottles into boiling-water, and leaving them there for some minutes. The stoppers, which should be of rather a conical form, tapering downwards, and smeared with a little wax, so that they may fit perfectly air-tight, and not become immovably fixed in the mouths of the bottles, are now to be inserted. In doing this each stopper will displace a portion of liquid from the mouth of the bottle, thus ensuring the total absence of air. As the liquid cools it will contract, and leave a vacuum in the upper part of the bottle. If the operation be carefully conducted, so as completely to exclude the air, the infusion will keep for weeks, or even for months, without undergoing any change. Mr. Alsop states that he has kept infusion of cusparia in this way for nine months, including the summer months, and at the end of that time it was in every respect as good as when first made. He suggests that the stopper of each bottle used for this purpose should be tied to the neck of the bottle, to prevent its being misplaced.]

## READING THE PRESCRIPTION.

[When a prescription is presented for preparation, the first thing to be done is, to read and to understand it. This is sometimes the most difficult part of the dispenser's duty. It requires the exercise of serious attention, quick perception, sound judgment, and prompt decision. The writing in prescriptions is often very bad, and the words are mostly abbreviated; moreover, the language in which prescriptions are written is, in the majority of cases, very imperfectly known to both the writer and the reader. There are, it is true, but a limited number of formal expressions which are commonly used for conveying the requisite instructions, and a knowledge of these is easily acquired; but the pharmaceutist will not be qualified for his duties as a dispenser, if he possesses only a knowledge by rote of the expressions most frequently used in prescriptions. The prescription is intended as a medium of communication between the prescriber and the dispenser, and an acquaintance with the language in which it is written is quite as requisite to the latter as to the former.

The dispenser has a two-fold difficulty to contend with; he must first decipher, and then translate the writing of the prescription. Moreover, he must do this not only correctly but promptly. If he stand poring over the prescription for too long a time, it may induce a suspicion on the part of the customer, that either he is ignorant or the physician careless. Nothing should be done that could possibly tend to weaken the confidence of the patient in prescriber or dispenser.

The prescription should be first looked over with the view of determining certain leading points, the knowledge of which will greatly facilitate the comprehension of minute details. The questions relating to these points will present themselves somewhat in the following order:—is the medicine intended for internal or external use?—is it to be in the form of a mixture, powder, pill, ointment, or what other form?—what is the quantity ordered, and what the dose? These points being determined, for which a single glance of an experienced eye will suffice, a more careful examination of every word and symbol must follow, with the view of fixing definitively in the mind, what are the several ingredients ordered, and the directions with reference to them. Should a doubt arise in deciphering the names of any of the ingredients, the knowledge of the purpose, form, and method of administering the medicine, will aid in the decision of such points, by affording suggestions as to what would be suitable and what inappropriate. It is much better to meet any difficulty that might arise with the previous knowledge of every attainable fact that could assist the judgment, rather than to seek these aids after an erroneous idea has been impressed upon the mind. In deciphering the writing it will often be found advantageous to compare the characters in a doubtful word with those most nearly resembling them in some part of the prescription which is intelligible. Should the difficulty still remain, the opinion of a second party, when attainable, should be sought; and in doing this, let not false pride prevent the inquiry being made from those who are capable of judging. Such inquiries, however, should not be made, if it can be avoided, in the presence of the customer.

Sometimes a word may occur in a prescription which is quite legible, but the meaning of which is not understood, in which case reference should be made to a dictionary, or other book, in which the terms used in prescriptions are explained, and in this case, again, it should be done without exciting the suspicion of the customer that any doubt exists as to the meaning of the prescription.

If, after adopting all these means, it be still found impossible to read or to comprehend the instructions contained in the prescription, it will be the duty of the dispenser to ascertain who the prescriber is, and to apply to him for an explanation.

But difficulties such as we have here contemplated are of rare occurrence. There is generally no difficulty that an experienced dispenser does not easily overcome in reading and understanding prescriptions.

If the medicine be waited for, let as little delay as possible occur before the preparation of it is commenced. A good and accomplished dispenser will make it his study to inspire a belief that he quickly comprehends and promptly executes the orders which are entrusted to him.

While the prescription is in course of preparation it should be placed in such a position that the operator can read it while he is dispensing the medicine. A small stand is sometimes provided for this purpose, on which the prescription is secured by means of a paper-weight, and being thus elevated, it is not liable to be soiled by any liquid that might be spilled over the counter.]

## MIXTURES; DRAUGHTS; DROPS.

[*Mixtures.*—The term *mixture* is generally applied to a liquid medicine, not intended for local application, which is administered by the mouth in an undiluted state, and of which the bottle in which it is dispensed contains more than one dose. It is a very common form for the administration of medicines.

Mixtures intended for adults usually measure four, six, or eight ounces. Sometimes, however, they extend to a pint or even a quart. When intended for children the quantity is generally from an ounce to four ounces.

The ingredients which usually enter into the composition of mixtures are salts and other solid bodies which are soluble in or easily miscible with aqueous menstrua, together with tinctures, spirits, syrups, infusions, decoctions, and distilled waters.

In preparing a mixture, the dispenser has to consider how he can best effect the solution of solid substances which are soluble; the equal diffusion of those which are insoluble, throughout the menstruum; and the intimate admixture of all the ingredients of whatever kind, so that every dose, when taken, shall be of similar composition.

It is not necessary, nor is it always desirable, or even practicable, to mix the ingredients in the order in which they are named in the prescription. The dispenser is expected to exercise his judgment in determining the best method of effecting the combination. Sometimes the ingredients require to be mixed in a mortar; in this case, of course, a Wedgewood's mortar would be employed. The mortar should not be used, however, unless it be necessary.

If all the ingredients consist of liquids which are miscible, they are poured at once from the measure-glass into the bottle, and mixed by agitation. It is customary to measure those ingredients first, the quantities of which are smallest, and to add the most bulky ingredient, which is often a mere menstruum for the others, last. There are cases, however, in which it is desirable to deviate from this course, as for instance, in adding hydrocyanic acid, or other very volatile substances, which should be added last, to prevent loss from evaporation.

When salts, or other substances readily soluble in the principal menstruum, are ordered, their solution may frequently be effected quite as well in the bottle as it would be in a mortar. In such case the salts should be used in fine powder, being more easily dissolved when in this state. There are some salts the solution of which is greatly facilitated by the use of warm water. Of this class are alum and sulphate of soda.

Some powders, such as magnesia, which are insoluble, but easily diffused through a liquid, may also be mixed with the liquid ingredients by merely shaking them together in the bottle. In doing this, it is well to introduce a small quantity of liquid before the powder, which will prevent the latter from adhering to the glass.

Powders which do not mix readily with liquids, such as rhubarb or gum, must be triturated in a mortar, commencing the trituration with a small quantity of liquid, and adding more when the powder has been brought to the state of a thin paste.

Extracts and electuaries also require to be rubbed in a mortar with a portion of liquid before putting them into the bottle.

In Germany and other continental countries, liquid as well as solid ingredients are always weighed; in this country the quantities of liquids are apportioned by measure, which is a much more convenient practice. Even should the letter indicating the prefix *fluid* be omitted in the symbol by which the quantity of a liquid is expressed, we should understand it to mean a measured quantity. Thus, ʒj of a tincture, spirit, or syrup, would be construed to mean a fluid-drachm, and not a drachm by weight.

The bottles used for putting medicines into are made of certain definite sizes, such as f℥vj, f℥viij, f℥x, f℥xij, &c., and physicians generally regulate the quantities of ingredients ordered in mixtures so as to correspond with the common sized bottles. Sometimes, however, this point is not observed by the prescriber, and the pharmaceutist may experience difficulty in finding a bottle that will exactly hold the quantity ordered, especially since moulded bottles have been brought into general use. If a mixture should measure seven ounces, a six-ounce bottle would not hold it, and an eight-ounce bottle would be but partly filled by it. In such case, if a stated proportion of the entire mixture be directed to be taken for a dose it may be allowable to add a little distilled water, or a little more of the menstruum, if it be inactive, so as to make the quantity more nearly correspond with the capacity of the bottle. This would be not only justifiable but necessary, if the bottle be marked with the divisions of its capacity, as is sometimes the case, to assist the patient in apportioning the dose.

Much perplexity has been caused by the change which has been introduced in the capacity of the pint measure. Medical men sometimes order half-a-pint or a pint of liquid under the impression that these quantities are still, as formerly, equivalent to f℥viij and f℥xvj, whereas the capacity of the pint is now=f℥xx. The pharmaceutist has but one safe and straightforward course to pursue in these cases. In the absence of specific instructions to the contrary, his text-book and guide is the Pharmacopœia, and according to this authority the symbols 0j, and 0ss, are synonymous with f℥xx, and f℥x.

*Draughts.*—The *draught* differs only from the mixture in being dispensed in bottles, each of which contains but one dose. The practice of ordering medicines, which are taken repeatedly, in the form of draughts, is not now so common as it was formerly. Such medicines are now more frequently prescribed in the form of mixture. There are some cases, however, in which there is decided advantage in having medicines put up in draughts. Such is the case when it is important that the doses should be very carefully apportioned, and also when the medicine is liable to undergo change from the action of atmospheric air. Thus, for instance, the *Mistura Ferri composita*, if dispensed in the form of mixture, will undergo continued and rapid change after the first dose has been taken out of the bottle, the protocarbonate of iron passing to the state of peroxide; whereas, if it be dispensed in draughts, and the bottles be filled and well corked, no such change will occur.

The quantity of liquid contained in a draught usually varies from fʒx to fʒxiv; sometimes, however, it amounts to f℥ij. The vials, used for dispensing draughts in, should be kept sorted, of several different sizes, such as fʒx, fʒxij, and fʒxiv.

It is customary, when a prescription directs that a draught shall be taken twice a-day, or three times a day, to send a sufficient supply for two days, unless there be express instructions to the contrary. If, however, the draught be taken only once a-day, a supply for three days may be sent, if the medicine will keep good for that time.

The requisite number of vials, of the proper size, are in the first place selected, and it is desirable that these should correspond as nearly as possible, not only in capacity, but also in length and general appearance. The vials are put into the *draught-stand*, and the operator, in the next place, proceeds to mix the ingredients for the draughts. The instructions which have been given with reference to the dispensing of mixtures, will not apply, in some respects, to the preparation of draughts. It is not customary to weigh and measure the ingredients for each draught separately; consequently the solution of salts, and the admixture of easily diffusible solid substances cannot be effected in the bottles. The principal ingredients for the whole number of draughts are mixed in a measure-glass of sufficient capacity, a mortar being used, if necessary, for promoting solution or intimate admixture, of solids ; and to these as much of the menstruum, or least active constituent, is added, as will about half fill the vials. This mixture is poured into the vials, and equally divided between them, the correctness of the division being determined by the eye of the operator ; and the vials are then filled up with the remaining part of the menstruum. It is necessary, in thus operating, to be careful that all soluble solids are completely dissolved before commencing the division of the mixture, and that insoluble substances are kept constantly suspended while the division is effected. If there should be any powder ordered in the draughts which cannot be kept suspended while the mixture is apportioned to the several vials, it will be necessary to weigh this out and introduce it into the vials separately.

After filling the vials each to an equal extent, they are corked and capped with paper. The operation of tying on the caps will be most expeditiously and elegantly effected by means of the *capping-knot*, which is described at page 297.

The vials, thus far prepared, are to be wiped with a clean cloth ; the directions for taking them are to be attached to one, which is distinguished from the others by being wrapped in a paper which extends only half-way up to the shoulder of the bottle, leaving the label partly uncovered, while each of the others is entirely enveloped in a wrapper ; and finally the whole of them are enclosed in a wrapper so as to form a neat parcel. If there be three draughts they are placed side by side in the parcel ; four draughts are placed in two layers each consisting of two : and six draughts form two layers, each consisting of three.

*Drops.*—If a medicine consist of tinctures, spirits, or other similar preparation, the dose of which is a teaspoonful or less, if it be diluted when administered, and the intended application of it, be similar to that of a mixture, it is generally distinguished by the name of *drops*.

No particular instructions are necessary in the preparation of drops, unless it be where some solid substance has to be dissolved.

Drops generally consist of clear solutions, and of more or less active medicines. If the medicine should be sent to a patient with any soluble substance in an imperfectly dissolved state, an unfavourable impression with regard to the carefulness and attention of the dispenser might be produced. The pharmaceutist has, therefore, to exercise his judgment, in producing at once such a state of combination as will be permanent. Thus, if *disulphate of quina* should be a constituent either of drops, or a mixture, its solution being promoted by the addition of diluted sulphuric acid, the acid should not be added immediately to the salt, as in this case a compound would be formed which would be very slowly dissolved, whereas, if the salt be first diffused through a little liquid, and the acid then added, the solution will take place immediately.]

## EMULSIONS.

[An *emulsion* is a mechanical mixture, having a milky appearance, of an oil, fat, or resin, with water, the admixture being promoted and rendered more or less permanent, by the presence of an alkali or gum, or some equivalent substance, such as albumen or caseine.

The milk of animals, as a natural production, may be considered a good type of this class of preparations. In this case, the fat or butter is diffused through an aqueous liquor, and held in suspension by the presence of caseine, sugar, and alkaline salts. The milky juices of plants present other instances of emulsions existing ready formed in nature.

The emulsions used in medicine, are produced by artificial means, but in their leading characters they resemble those met with in nature. They are formed, either by triturating certain seeds, which contain the necessary constituents for the production of an emulsion, with water; or by mixing the separate ingredients directly with each other, in such a way as to effect the desired object.

The most simple and easy method of forming an emulsion is, by triturating some suitable seeds, such as those of the almond, with water. Almond emulsion is thus made. The almonds being first deprived of their skins, by immersing them in hot water until the skins are loose and then pressing them between two fingers, are bruised in a Wedgewood's mortar, a little water being added, from time to time, to prevent the separation of oil, which otherwise would take place. When the almonds have been well comminuted and formed into a thin paste with water, by pounding and trituration, the remainder of the water is added to form the emulsion, and this is subsequently strained to separate the woody fibre of the seeds. The fixed oil of the almond forms the emulsion through the intervention of a portion of gum, and more especially of an albuminous constituent called emulsin, both of which are contained in the seed. Other seeds, besides those of the almond, may be used for making emulsions. In Germany, the poppy-seed is frequently employed for this purpose.

Emulsions are made with gum-resins, such as *myrrh*, *ammoniacum*, and *asafœtida*, in a similar way to that described for making almond emulsion. The gum-resin is first bruised in a mortar, then triturated with a small quantity of water, and finally diluted with the remainder of the water, and strained or decanted from the insoluble residue. Good specimens of the gum-resins should be selected for this purpose. In selecting myrrh for making emulsions, those pieces only should be used which, when broken, present a milky appearance within. Powdered myrrh should never be used.

Emulsions are sometimes made with *expressed oils and an alkali.* One of the most common emulsions, used as a simple remedy for cough, is formed by agitating some oil of almonds with solution of potash or spirit of ammonia and water. This is the first case in which we shall have to consider the method of operating when the separate ingredients have to be mixed by artificial means for the production of an emulsion. Six drachms of oil of almonds, one drachm of solution of potash, and five ounces of distilled water, will form a good emulsion if mixed in the proper way. It is not sufficient, however, to put these substances together and shake them or triturate them: there is a certain order and proportion in which they must be mixed. The best method of proceeding is, to put the oil into the bottle with rather less than its volume of water; to add the alkali to these, and shake them well together. An intimate admixture, of a perfectly milky character, is thus obtained, which may be diluted with the remainder of the water so as to form a good emulsion. If much water were put into the bottle in the first instance, or if the oil alone were shaken with the solution of potash in an undiluted state, the result would not be equally satisfactory.

Emulsions are frequently made with expressed oils or oleo-resins and mucilage. Castor oil and balsam of copaiba are often made into emulsions in this way. Much more art is required in making the emulsion of copaiba than that of castor oil, and a description of the method of proceeding, when the former of these substances is used, will, therefore, serve to illustrate the means most conducive to success in either case.

The mucilage used for making copaiba into an emulsion, ought to be rather thicker than that made according to the Pharmacopœia. On this account, and also with the view of obviating the chance of any acid, caused by fermentation, being present in the mucilage, it is better to use powdered gum-arabic. If mucilage be ordered, one-third the quantity of gum may be substituted. One drachm of gum will suffice for three drachms of the oleo-resin, and these may be formed into an emulsion with five or six ounces of water, in the following way. The gum is first triturated with a little water, in a Wedgewood's mortar, so as to form a thick mucilage; to this a few drops of the copaiba are added, and the trituration is continued until the ingredients are completely mixed. More of the copaiba is then put in, and the trituration maintained, until the mixture assumes the condition of a thick emulsion. This must now be diluted with a little water (ʒſs or ʒj), before adding more copaiba. Without this dilution the mixture would assume a condition in which it would no longer mix with water. When the whole of the copaiba has been mixed in, with sufficient water to prevent it from becoming too thick, the remainder of the water may be added. Tincture or other ingredients should not be introduced until the emulsion has been completely formed.

If, instead of adding the oil gradually to the mucilage, the mucilage were added to the oil, a good emulsion would not be formed; and, although it is desirable on commencing the admixture to have the mucilage rather thick, yet, after part of the oil has been incorporated, some degree of dilution becomes necessary.

Mucilage answers better than an alkali for making an emulsion with castor oil or copaiba, but the alkali forms the best emulsion with oil of almonds. A good emulsion formed with either of these agents alone, is often caused to separate if the other be added. Thus, the emulsion made with oil of almonds and potash, will lose, in great measure, its milky character, on the addition of mucilage.

The presence of soluble salts in an emulsion generally tends to cause a separation of the oil. Much spirit will produce a similar effect, especially in emulsions made with mucilage; and acids, in those made with alkali. Alkaline salts, however, in small quantity, are beneficial. Thus, a little borax will often be found greatly to improve an emulsion.

There are some substances which cannot be formed into good emulsions with an alkali or with mucilage. Spermaceti and other solid fats belong to this class, and so also does oil of turpentine. In such cases yolk of egg is the best agent for effecting the admixture, the ingredients being rubbed together in a mortar; and, should any difficulty be expected, the oily or fatty body should be added gradually to the yolk of egg, and the mixture diluted with a little water, from time to time, as it thickens.

Scammony mixes very readily into an emulsion with a little milk; and resin of jalap, which will not mix with milk, may be diffused through emulsion of almonds by triturating it with the almonds and water.]

## POWDERS.

[Very little art is involved in dispensing powders.

If a prescription should order a powder, which is directed to be taken repeatedly at stated periods, a sufficient supply for two, three, or more days, is usually sent, unless there be instructions to the contrary, or some special reason for deviating from this course.

When several powders have to be dispensed from a formula in which the proportions for one powder are given, it is customary, to mix the ingredients for the whole number together, and subsequently to divide the aggregated powder into its appropriate parts.

The ingredients of powders are mixed in a Wedgewood's mortar, or on a piece of smooth paper. As a general rule, a mortar should be used excepting when the ingredients constitute but one dose, or when the quantity mixed is so small that it is necessary to avoid losing the portion that would adhere to the mortar and pestle. It is important in all cases, that the admixture of the ingredients should be effected as completely as possible, and more especially when, as is often the case, the ingredients are of very unequal degrees of activity.

The order in which the several substances to be mixed are put into the mortar, should be the reverse of that which is adopted in introducing the ingredients of a mixture into the bottle. Instead of beginning with the least bulky ingredient, the most bulky, or it should rather be said, the most inactive, ingredient, should be put in first, and the more active on to the top of this. The object in adopting this mode of proceeding is, to avoid as much as possible the loss of any part of the active ingredients by their being taken up in the pores of the mortar. The mixture is effected by trituration with the pestle, and this should be continued for a sufficient length of time to ensure the perfect distribution of the ingredients. If there should be a large quantity of an inactive powder, and a very small quantity of an active ingredient, it may be desirable to put only a part of the former into the mortar, and placing the active ingredient on the top of it to effect their intimate admixture before introducing the remainder of the inactive powder. So, also, if the powders to be mixed should differ much in specific gravity, and the quantities to be mixed be large, it would be desirable to put only a part of the lightest powder in first, and after that has been mixed with the other ingredients, to add the remainder.

After effecting the due admixture of the ingredients, if they are to be divided into several separate doses, the papers for their reception are spread out on the counter and the powder is distributed to each on the point of the knife. The equality of the division is generally determined by the eye of the operator, but as some persons are incapable of distinguishing differences of quantity with sufficient accuracy by the eye, the use of the balance should in such cases be resorted to.

There are some powders, containing volatile ingredients, which are advantageously enclosed in waxed-paper.

When a powder, consisting of several doses, is sent out, undivided, the patient being left to apportion the dose on taking it, it should alway, unless otherwise desired, be put into a wide-mouthed bottle.]

### ELECTUARIES; CONSERVES; LINCTUS.

[The *electuary* or *confection* is a very ancient form for the administration of medicines. It consists of solid substances which are brought to the condition of a thin paste by admixture with some saccharine or mucilaginous liquid.

The *conserve* is a preparation, similar in consistence to the electuary or confection. The names seem to indicate that in the conserve (*conservo*, to keep,) the saccharine matter is used for the purpose of preserving the substance to which it is added, while in the confection (*conficio*, to make up,) the saccharine liquid is added only to impart convenience of form.

The *linctus* differs from the two preceding forms in being made thinner. The name appears to be derived from the word *lingo*, to lick, the consistence being such that it can be licked from a spoon.

These forms of medicine are very rarely prescribed in the present day, and no particular directions are required for their preparation.]

### LOZENGES.

[The *lozenge* is a very common and convenient form for those medicines which are intended to act, by continued application, on the pharynx and upper part of the trachia.

A great variety of lozenges are kept by the pharmaceutist, but these are almost always made by the confectioner. Sometimes, however, the pharmaceutist has occasion to prepare medicines of this kind himself.

Lozenges may be divided into three classes:—

1st. Those, the principal basis of which is sugar, and in the preparation of which the ingredients are combined without the aid of heat. The application of the term *lozenge* is sometimes confined to these.

2nd. Those, the principal basis of which is sugar, and which in their preparation are rendered fluid by means of heat. These are sometimes distinguished by the name of *drops*.

3rd. Those which retain a permanently soft and pasty consistence, their principal basis being generally a vegetable juice or pulp. These are usually called *pastes*.

1. *Lozenges.*—In making the first class of lozenges, the sugar is employed in powder; other more active ingredients are added, in the state either of powder or liquid; and the mixture is formed into a tenacious paste with the addition of some liquid, either water or mucilage.

The liquid, which appears to answer best for making lozenges is mucilage of tragacanth. This is made from the best gum tragacanth, which should be carefully picked to ensure the absence of any foreign matter that might discolour the lozenges. The gum, which should not be used in the state of powder, is mixed with eight or ten times its weight of distilled water, and allowed to stand in a warm place for a day or two. It is then strained through a cloth, and subsequently beaten up in a mortar.

The sugar being mixed with the other ingredients, the mixture is made into a stiff paste with the mucilage. Sometimes, part of the sugar is mixed with the powder or other active ingredients of the lozenges, while the remainder of the sugar is made into a thin paste with the mucilage, and then the two mixtures are incorporated.

The paste is rolled out on a marble slab, some powdered starch being used to prevent adhesion to the slab or to the roller. A frame of wood or iron, of the thickness of a lozenge, is placed on the slab, so that by rolling out the paste until the roller comes on to the frame, the paste will have a uniform and proper thickness.

The lozenges are cut out of the extended paste with a small tinplate punch, which gives them the required shape and size. They are then placed on sieves in a drying-room or closet until they become hard and dry.

2. *Drops.*—In making the second class of lozenges, commonly called *drops*, the sugar is used in coarse powder, all the finest particles having been removed by means of a sieve. A little water or

other liquid, such as the formula may direct, and also any ingredients intended for colouring or flavouring the drops, are added to the sugar so as to moisten it. A portion of this mixture is put into a small pan furnished with a lip and suitable handle, and this is placed over a clear fire until the sugar has melted. The pan is now removed from the fire, and the melted mixture is allowed to drop, in quantities sufficient to form masses of the required size, on to a greased iron or tin plate. The drops are allowed to harden, and are then removed.

3. *Pastes.*—The third class of lozenges usually consist of inspissated juices, or decoctions, to which gum, sugar, and other ingredients are added. They are brought to the proper consistence, either by the application of heat, and then poured into flat tin moulds, or they are mixed without heat, and rolled out on a marble slab, in the manner already described.]

## PILLS.

[There is probably no form of medicine more frequently prescribed than that of the *pill.* It is a form well adapted for the administration of many medicines, including those of a fetid or nauseous character, those whose specific gravities render them difficult of administration when mixed with liquids; those which are designed to act slowly, such as alteratives, and those, the action of which is desired to be retarded until the medicine shall reach the lower intestines.

Among the substances which enter into the composition of pills, are the vegetable and other extracts, the resins, gum-resins, balsams, and essential oils. These are more frequently administered in the form of pill than in any other form, and with them are combined many powders and mineral preparations.

The object in forming a pill-mass is to obtain a consistent, firm, and adherent paste, which shall be sufficiently plastic to admit of being moulded without adhering to the mould, and sufficiently stiff to prevent the pills from losing their shape when made into the proper form.

A pill-mass may be said to consist of two essential parts,—the *active ingredients* which enter into its composition, whether of a solid or liquid nature,—and the *excipient*, by which the proper degree of consistence and tenacity are given to the former.

The substances employed as excipients in pill-making are both numerous and of very different natures. The most common are, syrup, mucilage, soap, water, spirit, or tinctures, gum, sugar, magnesia, starch, &c.

The principal art in pill-making consists in selecting the proper substances as excipients to suit the peculiar nature of the other ingredients of the pills.

The pill-mass ought to possess *tenacity* or *adhesiveness*, *firmness*, and *plasticity*; and it will be well to consider what the conditions are upon which these properties depend, and how they are best attained.

*The tenacity or adhesiveness* of the mass depends upon two principal conditions. The first of these is, the presence of a property inherent in the particles of the substance, through which they are readily made to attach themselves to particles of the same, or of a different kind; and the second is, the existence of a certain state of partial fluidity or softness, which appears to promote, and, indeed, to be essential to, that particular kind of tenacity under consideration. Deprive an otherwise adhesive substance of all tendency to fluidity, and you deprive it of its adhesiveness. In order, then, that a body should be tenacious or adhesive, it is necessary that it should have some of its particles in a fluid or semi-fluid state. Hence, a substance which, when deprived of all tendency to fluidity, possesses no adhesiveness whatever, will sometimes become adhesive on adding a small quantity of some liquid which is capable of acting as a solvent. Resin, when perfectly dry and hard, has no adhesiveness, yet it becomes adhesive on adding a few drops of spirit, which acts as a solvent of some of its particles. Gum, in like manner, which is not adhesive when dry, becomes so on the addition of water. But by this method of adding an excipient which, without possessing any adhesiveness itself, acts simply as a solvent of some of the solid particles present, we can only *develope*,—we cannot *impart* adhesiveness. If the property of adhesiveness be not inherent in the solid substance, the use of an excipient which acts merely as a solvent, will not be sufficient. Thus, the addition of spirit does not render camphor adhesive, because there is none of that property inherent in the camphor. In cases of this kind, therefore, it is necessary to employ *excipients* which *possess* and can *impart* adhesiveness.

*Firmness* is the next requisite property in the pill-mass—a property not less essential than that of adhesiveness or tenacity. The pill-mass should have a due degree of firmness, so that the pills when formed shall retain their shape. Now, whilst a state of solution or fluidity of some of the particles is essential to adhesiveness, so, on the other hand, the hardness and insolubility of others of the particles is necessary to ensure the requisite firmness. These two properties, then, depend upon opposite conditions,—the one, upon partial solution or fluidity,—the other, upon the hardness and insolubility of a part of the ingredients.

The firmness of a pill-mass,—that state in which the pills will retain their shape,—is a very important point to attain in pill-making. The mass may possess the proper degree of adhesiveness, and be of a good consistence for rolling into pills, and yet, from its not having a sufficient proportion of the ingredients in a hard and insoluble state, it may be subject to this serious objection, that the pills made from it will lose their globular form, and perhaps run into one mass in the box. This result will be very likely to occur, if a liquid excipient be employed which is capable of acting as a perfect solvent to every part of the solid ingredients of the pill-mass. Pills formed from a resin, perfectly soluble in spirit, and which has been moistened with spirit to form the mass, can hardly be made to retain the globular form, unless the whole, or nearly the whole, of the spirit be again driven off.

The method of proceeding in making pills is similar to that adopted in building a house,—both bricks and mortar must be used,—the bricks to give solidity and firmness, and the mortar to act as a cement in causing the solid particles to adhere together. The condition of pills made from a mass the whole of which is in a semifluid state, might be compared to that of a house built of nothing but mortar. When, therefore, a pill-mass is in such a state that the pills made from it refuse to retain their shape, it may be inferred that more bricks are required, that is to say, that there is a deficiency of solid, insoluble, particles, to give firmness and stability to the structure.

*Plasticity* is the next and last requisite in the pill-mass. A mass may possess so much firmness—so much hardness—that it will not take the form we wish to give it ; or, on the other hand, it may have so large a proportion of the particles in a semifluid condition, that it cannot retain the form which has been given to it. The medium between these two states is the condition required. A mass to be well adapted for making into pills, should possess adhesiveness and firmness duly balanced one against the other, and this, in fact, constitutes the *plastic condition.*

Such, then, are the conditions to be fulfilled in forming a good pill-mass, and with a view to the realization of which, the selection of excipients should be made.

But there are other considerations besides those above alluded to, which ought to influence the selection of excipients. Those substances only, should be used as excipients which, fulfilling the specified requirements in other respects, will not be incompatible with any of the ingredients of the pills; will modify as little as possible their action, either by causing them to become hard, or in any other way; and will not unnecessarily or inconveniently increase their size.

Powdered gum, either gum Arabic, or more frequently gum tragacanth, is often employed as an excipient, without discrimination, whenever increased tenacity is required in the pill-mass, or there is a superabundance of moisture in the prescribed ingredients. This practice of constantly adding gum is very objectionable, as it often causes the pills to become so hard that their operation is materially modified. Pills prepared in this way will sometimes pass through the intestines without being dissolved, producing, of course, little or no action. There are many cases in which the use of gum is justifiable, and cannot be well avoided, but the indiscriminate use of it, especially of tragacanth, cannot be too strongly condemned.

The physician frequently names, in the prescription, some particular excipient, which is directed to be used. Whenever this is done the instructions of the prescriber should be carried out if practicable. It is not always, however, that this is practicable, and then the dispenser must follow his own judgment. It would be much better that the selection of excipients in these cases should be always left to those who dispense the medicines, as the prescriber rarely possesses the practical knowledge requisite to enable him to determine what kind of excipient is required. We frequently find two or three soft extracts, which when combined are too soft to admit of being properly made into pills, ordered to be mixed with mucilage or syrup *quantum sufficiat.* In this case, although the dispenser cannot act up to the letter, yet he may carry out the spirit of the instructions, by using gum or sugar.

A few instances will now be specified in illustration of the foregoing principles, and with the view of more fully explaining the mode of proceeding in the preparation of pills. The principal substances which enter into the composition of pills will here be divided into classes which will be considered separately.

*Rhubarb* may be taken as the type of a class of substances frequently administered in the form of pill. *Jalap*, *ipecacuanha*, *ginger*, *conium*, *digitalis*, and other vegetable powders belong to this class. Now, taking these substances as a class, syrup is perhaps the best excipient to use for giving them the pilular form. With some of these powders, the use of an excipient that possesses and can impart adhesiveness is necessary; and with all of them the presence of sugar is beneficial in preserving the vegetable principles from decomposition, and preventing the pills from becoming very hard. Simple syrup is commonly used as the excipient, but there is an advantage in the substitution of uncrystallizable for the crystalline sugar which the simple syrup contains; treacle, therefore, is sometimes employed with advantage. If it be desired to deprive the treacle of its peculiar taste and smell, and of some of its colour, this may be done by diluting it with three or four times its weight of water, filtering the solution through a bed of animal charcoal, and finally evaporating it to the required consistence. Powdered conium, and other powders of this kind, retain their properties unimpaired for a great length of time when made into pills with a syrup of uncrystallizable sugar.

There are cases, however, in which the use of syrup with some of the powders alluded to is subject to inconvenience. Thus, when rhubarb or jalap is made into pills, it is often desirable to have as large a quantity as possible of the active ingredients in each pill. From three to five grains of the powder are frequently prescribed in a pill, and in such case it is desirable to use an excipient that will add as little as possible to the bulk. If syrup be used as the excipient for rhubarb, it will be found that a drachm of the powder will require a fluid-drachm of syrup; and this would make pills of four or five grains of rhubarb inconveniently large. Where it is important to add as little as possible to the bulk of the pill, water may be used as the excipient for rhubarb. It does not form so plastic a mass as syrup does; and, moreover, the pills, if long kept, become very hard, but the size of the pills will be less than would be the case if syrup were used. Spirit, especially rectified spirit, does not answer so well as water.

In making rhubarb into pills with syrup, the whole of the syrup required for forming the mass should be added at once. A drachm of powdered rhubarb requires a fluid-drachm of syrup. If a portion of this quantity of syrup be first mixed with the rhubarb, a hard mass would be formed, not sufficiently plastic to admit of being made into pills, and which it would be found very difficult to incorporate with the further portion of syrup required. On adding the required quantity of syrup at once the mass is formed without any difficulty. The mode of proceeding in this case is just the reverse of that which should be adopted when a hard elastic extract, such as some specimens of extract of rhubarb, has to be incorporated with a powder such as calomel or ipecacuanha, through the intervention of a liquid excipient, such as syrup. Under such circumstances the quantity of syrup required should be added very gradually. If the whole of the syrup were put in at once, so as to make a very soft paste with the powder, the hard extract would slip about in this, and might perchance be projected out of the mortar in the attempt at effecting the incorporation of the ingredients. The quantity of syrup first added should be only sufficient to form a very stiff and tenacious paste with the powder, and this should be partly incorporated with the extract before adding more.

*Jalap* is sometimes made into pills with tincture of jalap, when it is desired to have as much of the active ingredient as possible in each pill. In this case the spirit, as a solvent of some of the adhesive constituents of the jalap, imparts some degree of tenacity to the mass. The ingredients, however, do not yield a very plastic mass, and to succeed well in forming the pills, it is desirable to add the full quantity of tincture required at once, to make the mass rather soft, and to roll out the pills as quickly as possible.

In making *rhubarb and ginger pills*, spirit and soap are sometimes used as excipients with advantage. ʒjſs of rhubarb, ʒj of essence of ginger, and ℈j of castile soap, will form a mass which may be divided into twenty-four pills, the size of which will not be inconveniently large. If strong essence of ginger, made as described at page 92, be employed, each pill will contain the active matter of fully two grains of ginger. The soap should be first rubbed with the essence, the rhubarb added, and the mixture allowed to stand until, by the evaporation of part of the spirit, it has acquired a good pilular consistence.

*Aloes* may be taken as the type of the next class of substances to be noticed. The *resinous extracts*, *resins*, and *gum-resins*, will come into the same class. Soap, mucilage, proof spirit, and alkaline solutions, will be found to be suitable excipients in these cases. *Aloes* form an excellent pill-mass with a few drops of compound decoction of aloes, the efficacy of which probably depends upon the presence of the alkali. The *gum-resins* will assume a good pilular consistence on pounding them with a little carbonate of potash without any other addition. The *resins* sometimes require a little spirit, but unless there be other solid ingredients present which are insoluble in the spirit, the pills thus made will often lose their shape. In such case soap should be substituted for spirit. Thus, the *aloes and mastic dinner pills*, when spirit is used in making them, inevitably lose their globular form, but this will not occur if soap and a little water be employed as the excipients. ℥vj of aloes, ℥ij of mastic, ℥ss of soap, and f℥ss of water, mixed in an iron mortar previously made hot, will afford a good plastic mass while warm, and if rolled out while in this state, the pills may be kept in quantity without losing their form. They may also be made with tolerable success with mucilage.

*The volatile oils* and *oleo-resins* constitute a class of substances which are occasionally made into pills, and in such case require peculiar excipients. Balsam of copaiba may be taken as a type of this class. Magnesia is the excipient most generally applicable. The copaiba balsam will generally assume a pilular consistence when mixed with an equal weight of carbonate of magnesia, and this is the best method of solidifying it, when the pills are required for immediate use. If the balsam should contain an unusually large proportion of essential oil it may require more of the excipient, or it may be found convenient to dissolve a little white wax in the balsam previously to the addition of the magnesia. Sometimes the balsam is solidified by the addition of white wax alone. When sufficient time can be taken for the purpose, a very small quantity of calcined magnesia may be made to solidify balsam of copaiba or any of the fluid turpentines. One part of recently calcined magnesia, added to sixteen quarts of balsam of copaiba, or true Venice turpentine, and allowed to stand for a week or two, will become solid and fit to form into pills. The mixture should be exposed to a gentle heat for about an hour, and should subsequently be stirred from time to time until it becomes solid. In this case, as in that previously alluded to, it must be observed that some specimens of copaiba, which are very rich in volatile oil, do not completely solidify without the addition of wax or of a portion of turpentine, such as Bordeaux turpentine. The peculiar action of the magnesia consists in the formation of a soap with the acid resins of the copaiba or turpentine, and this soap absorbs the volatile oil, which is the other constituent of the oleo-resin. Quick lime might be substituted for magnesia, and in some cases has been found to answer better.

Certain *volatile oils*, without any other active ingredients, are sometimes prescribed in the form of pill. Thus, *oils of pimento*, *cloves*, *peppermint*, &c., have been ordered to the extent of three or four drops in each pill, the selection of an appropriate excipient being left to the dispenser. The best excipients to use in such case are soap and magnesia.

*Calomel* will form the type of a class of powders requiring an excipient which possesses and can impart adhesiveness. *Emetic tartar*, *antimonial powder*, and many other substances of this kind will come into the same class. Conserve of hips is a very useful excipient for this class of substances, at least for those of them which are not decomposed by the vegetable acid contained in the conserve. It answers very well for making calomel pills, the pills retaining a soft consistence for a great length of time. In some cases crumb of bread, treacle, or extract of liquorice, may be substituted for it. Pills made with crumb of bread, however, become very hard after being kept for some time. Castor oil is an excellent excipient for the *compound calomel pills* of the Pharmacopœia. The mass when made with this excipient will retain a uniformly good consistence, which is not the case when treacle is used.

Crumb of bread is frequently employed as the excipient for *creasote*, and for some active agents which are administered in very small doses.

The effect, in some cases, of a judiciously selected excipient is quite surprising, and the pharmaceutical student would find that the subject offers an interesting field for further experiment. When it is found that a substance so apparently ill-adapted for making into pills as a liquid oleo-resin, may be rendered fit for that purpose by the addition of a very small quantity of magnesia or lime, and that fatty substances, such as mercurial ointment, will assume a pilular consistence on the addition of a little phosphate of lime, he may hope to find equally simple means for subjecting other apparently intractable substances to the required purpose.

In all cases it is very important that the whole of the ingredients of the pill-mass should be perfectly mixed and incorporated. When small quantities of active medicines form part of the ingredients, the precaution already alluded to in reference to the preparation of powders should be observed, that is, that such substances should be placed on the top of other less active ingredients, and well mixed with them.

The pill-mass being formed, the next operation consists in dividing it into pills. This is effected by means of the pill-machine. Little need be said with reference to the use of this instrument. In most cases the formation of the pills is a simple and easy process, yet cases will sometimes occur, in which, after exercising all his skill in making the pill-mass, the dispenser will find it difficult to roll the mass into pills, in consequence of its tendency to crumble. This is the case with jalap pills made with tincture of jalap, and more especially with the pills of volatile oil magnesia and soap. When the mass has a great tendency to crumble, the processes of forming the mass and of rolling out the pills, should be performed as quickly as possible. The mass should be made rather soft, and then immediately rolled and cut into pills, with a quick and dexterous hand, avoiding the application of much pressure in the process of rolling.

*The pill-finisher*, fig. 384, is a useful appendage to the pill-machine. It is used for finishing off the pills after they have been cut in the machine, obviating the necessity for rolling them separately in the fingers. The finisher consists of a circular disk of wood, of which fig. 384 is a section; with a projecting rim on the lower surface, and a broad flat knob on the top, which serves as a handle. It may be made of pear-tree, or any other hard wood; it should be about three inches in diameter, and the depth of the rim should be rather less than the diameter of a pill. In fact, there should be two or three of these finishers with rims made to suit different sized pills.

*Fig.* 384.

THE PILL-FINISHER.

In using the finisher, the pills are placed on a tray, or on the platform of the machine, with some of the powder used for covering them, and the finisher, held by the knob, being placed over them, is moved in a circular direction with increasing velocity, while a very slight pressure is applied.

Several substances are used for covering pills, such as *magnesia*, *starch*, *liquorice powder*, *lycopodium*, *gold and silver leaf*, *gelatine*, and a mixture of *gum and sugar*. The application of these substances to the surfaces of pills is intended to prevent their sticking to each other or to the box, and also to prevent their being tasted during the act of deglutition.

*Magnesia* is very commonly used for covering pills. As a light absorbent powder it answers the required purpose very well, yet there are some cases in which its use is not free from objection. Thus, for instance, if calomel pills be covered with magnesia, decomposition will, after some time, occur, the mercury being reduced, or oxide formed together with muriate of magnesia. Calomel pills that are kept ready made should never, therefore, be covered with magnesia; powdered starch might be used in this case.

*Liquorice-powder* is sometimes employed in preference to magnesia for covering pills, its sweet taste being considered advantageous in masking that of the other ingredients of the pills. There is, however, a very serious objection to the indiscriminate use of this powder, which arises from the fact that, with some persons, it occasions an irritation of the fauces, which deprives them of the power of swallowing pills which are thus covered.

*Lycopodium* is but little used for covering pills in this country. It is extensively employed on the continent, and it forms, undoubtedly, the most suitable powder for the purpose. It is a light powder, the particles of which readily adhere to the moist surfaces of pills, without becoming themselves moist. It is also free from taste, and has no tendency to cause or to undergo decomposition. When lycopodium is used it should be applied to the pills on the machine or in the finisher, and none of the powder excepting that which adheres to the surfaces of the pills should be put into the box. Pills thus prepared have a much cleaner and more finished appearance than those to which a quantity of unattached powder is added, as is generally the case when magnesia or liquorice-powder is used.

The application of *gold or silver-leaf* to the surface of pills is a very ancient method of covering them. The gilded or silvered pill is still occasionally administered, but much less frequently than formerly. The method of gilding pills is very simple. The pills are first rolled and cut on the machine, the mass having been previously made rather stiff, and little or no powder of any kind used on the pill-machine. Two or three sheets of gold-leaf are now put into a suitable box. A turned box of a globular form, consisting of two hemispheres fitting together, and the capacity of which is about two ounces, is usually employed; but, in the absence of this, a two ounce chip-box will answer the purpose. The metallic leaves being put loosely into the box, the fore-finger and thumb of each hand of the operator is moistened with thin mucilage of gum-acacia, and two pills being rolled in the fingers so as to moisten their surfaces and render them adhesive, these are dropped into the box; others of the pills are subsequently treated in the same way, taking care that none of the pills thus introduced shall come into contact with the ungilded surfaces of those previously put in. When six or eight pills have been introduced into the box, the lid is put on, and a circular motion is given to the box, by which the gilding is effected. The process is repeated in this way until the whole number of pills required have received the metallic coating.

The same mode of operating is adopted when silver-leaf is used.

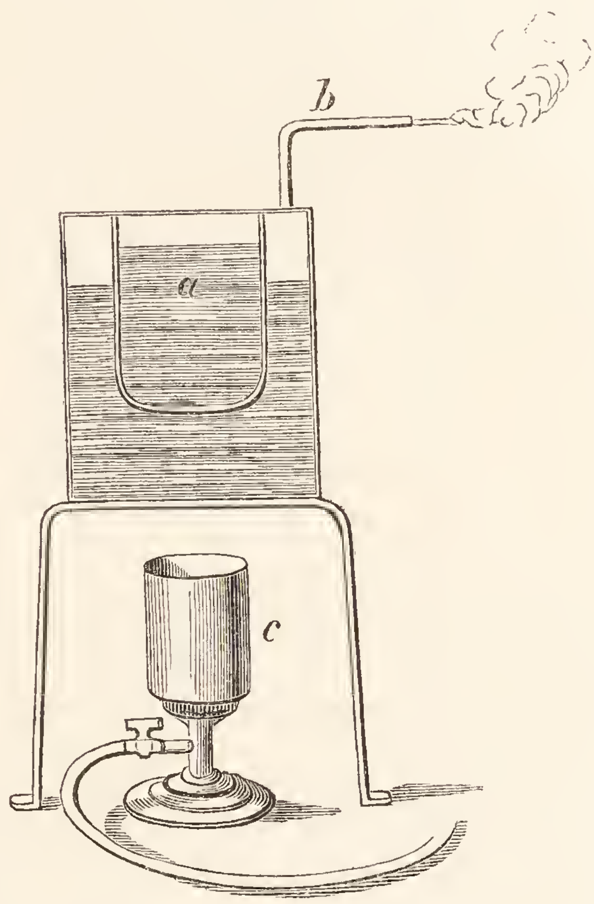
Of all the methods adopted for covering pills this is the most objectionable. Gilded pills have often been found to pass through the entire alimentary canal without undergoing any alteration, being completely protected by their metallic covering.

*The covering of pills with gelatine* is the most elegant and efficient method of fulfilling the objects contemplated in the processes now under notice. A pill, when thus covered, has a clean, shining, surface, which is dry, hard, and not at all sticky. No powder is, therefore, required in addition to the gelatine. The ingredients of the pill, being enclosed in a gelatinous case, are preserved from the action of the air, and, to a certain extent, are prevented from undergoing volatilization; moreover, the pill itself may be swallowed without perceiving taste or smell.

The following is the method of covering pills with gelatine:—

In the first place, a solution of gelatine is prepared, consisting of one part of gelatine and two parts of water. This solution may be made in a little water-bath such as that represented in fig. 385. The gelatinous mixture is put into the vessel (*a*), where it is surrounded by hot-water contained in the outer vessel, and the heat is maintained by the gas-lamp (*c*), while the steam escapes through the tube (*b*).

*Fig.* 385.




The pills are now made, as in the preceding case, without using any powder, or if powder be used on the machine, it must be subsequently wiped off the pills.

A number of straight, pointed, wires, are in the next place, provided, each of which should be about four or five inches long. The black hair-pins used by ladies, when made straight, answer the purpose very well. A large pincushion, or a dish filled with sand, in which the wires can be fixed erect, will also be required.

Each pill is to be stuck on the point of one of the wires, and when they are all mounted in this way, the pills are dipped, one at a time, into the solution of gelatine, so as to be completely covered, and the wires are then stuck into the pincushion or sand with the coated pills at the top, as shewn in fig. 386. They are left in this position until the gelatine has become firm, which will be in about ten minutes or a quarter of an hour, when the pills are removed from the wires and put into a tray, fig. 387, where they are left to dry.

*Fig.* 386.

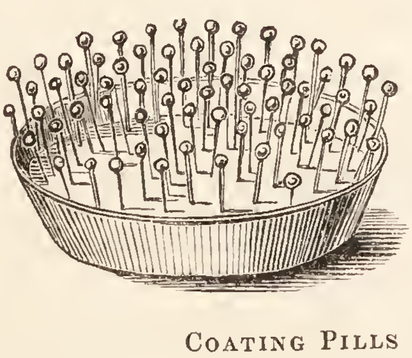
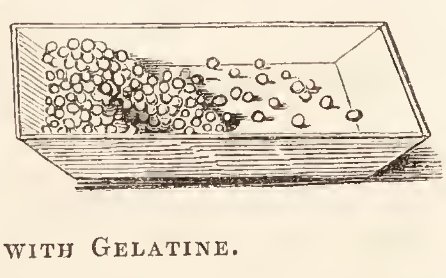


*Fig.* 387.



Coating Pills with Gelatine.

It will generally happen that in dipping the pills, a portion of the wires will become covered with gelatine, and this, on removing the pills will remain attached to them, forming little projecting tubes, which should be cut off with a pair of scissors. If it be desired to make the coating of gelatine perfect, the hole at which the wire has entered the pill must be touched with the point of a camel's hair pencil previously dipped into the solution of gelatine.

*Gum and sugar* are sometimes used for covering pills. The pills are put into a hemispherical metallic pan, which is slightly warmed, and a small quantity of a solution of one part of gum in two parts of water is added so as to moisten the surface of the pills. Some powdered sugar is then sprinkled over them, and by moving the pan they are thus covered with a coating of sugar. They are subsequently placed on a sieve and exposed in a warm room until they become dry. If a thicker coating be required the process is repeated.]

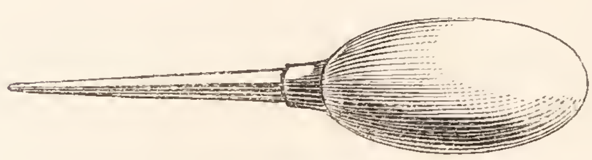
## CAPSULES.

[Some nauseous medicines, especially copaiba, are administered in capsules, which are made either of a mixture of gelatine with sugar, and sometimes with gum, or of prepared gut-skin.

*Gelatine-capsules.* — These are small egg-shaped vessels, into which a liquid or semiliquid medicine is introduced through a small aperture at one end, which aperture is subsequently sealed.

In making the capsules, a number of moulds, consisting of polished iron bulbs, are provided, of which fig. 388 is the real size. These bulbs are turned at the lathe, so as to be perfectly smooth, symmetrical, and uniform; and each bulb is fixed to one end of a wooden rod, six or eight inches long, while the other end of the rod fits loosely into a round hole in a board, as shewn at *a b c*, fig. 389. The board (*a*) has a great number of holes perforated in it, which are intended to receive either the moulds (*b c*), or the capsules (*d*).

*Fig.* 388.

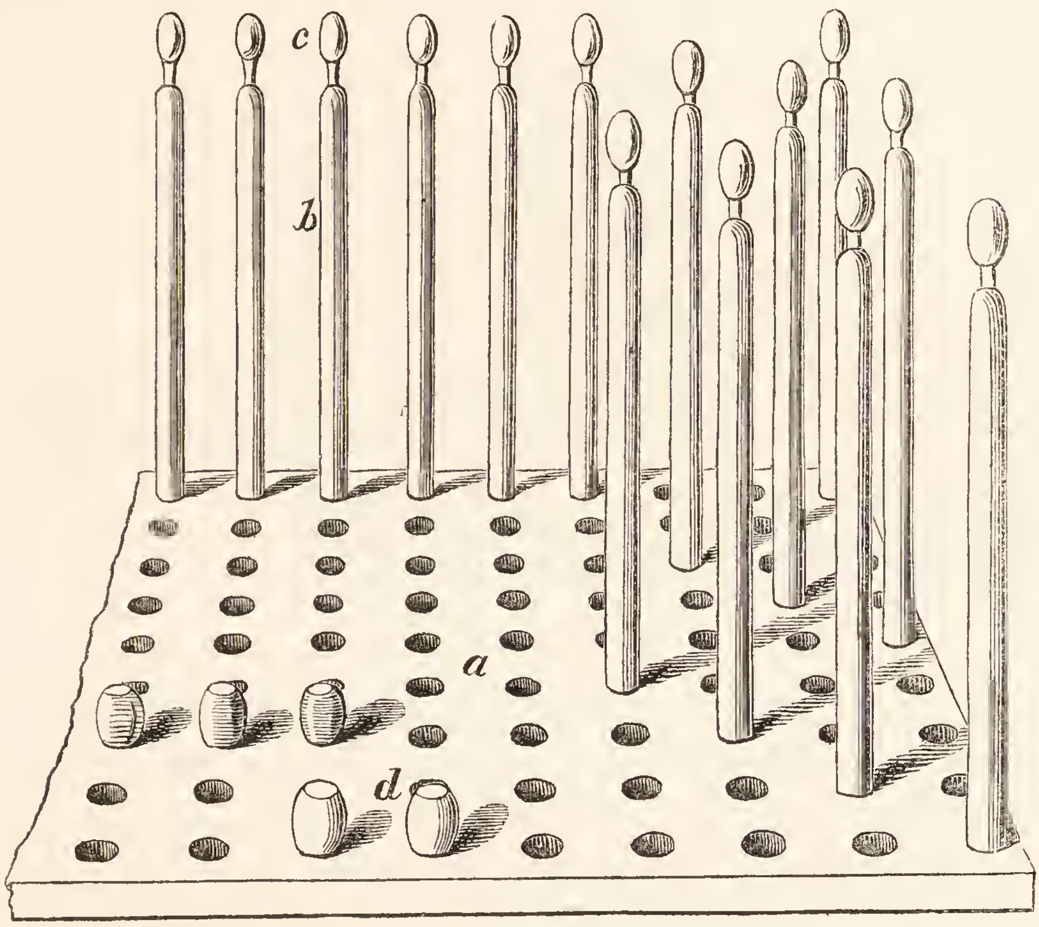


THE CAPSULE MOULD.

A solution of six parts of gelatine and one part of sugar, in twelve parts of water, is made in the water-bath, fig. 385, in which it is kept constantly hot and fluid.

The moulds are first wiped with a cloth slightly moistened with oil; they are then dipped into the solution of gelatine, so that the bulbs may be completely covered; and on taking them out, the excess of solution is allowed to run off until they cease to drip, when they are fixed on the board (*a*) with the coated bulbs upwards, as represented in the drawing. This operation is continued

*Fig.* 389.

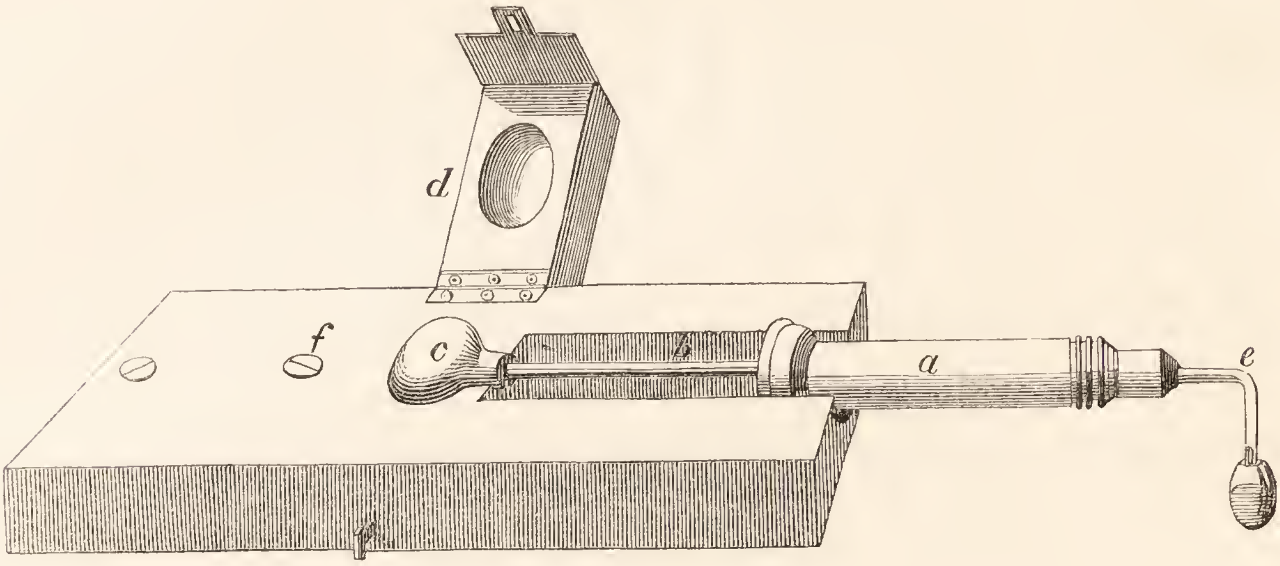



PREPARATION OF CAPSULES.

until a great number of moulds have been dipped, by which time the gelatinous coating on those first dipped will have become cold and firm. The separation of the capsules from the moulds may now be commenced. A knife is passed round the shank of the mould, close to the bulb, so as to separate the gelatinous covering from that which adheres to the handle, and the capsule is then pulled off by a dexterous application of the thumb and two fore-fingers of one hand of the operator, while the handle of the mould is held in the other hand. If the gelatinous solution has been well prepared, and is in good condition, the orifice of the capsule will expand so as to pass over the thickest part of the bulb without breaking, and will resume its original size when it has slipped off. The gelatinous mixture becomes more elastic after it has been kept melted for some time: the addition of a little gum also increases its elastic property, but gum makes the capsule more speedily soluble in the contents of the stomach, which is sometimes objected to. On removing the capsules from the moulds they are placed on a tray, and exposed in a warm room until they become perfectly dry.

The next operation consists in filling the capsules with the liquid they are intended to receive. In doing this, the dry capsules are placed with their mouths upwards on the perforated board, as shewn at *d*, fig. 389. The capsules are conveniently filled by means of a syringe, as represented in fig. 390. The syringe (*a*) being charged with the liquid, is placed in a groove (*b*), cut for

*Fig.* 390.




Filling Capsules.

this purpose in a board (*f*) which is secured on the top of a table, while the piston of the syringe is fixed at *c*, by the bar (*d*) which is fastened down over it. There is a very slender nozzle to the syringe, which is bent as shewn at *e*. The operator places one of the capsules over the point of the nozzle, while he gently presses the syringe against its piston, thus forcing the required quantity of liquid into the capsule. On removing the capsule after it has been thus filled, it is desirable to avoid leaving any of the oil on the edges of the orifice, as this would interfere with the subsequent sealing process. If the capsule were removed from the nozzle while a drop remained attached there, the mouth of the capsule would almost inevitably catch the drop, but this is obviated by slightly drawing the syringe forward, by which the suspended drop is sucked into the tube, before removing the capsule. The liquid introduced into each capsule should be equal to about three-fourths of its capacity; if more than this be introduced, it would be difficult to prevent leakage, which would be caused by atmospheric changes, for increase of temperature occasions expansion of the liquid, and at the same time contraction of the containing vessel.

The capsules being all filled and restored to their position on the board (*d* fig. 389), the sealing process is commenced. A small camel's-hair pencil is dipped into the gelatinous mixture, which when used for this purpose should always contain a portion of gum, and the mouth of each capsule is touched so as to leave a sufficient quantity of the gelatine to seal it. When they have all been thus sealed, some of the gelatinous mixture is thinned with water, and the top of each capsule is dipped into this solution, and then again placed, with the sealed end upwards, on the board. By this last operation a little cap is formed over the mouth of the capsule, which renders the sealing more secure.

Finally, when dry, the sealed capsules are put on to a cloth slightly moistened with oil, and rubbed, so as to give them a clean and polished appearance.

*Membrane capsules.*—A patent has been taken out for the manufacture of capsules from animal membrane, which is purified and prepared for this purpose. The prepared and moist membrane is stretched over a mould so as to give it the form of a conical bag. Into this, when dry, the liquid is introduced; the mouth of the bag is then tied with silk, and sealed with a little gelatinous varnish.

These capsules possess some advantages over those made of gelatine. In proportion to their external size, they hold more liquid than the gelatine capsules do, in consequence of the membrane of which they are made being very thin. They are also very flexible and compressible, which is a great recommendation with some patients, who are fearful of attempting to swallow a hard, rigid, body, of the size of a capsule. Moreover, the membrane being less rapidly dissolved than the gelatine mixture is, by the juices of the stomach, the capsules made of the former do not discharge their contents so soon as those made of the latter, and eructations are, therefore, less likely to ensue.]

## GARGLES; ENEMAS; INJECTIONS.

[These forms of medicine resemble the *mixture* in their general characters, and the mode of preparing them is similar. Being intended for local application, and not to be introduced into the stomach, the labels attached to them should clearly indicate this distinction. The old method of administering enemas with a pipe and bag is now entirely superseded by the use of the syringe.]

## LOTIONS, LINIMENTS, EMBROCATIONS.

[These are medicines, of a more or less fluid character, which are intended for external application. *The lotion*, as the name implies, is a wash, and it may be for any part of the body. Lotions for the eyes are sometimes called *Collyriums*. The terms *liniment* and *embrocation* are frequently used synonymously; the former, however, being derived from *lino*, to besmear, is applicable to something thick as well as fluid, while the latter, being derived from ἐμβρέχω, to moisten or foment, applies exclusively to a liquid.

It has been proposed that liquid medicines intended for external use should be always dispensed in bottles made of blue glass, to distinguish them from those designed for internal administration, the latter being dispensed in white glass. If such a practice were universally adopted, it would certainly be a good method of guarding against accidents which sometimes occur in consequence of an embrocation being mistaken for a draught. It is questionable, however, whether the partial adoption of the practice would be beneficial; but it is very important, at all events, that there should be some prominent indication, in the form of label or otherwise, to distinguish external applications from medicines to be administered through the stomach.]

## OINTMENTS.

[Under the general denomination of *Ointments* are included medicines intended for external application, the principal basis of which consists of some kind of grease, which is either naturally, or from the admixture of other substances, in the condition of a soft solid. Ointments to which a firm consistence has been imparted by the addition of wax are sometimes called *Cerates*.

Salts and other solid substances are frequently ordered to be extemporaneously mixed with ointments, and the principal art connected with the dispensing of this form of medicine, consists in the adoption of the best methods of effecting the most intimate admixture of such ingredients, or of any others which may not readily combine.

Ointments are mixed either in a Wedgewood's mortar or on a marble slab. The mortar should always be used when salts or other substances, which require to be previously powdered, form part of the ingredients. The presence of hard particles, giving a gritty character to the ointment, is very objectionable, and would indicate want of skill, or of careful attention, in the dispenser. The mere admixture of two or more ointments may be effected by rubbing them on the slab with a spatula.

Some salts, such as iodide of potassium, are with difficulty reduced to fine powder even in a mortar, and in these cases it is desirable, when practicable, to add some liquid which shall act as a solvent before the addition of the unctuous constituents of the ointment. Thus, iodide of potassium, if it be first dissolved by a few drops of water, before mixing it with the grease, will form a perfectly smooth ointment, which it would be difficult otherwise to obtain.

Ointments are dispensed in covered gallipots, and it is customary to put a piece of waxed paper over the top of the pot, beneath the cover, so as to prevent the latter from becoming smeared with the grease.]

## SUPPOSITORIES.

[*The suppository* is a form of medicine now very rarely adopted. It is intended for the administration of medicinal agents to the rectum. The ingredients are made into a paste, which is usually rolled into a conical form, like a pastil. Soft soap or grease is generally used as the excipients for giving the required consistence to suppositories.]

## CATAPLASMS.

[*The cataplasm or poultice* generally consists of a pulpy substance, capable of absorbing much moisture, which is applied to various parts of the body in a moist state. Poultices are almost always prepared by the nurse: their action usually depends upon the liquids with which they are moistened, or the heat which the mass retains. The solid ingredients of the poultice being useful only for holding a large quantity of liquid, which is thus applied continuously to a diseased part, it has been proposed to substitute an absorbent fabric, called the *spongio-piline*, which is made expressly for the purpose. This is a kind of thick cloth, composed in great measure of sponge. Over one of its surfaces there is a thin coating of some water-proof material, which prevents evaporation, when the other side, previously wetted, is applied to the skin.]

## PLASTERS.

[Plasters are solid and tenacious compounds, intended for external application. They frequently contain the oleate and margarate of oxide of lead as a principal basis; wax, resin, solid fats, and essential oils, are also among the ingredients which often enter into their composition. At the usual temperature of the human body they should be flexible, and more or less adhesive, but not so soft as to run.

Plasters are used, *mechanically*, for affording support or pressure to the parts to which they are applied, for binding up wounds, and for preventing atmospheric contact; and, *medicinally*, as stimulant, epispastic, discutient, or anodyne applications.

The spreading of plasters is one of the operations connected with the dispensing of medicines, in which the pharmaceutist has occasion to exercise more acquired skill than is involved in many other departments of his art.

Plasters are generally spread on leather, calico, or linen. Sometimes, however, silk, animal membrane, and even paper, are used. Those spread on leather will be first noticed.

When a plaster is ordered by the prescription of a medical man, in addition to the ingredients of which it is to be composed, the size and form, are frequently, but not always, indicated. In some cases, the part is named to which the plaster is to be applied, and the determination of the form and size is left to the judgment of the dispenser. There are certain forms of plaster which are generally adopted for application to particular parts of the body, and in the absence of specific instructions, the dispenser should comply with the usual and recognised practice in this respect. Thus, fig. 391 represents the form of plaster usually applied to the chest; fig. 392 is the form for application between the shoulders; fig. 394 for the small of the back, or for parts not indicating any other particular form; fig. 395 is the form usually adopted for the side; fig. 393, for applying pressure to the navel of children; and figs. 396, and 397 for applying behind the ears, the former being for the left, and the latter for the right ear. It will, of course, be understood that the figures represent only the forms, and not the relative sizes, of the plasters. Some of these forms, especially figs. 391 and 392,

*Fig.* 391.

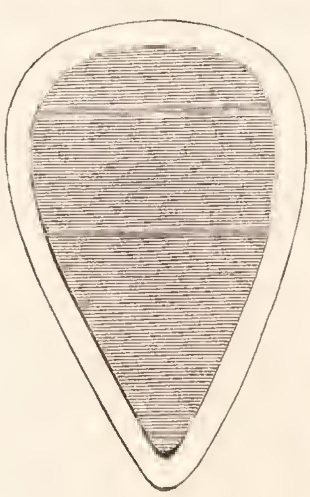


*Fig.* 392.

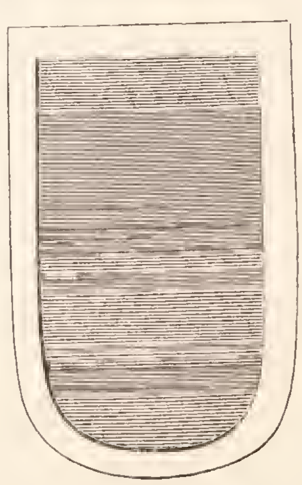
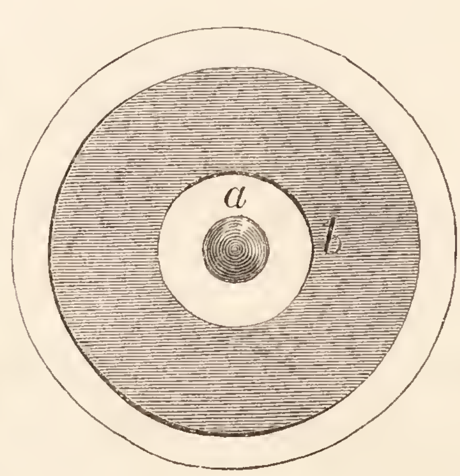


*Fig.* 393.




are so frequently employed, that it is found convenient to keep the pieces of leather on which they are spread cut ready for use. By adopting this practice a skin may be cut up to much greater advantage than it would be if each piece were cut out when required.

*Fig.* 394.

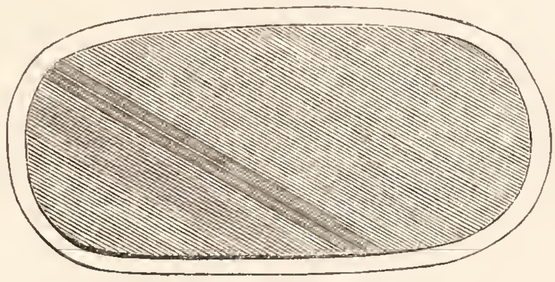


*Fig.* 395.

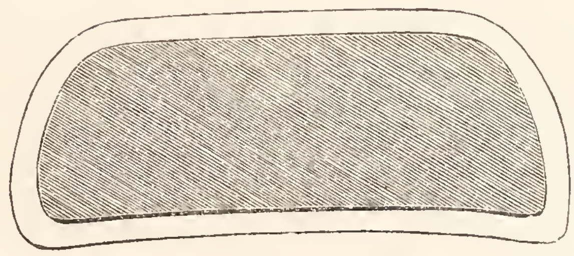


*Fig.* 396.

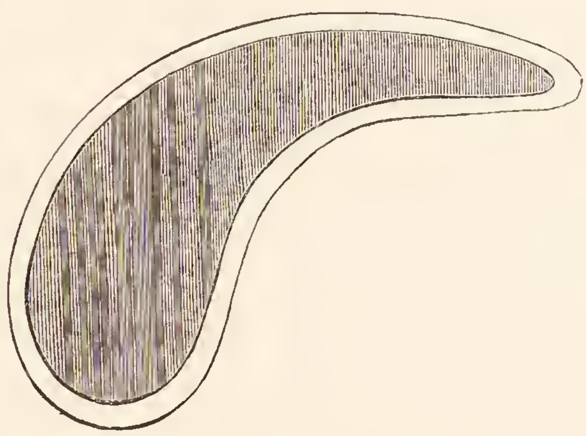
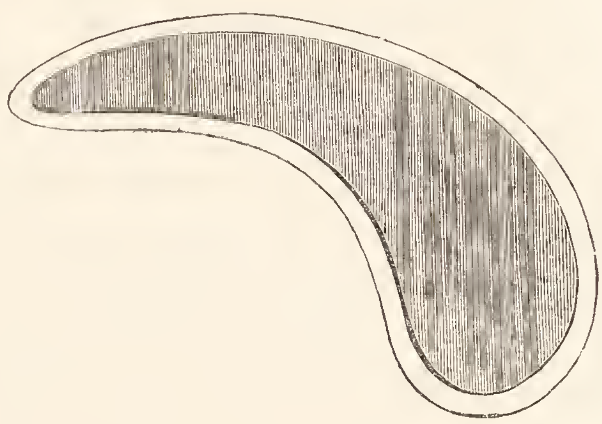


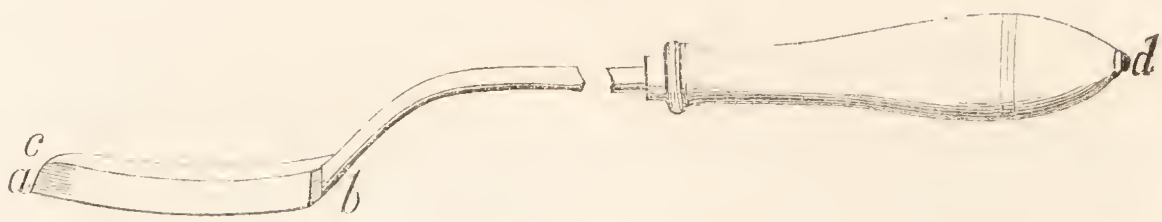
*Fig.* 397.



Patterns of the forms and sizes most frequently required, made of thick pasteboard, should be kept for marking the skins with a pencil previously to cutting them. There might be two or three sizes of fig. 391; two of fig. 392; and several of fig. 394. These pieces of leather, when cut, should be kept in a drawer, properly divided for the reception of each size separately, the pasteboard pattern being put at the bottom, and a thick piece of flat sheet lead at the top, the latter serving as a weight to press the leathers, and keep them smooth.

The plaster-spatula, fig. 398, is employed for spreading plasters, and the facility with which the operation is performed will greatly depend upon the selection of this instrument. There should be several spatulas kept, varying in size and form, so that the dispenser may choose one suitable for its intended application. The spatula serves as the medium through which heat is conveyed to the plaster for the purpose of melting it, and it is subsequently used for spreading the melted mass smoothly over the surface of the leather. The heat of the spatula passes off during the operation, partly by conduction, to the plaster, and partly by radiation, into the air; yet it is necessary that it should retain a certain degree of heat until the process is completed. As the temperature of the spatula when its use is commenced must be always nearly the same, the different amounts of heat required for spreading small and large plasters can only be provided by varying the size of the blade of the instrument.

*Fig.* 398.



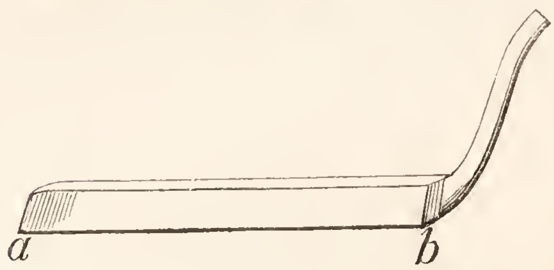




*Fig.* 399.

PLASTER SPATULAS.

It is desirable that the spatula should not be larger than is necessary, in order to provide a sufficient supply of heat, especially in spreading small plasters and those having sharp angles, such as fig. 391, as it would be difficult, with a large spatula, to avoid soiling the margins. For small plasters it will be found advantageous to use a spatula, the lower surface of the blade of which is slightly curved, as represented in fig. 398. In using this kind of spatula, the end (*a*) of the blade may be applied to the surface of the plaster without bringing the heel of the instrument (*b*) into contact with any part of it. Spatulas used for spreading large plasters, such as those applied to the small of the back, should have flat blades, as shewn in fig. 399, for it would be difficult with a curved blade to make the surface of a large plaster sufficiently smooth. In all cases the blades should be thick in the direction *a c*, fig. 398. It is also very important that the iron shank of the spatula should pass through the wooden handle to the end *d*, and be secured there by a nut. If the handle is not thus secured, it will be constantly coming off, being loosened by the action of the heat.

The leather on which the plaster is to be spread being cut to the required shape and size, and a suitable spatula selected, the blade of the latter is made hot by putting it into the fire. A little experience will enable the dispenser, by holding the instrument within a few inches of his face, to determine when it has acquired sufficient heat. The heated iron is first rubbed on a mat to make it clean ; it is now ready for use, and should be promptly employed before it loses any material part of the store of heat which it holds, and which is intended to impart the required degree of fluidity, or softness to the plaster, and to maintain this condition until its extension over the leather has been completed.

Ten or twelve sheets of paper are placed upon the counter, and the leather is laid on the top of these. The paper forms a bed of a due degree of elasticity, and which prevents the too rapid conduction of heat from the plaster while it is being spread. If the leather were laid directly on the counter, or with only one or two sheets of paper intervening, the heat of the liquefied plaster would be rapidly carried off by the cold surface of the polished wood.

Before commencing the melting of the plaster, the leather is smoothed out by passing the hot iron over it, and, in doing this, it is very necessary to be careful that the iron is not so hot as to cause the leather to shrivel up. If the spatula be in a fit state for melting the plaster, it will not injure the leather when applied to it.

If the material of which the plaster is composed be sufficiently adhesive to ensure its remaining fixed to the part of the body to which it is applied, it is spread, without any previous preparation of the leather, to within about half an inch of the edge, leaving a margin of this width of uncovered leather ; but plasters possessing little or no adhesiveness, ought to be surrounded by an adhesive margin, and in such case the margin must be prepared before spreading the plaster. There are two methods of preparing the adhesive margin, —the adhesive plaster may be either spread entirely over the leather to the very edge, or it may be merely applied around the edge of the leather, so as to form a border of about an inch in width. The former of these methods should be adopted if the plaster, when exposed to the heat of the body, is liable to run through the leather, as is the case with the blistering plaster of the Pharmacopœia, for the substratum of adhesive plaster would tend to prevent such a result. In other cases it may be unnecessary to protect the leather, and even desirable to avoid increasing the thickness of the plaster by having two strata throughout.

When the adhesive plaster is merely spread as a border around the edge of the leather, it is customary to melt the plaster by applying the end of a roll of it to the hot iron, allowing it to drop as it liquefies on to the part of the leather to be covered, and subsequently to spread it with the spatula. In doing this the iron should be only just hot enough to melt the plaster, as otherwise the drops of hot melted plaster would occasion permanent marks on the leather, which would disfigure its subsequent appearance.

When the adhesive plaster is extended over the whole of the leather, it should be allowed, as it liquefies from contact with the hot iron, to run on to a piece of strong paper, and transferred from thence to the leather.

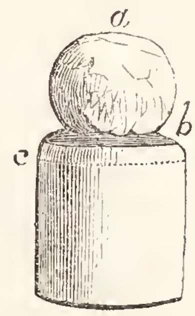
The adhesive margin, if required, having been prepared as above directed, the spreading of the plaster may be proceeded with. The spatula, after being used for the preceding operation, will require to be heated again before it can be applied for melting another portion of plaster.

The melting of the plaster may be effected in the manner already described, by applying the hot iron to one end of a roll of plaster, and allowing the liquefied portion to run on to a piece of strong paper, from whence it is subsequently transferred to the leather. If the leather has not been rendered adhesive, the paper on which the melted plaster is received should be placed upon it while the process of liquefaction is being conducted, so that whatever heat passes off by conduction, may be communicated to the leather and to the paper beneath it, and these being thus warmed, the subsequent cooling of the plaster, while it is being spread, will take place more slowly. Every available means by which the expenditure of heat can be economised should be put into requisition in spreading a plaster, especially if it be of large size. The careless or inexperienced operator will sometimes commit the two-fold error of commencing the melting of the plaster by the application of a spatula heated to such a temperature that it causes a decomposition of some of the constituents of the plaster, and the evolution of acrid vapours, while, at the same time, the means of economising heat are so imperfectly adopted, that the mass becomes hard and intractable before its extension over the leather has been completed.

When the blade of the spatula has expended so much of its heat in melting the plaster, that it is scarcely hot enough to melt any more, it will be in a fit condition for spreading the melted mass. The method of effecting the extension can be properly acquired only by practical experience; it may be observed, however, that the plaster should not be spread out to its furthest intended limits until it has passed from the fluid or semi-fluid to the plastic condition. It is only while in this latter condition that it can receive with effect the last finishing touches of a skilful hand. When completed, the plaster should be of equal thickness in all parts; the surface should be even, but not too glossy; and the edge should rise perpendicularly from the margin.

There are some special cases in which a mode of proceeding somewhat different from that previously described is required to be adopted, as for instance, in preparing the plaster, fig. 393, for applying pressure to the navel of a child. This plaster has a globular protuberance in its centre, which is surrounded, first, by a circle of uncovered leather (*a*), then by a broader circle (*b*) of adhesive plaster, and, finally, by a margin of uncovered leather. The globular protuberance is formed by cutting the end of a large vial cork as shewn in fig. 400, and fixing this in the centre of the plaster. A piece of soft white glove-leather is stretched over the globular end (*a*) of the cork, and tied with fine string in the groove (*b*); the cork is then cut off at the dotted line (*c*). A piece of thin leather of the intended size of the plaster is, in the next place, spread with a thin coating of adhesive plaster, and the glove-leather with the cork attached, is laid over the adhesive surface of this, the cork being in the centre, and its globular part upwards, while a warm and clean spatula is rubbed over the surface of the glove-leather, so as to make it adhere firmly to the plaster beneath. The broad adhesive circle (*b*) has now to be spread. A small piece of tissue-paper is placed over the globular protuberance in the centre to protect it from being soiled by the spatula. A piece of stiff writing-paper, of the size of the circle (*a*), is also placed over the part of the leather which is to be left uncovered by the plaster. These preparations having been made, the adhesive plaster is spread over the part *b*, with the curved spatula, fig. 398, in the manner already described.

*Fig.* 400.




In spreading blisters, the leather having received an adhesive surface, the blistering plaster is extended over it by the application of the thumb of the operator. The hot iron should not be applied at all, being quite unnecessary, and calculated to injure the plaster as regards its vesicating property. The thumb may be moistened with water to prevent the adhesion of the plaster to it.

The margins of plasters are sometimes formed by placing over the leather, while the plaster is being spread, a piece of tin-plate or stiff paper, having an open space in the centre, of the size and form of the intended plaster. This is taken off after spreading the plaster, and with it is removed any portion of plaster which has extended over it, leaving the margin untouched. Plasters thus prepared have, generally, a less finished appearance than those spread in the manner previously described, and, indeed, this method of operating is adopted only as an expedient to obviate the necessity for acquired skill and careful manipulation.

Dr. Mohr gives the following description of the methods of spreading plasters on calico or linen.]

The cloth on which the plaster is to be spread is cut into strips of about seven or eight inches in width, and three feet in length. These strips must be stretched out, so as to present an even surface for the spreading of the plaster. For effecting this, two flat pieces of wood about fifteen or sixteen inches long, and of the width and thickness of a common lath, are provided. A row of sharp wire points are stuck into one edge of each of the laths for a space of about nine inches, leaving a few inches at each end without any. The points should project about the sixth of an inch above the surface of the wood, and they may be at a distance of a quarter of an inch from each other; after being fixed they must be sharpened with a file. The ends of the laths, which are left free from points, are intended to serve as handles. The extreme ends of one of the strips of cloth are fixed to the laths by means of the points, a straight line across the strip, at each end, being found by drawing a thread. Two assistants lay hold of the laths by their ends or handles, and stretch the cloth by pulling in opposite directions. The plaster having been previously melted in a small copper dish, and stirred until it has partly cooled, so that it may not run through the cloth, is poured out in a uniform layer across one end of the strip, and extended evenly and equally by bringing the warm plaster-knife against it, and pressing it forward with a steady progression until it has reached the other end. If the plaster be not uniformly spread by one operation, as above described, the plaster-knife may be passed over it again to remove any inequalities.

*Fig.* 401.

*Fig.* 402.

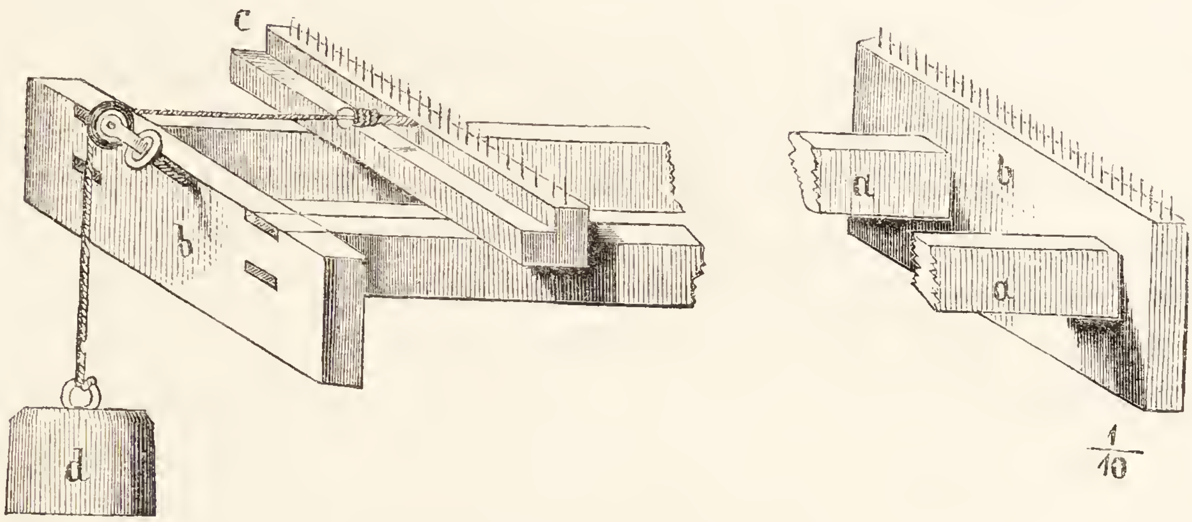
PLASTER-KNIFE.

The plaster-knife is represented in fig. 401. It consists of an iron blade about ten inches in length, and, therefore, longer than the width of the plaster. It is flat on one side and convex on the other, as represented in the section (fig. 402), which is drawn to its real size. It has a wooden handle at one end, by which it is used.

Plasters may be spread without much difficulty, as above described, so as to present a tolerably even and uniform surface, when the edges have been cut off. It is a great objection to such a method of operating, however, that the operator requires the aid of two assistants.

With the view of obviating the necessity for manual assistance in the process, I have adopted the following arrangement, which has been found to answer perfectly. A light wooden frame is constructed, which consists of two bars (*a a*, fig. 403), which run

*Fig.* 403.




Apparatus for Spreading Plaster.

parallel to each other, and are inserted into two end-pieces (*b b*). The side-bars are four feet in length; they are two and a half inches deep, and three quarters of an inch wide. They are fixed at a distance of five and a half inches from each other. The end-piece on the right hand side consists of a board ten inches long, five and a half inches deep, and one inch in width. It has a row of pointed wires fixed in the top in the manner already described. The left hand end-piece (*b*) is level with the top of the side-bars. It is ten inches long, three and a half inches deep, and one inch in width. Midway between the two ends of this end-piece there is a pulley fixed as represented in the drawing, so that the top of the groove is at the same height as the wire points of the right hand end-piece. There is a moveable cross-bar (*c*) which rests on the side-bars, and the top of which, when in such position, is at the same height as the top of the right hand end-piece, and, like the latter, it is furnished with a row of wire points.

In using this apparatus the strip of cloth is fixed on the points in the manner already described, and a weight (*d*) of about fifteen or twenty pounds, is attached to the moveable cross-bar (*c*) by a cord. The cloth is thus kept uniformly and constantly stretched by the action of the weight.

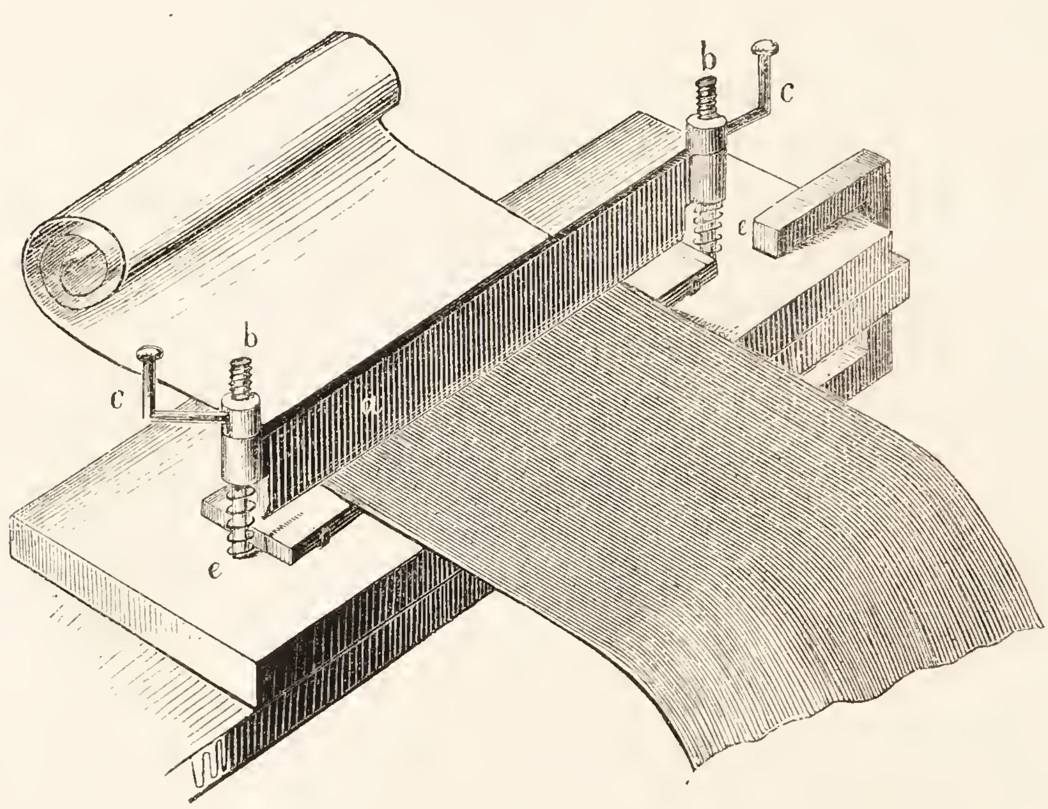
The instrument used for spreading the plaster is a hollow triangular vessel, filled with boiling water. A transverse section of it would form an equilateral triangle. At one end it has a wooden handle; and at the other, a short projecting tube, through which hot water is introduced, and this is subsequently stopped with a cork. It contains about eight ounces of water. This instrument, when charged with boiling water, will continue hot for some time, in consequence of the great capacity for heat which water has; and any plaster which may adhere to it after being used, is easily removed in consequence of its remaining soft.

The strips of cloth are sometimes stretched by means of a screw attached to one of the end-pieces of the frame, but this arrangement is less convenient than that in which the weight is used, because, although the cloth may be made tight before the spreading is commenced, it will often become loose during the process.

There is yet another method of spreading the plasters now under notice, which consists in drawing the cloth, on to which the plaster has been poured, beneath a straight blade of metal, which leaves only a thin and even coating of the plaster. In operating in this way, pieces of cloth of any length may be covered, which is a great advantage. Many forms of apparatus have been recommended for this process, of which that represented in fig. 404 is one of the most simple.

Upon a solid oaken board, of suitable size, are fixed two screws

*Fig.* 404.




Apparatus for Spreading Plasters.

(*b b*). These receive the cylindrical ends of the spreading-blade (*a*), which fits loosely on to the screws, and above them there are two nuts (*c c*), each of which has a small lever handle by which it is screwed on and off. The cylindrical ends of the blade (*a*) are only half the depth of the blade itself, and the threads of the screws (*b b*) extend only as low down as the nuts are required to be screwed. Surrounding the lower part of each screw, there is a strong spiral spring (*e e*) which presses the spreading-blade upwards, and keeps it in the exact position at which it has been adjusted by the nuts.

Immediately below the knife there is a smooth solid plate of iron, which is retained in its place by four small pegs fixed in the wood. On taking out the pegs the iron plate is easily removed for the purpose of cleaning it, and again fixed in its place for use.

The edge of the spreading-blade, which is not sharp, but somewhat rounded, as shewn in the section, fig. 405, should be perfectly straight and smooth, as also should be the surface of the metallic plate beneath it. In order to test the correctness of this part of the apparatus, the blade (*a*) should be screwed down by means of the nuts until it is almost in contact with the plate beneath, and then, holding it against the light, it should be observed whether the intervening space forms a straight and uniform streak.

*Fig.* 405.

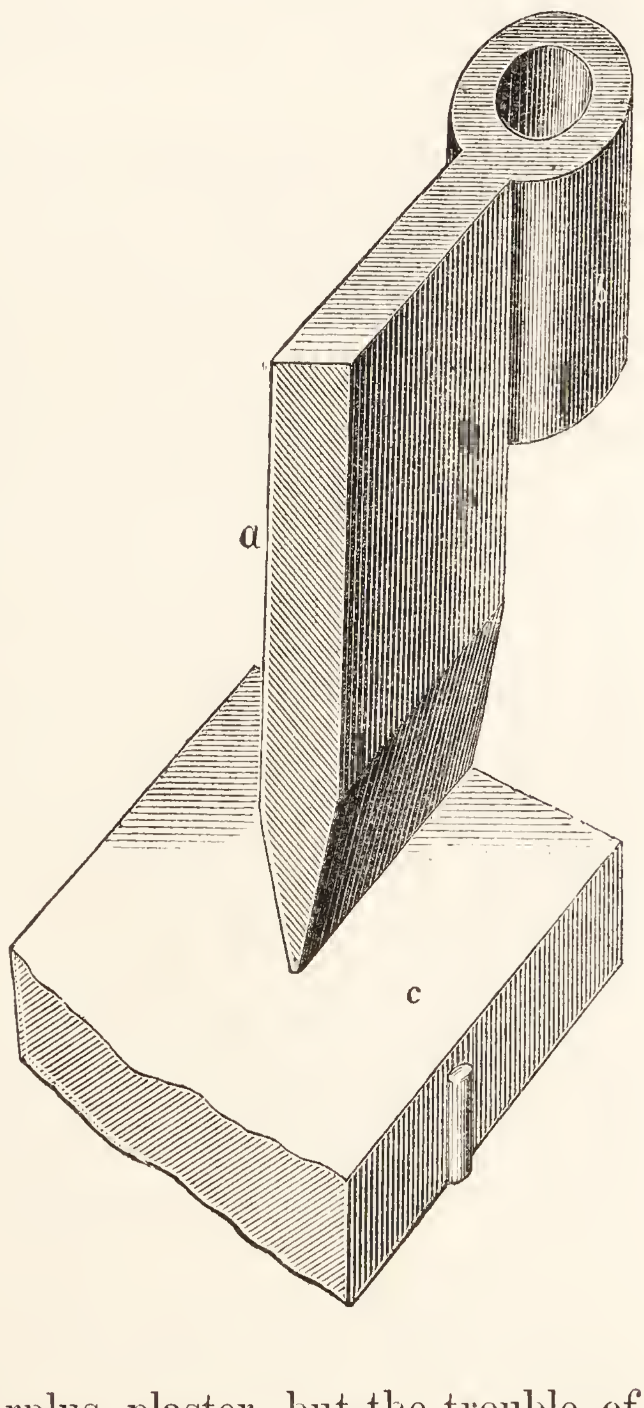



Fig. 405 represents a section of the spreading-blade (*a*), with one of its cylindrical ends (*b*), and part of the metallic plate (*c*). One of the pegs by which the plate is kept in its place is also shewn.

The following is the method of using this apparatus. In the first place the board is fixed to a table; then, a sheet of smooth writing-paper is placed over the iron plate, beneath the edge of the blade, and fixed there by attaching it with a little gum or paste to the board. This paper receives the portions of plaster which run off in the process of spreading. Sometimes a small trough is placed in front of the blade to receive the surplus plaster, but the trouble of cleaning out the trough is greater than that of removing the plaster from the paper. The cloth is placed between the edge of the blade and the paper, and the blade is so adjusted, by means of the nuts, that while the cloth can be drawn through with tolerable facility, it nevertheless occasions some friction. The plaster, in a semifluid state, is now poured on to the cloth immediately behind the spreading-blade, and the cloth is drawn through, steadily and not too rapidly, on the opposite side. If the coating of plaster is found to be too thick, the blade must be depressed a little more, care being taken that this is done equally at both ends. Should a knot occur in the cloth, so as to prevent it from passing beneath the blade, it will be necessary to unscrew one or both of the nuts to admit of its passage, and then to restore the blade to its original position. It would be found advantageous to examine the cloth before commencing the spreading of the plaster, and to remove any knots that may be found in it. The examination is conveniently effected by passing the cloth through the apparatus, screwed rather close, before adding the plaster, the apparatus itself being the best test of the absence of knots.

The strips of plaster, after being spread should be hung across a line in a cold cellar, and left there for ten or twelve hours, to harden. They may then be rubbed over with a little soap, which prevents their adhering together when rolled up.

*Cerated-cloth* is made by drawing strips of calico or linen through a melted mixture of eight parts of white wax, four parts of olive oil, and one part of Venice turpentine : and subsequently, before the adhering mixture has cooled, passing the slips between two wooden rollers, by which the superfluous cerate is removed.

*Court-plaster* is prepared by spreading a solution of isinglass over the surface of silk. The solution is made by soaking two ounces of the best isinglass in sixteen ounces of water, and when the former has become soft, adding sixteen ounces of rectified spirit. The mixture is digested, with the heat of a water-bath, in a partially closed vessel, until solution has been effected, and the product is then strained through linen.

The silk on which the plaster is to be spread is stretched by means of an apparatus similar to fig. 403, and the solution is then laid on, while in a fluid state, with a camel's-hair brush, several successive layers of it being applied as the preceding ones have become dry.

It is frequently recommended that a thin coat of an alcoholic solution of balsam of Peru, or resin of benzoin, should be applied over the surface of the last layer of isinglass ; but this addition is of very questionable advantage, as it is apt to occasion irritation of the part to which the plaster is attached. The silk used for the purpose may be black, white, or flesh-coloured.

[*Transparent isinglass plaster* is now frequently used for surgical purposes. It is made by spreading a solution of isinglass, similar to that above described, over the surface of oiled silk or animal membrane; the latter answers best. The peritoneal membrane of the cæcum of the ox is prepared expressly for this purpose. The best method of applying the gelatinous solution is, to stretch the moist membrane over the surface of a flat deal board, attaching it by small nails at its extreme edges. When the membrane has dried, the gelatinous solution is brushed over it with a flat varnishing brush, the motion of the brush being maintained in one direction, as in painting wood. This coating is allowed to dry spontaneously, and then another is applied in a similar way, only observing to move the brush in a direction at right angles with that previously adopted. Four or five coats are thus successively laid on, changing the direction of the brush each time, and using rather a thinner gelatinous solution for the last coat than for those preceding. When a sufficient coating of gelatine has been thus formed, the membrane is to be turned over on the board, so as to bring the uncoated surface upwards, and a thin coat of drying oil is to be applied on this side.]

*Blistering-tissue*, which is sometimes substituted for the ordinary blistering-plaster, is prepared in the following way. Any quantity of powdered cantharides is treated with ether until it is entirely exhausted. This will be best effected by the use of the apparatus described at page 84, fig. 76. The ether is subsequently distilled off by the heat of warm water, when a greenish oily residue, of the consistence of butter, will be obtained. This is a powerful vesicating agent. It is mixed with twice its weight of melted white wax, and the mixture is spread in a very thin layer over the surface of paper. The spreading is best effected by means of the apparatus fig. 404.

*Gout-paper* is prepared in a similar way to that last described, by spreading a mixture of an ethereal or a spirituous extract of the bark of mezereon root, with wax, spermaceti, and oil, over the surface of paper.

## INHALATION.

[The inhalation of the fumes of orpiment is said to have been practised in the time of Galen, and it is probable that from that time to the present medicines, in the state of vapour, have been occasionally administered through the lungs.

In the latter part of the last century the attention of medical men was prominently directed to this method of combating disease, by Dr. Beddoes, who in conjunction with Mr. Watt and others, pursued a lengthened course of experiments, with the view of determining the action of various gases upon the human system, when inhaled. Sir Humphrey Davy commenced his career as a chemist in the capacity of assistant to Dr. Beddoes, at the Pneumatic Institution, which was established at Clifton, about the year 1796, for the administration of gases.

More recently renewed interest has been excited with reference to the subject of inhalation, in consequence of the remarkable effects which have been found to result from the administration of the vapours of ether and chloroform.

It is probable that other substances, besides those which have hitherto been used in this way, will be found to admit of advantageous application, by administering them in a gaseous state through the lungs; and as chemists may expect to be applied to for assistance in devising the best methods of operating in such cases, it may be well to direct attention here to some of the conditions essential to the successful administration of gases, vapours, and fumes.

The terms *gas*, *vapour*, and *fume*, will be here used in their popular significations. By the term *gas* is meant an aëriform fluid which retains this condition at all ordinary temperatures. The term *vapour* is used to signify a solid or liquid body which has assumed the aëriform condition under the influence of heat, but which would return to its original state when exposed to a diminished temperature. The term *fume* signifies a vapour in the act of condensation, the condensed particles being still suspended in the surrounding air. Fumes are therefore distinguishable from gases and vapours in being visible, and more or less opaque. Medicinal agents are administered by inhalation in each of these three states.

Among the gases which have been employed therapeutically, are oxygen, nitrous oxide, and chlorine. These substances, as the term applied to them indicates, being permanently aëriform, may be collected and retained, unmixed with other matter, in vessels suitable for their reception. They are administered either in a pure or a diluted state.

*Oxygen gas* has been sometimes given alone, but more frequently mixed with a portion of atmospheric air. The admixture may be made with perfect accuracy, by means of the usual pneumatic apparatus, and the mixed gases may be inhaled from a bladder or an oiled silk bag, or directly from a gasometer.

*Nitrous oxide gas*, like oxygen, is given either alone or mixed with atmospheric air. It is generally inhaled from a bladder or oiled silk bag.

*Chlorine* cannot be administered alone. Even when considerably diluted with common air the attempt to inhale it might prove fatal to the individual. Extremely minute quantities only, mixed with air, can be safely taken into the lungs. The usual and best method of administering this gas is, to put some warm water into the bottom of a bottle, such as fig. 406, furnished with two glass tubes inserted through a cork; to add about half an ounce of an aqueous solution of chlorine to the water; and then to inhale through the bent tube. The mouth-piece is not required in this case, the inhalation being effected from the open end of the bent glass-tube. As the patient draws air out of the bottle through this tube, fresh air from without enters through the straight tube, and, passing in bubbles through the liquid, it carries a portion of chlorine with it, and thus becomes sufficiently charged with the gas. There is no danger, in this way, of getting too strong a dose.

The vapours of water, of acetic acid, of the volatile constituents of certain plants, of tar, &c., have long been occasionally applied by inhalation; and within the last year or two the vapours of ether and chloroform have been extensively administered in the same way, as anæsthetic agents. In all these cases the substances administered are incapable of existing in the aëriform state at the temperatures at which they are inhaled, if exposed to the pressure of the atmosphere, and unmixed with permanent gases.

A liquid, water for instance, does not assume the aëriform condition, so as to be capable of resisting the pressure of the atmosphere and occupying a space free from other matter, unless it has a large quantity of heat in combination with it, and is maintained at a temperature of at least 212°. Pure steam, therefore, cannot exist, under the pressure of the atmosphere, at a lower temperature than 212°. When the temperature falls below this point, condensation commences, and the *vapour*, which was invisible, becomes, under certain circumstances, converted into a *fume*, which is visible steam containing a great number of minute globules of water, resulting from the condensation.

Other liquids, besides water, have certain temperatures at which they are capable of maintaining the aëriform condition under the pressure of the atmosphere, and these temperatures are called their boiling points, the boiling of a liquid being the result of its transition from the liquid to the aëriform state. Thus, ether boils at about 96°, and chloroform at 141°; and at these, but not at lower temperatures, the vapours would be capable of occupying spaces free from other matter, and of being inhaled in a pure state.

But the vapours of many liquids, in common with gases, have a tendency to diffuse themselves through aëriform fluids, and if the space into which this diffusion takes place be occupied by a permanent gas, the diffused vapour will be capable of maintaining its aëriform condition under pressures and at temperatures at which it could not otherwise exist in this state. Thus, although the vapour of water is incapable of occupying a space free from other matter, under the pressure of the atmosphere, at a lower temperature than 212°, yet its vapour diffuses itself into atmospheric air and other permanent gases, and thus maintains the aëriform condition, at all common temperatures. So in like manner, the vapours of ether, of chloroform, and other volatile liquids, readily diffuse themselves into air and gases generally, at low temperatures, and they thus become permanently aëriform under such conditions.

It is in the state of diffusion with atmospheric air that the volatile substances now under notice are administered by inhalation. The diffusion of the vapour of water, at temperatures below the boiling point of that liquid, has been already alluded to in treating of spontaneous evaporation, at page 76, but the object there has been to shew how diffusion affects the loss of a volatile liquid from an open vessel. Here, we have to consider the circumstances affecting the accumulation of the vapour of a volatile liquid in a space previously filled with air. These circumstances may be thus briefly stated.

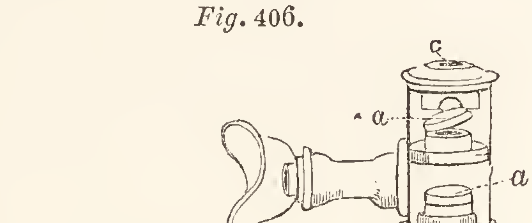
If a jar, partly filled with dry air, be inverted over water in the pneumatic trough, and left there for some time, a portion of the water will become converted into vapour, and this will diffuse itself equally throughout the air, and will increase the volume of the aëriform contents of the jar, displacing part of the water. At length, the further accumulation of the vapour of water will cease; diffusion will now have taken place to the greatest extent possible under the circumstances. During the formation of the vapour of water, which thus becomes diffused into the air of the jar, a reduction of temperature takes place, in consequence of some of the sensible heat of the air and vaporizing liquid being rendered latent in the transformation of water into steam. The diffusion, however, will not permanently stop until the heat of the air in the jar has become equalized with that of surrounding objects, for the temperature of the air will be found to set the limit to the extent of diffusion. If, after diffusion has ceased, the temperature be reduced, a portion of the vapour will immediately be condensed; or if, on the other hand, the temperature be raised, a further portion of water will pass into vapour, which will undergo diffusion. The extent of surface of the liquid exposed to the air will influence the velocity with which diffusion takes place. The greater the surface exposed, the more rapid will be the vaporization and consequent diffusion.

Such are the conditions which are found to influence the diffusion of the vapour of water, and the same conditions principally affect the results in other cases.

The quantity of the vapour of a volatile liquid that can diffuse itself into a given space filled with air will depend upon the temperature maintained by the mixed atmosphere. It will be equal to the quantity that would diffuse itself into a vacuous space at the same temperature. The quantity will vary, however, at any one point of temperature, according to the nature of the liquid.

The velocity with which the diffusion of the vapour of a volatile liquid takes place into a given space filled with air, will depend upon the nature of the liquid, the extent of surface exposed, and the temperature at which the diffusion occurs. It will be much less rapid than it would be if it took place into a vacuous space.

*Fig.* 406.



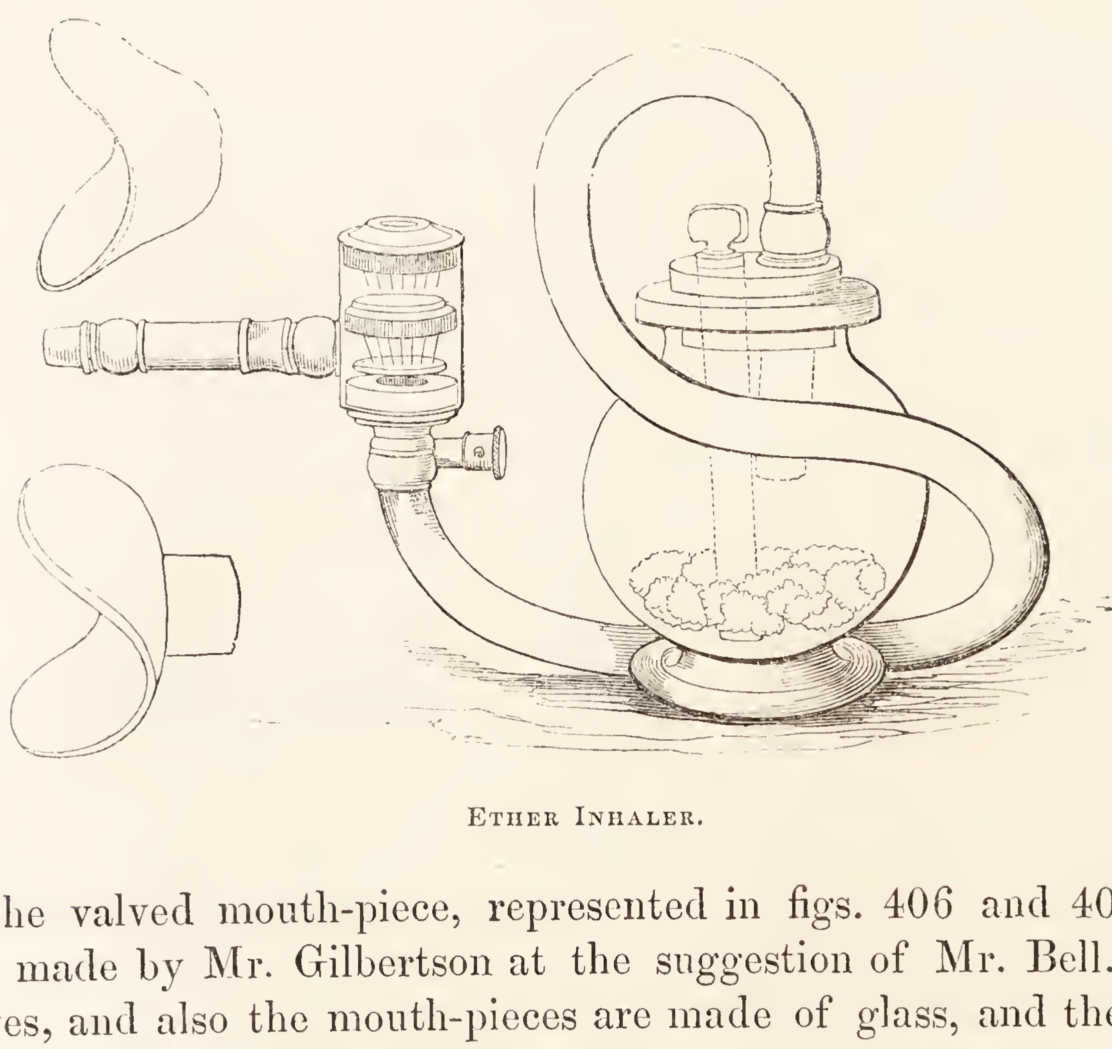

INHALER.

The most generally applicable form of apparatus for the purpose of administering diffused vapours by inhalation, is that represented in fig. 406. It consists of a wide-mouthed bottle, to which two tubes are adapted by means of a cork. The straight tube dips into the liquid at the bottom of the bottle, and is open at both ends; the bent tube passes only into the upper part of the bottle, and the other end of it is applied to the mouth. Its use in this way has been already described in alluding to the inhalation of chlorine. The same form of apparatus has been employed for inhaling the vapour of ether. In this case the ether is allowed to float on the surface of some water at the bottom of the bottle, and the vapour, having diffused itself into the air above, is inhaled through the bent tube, to the end of which the valved mouth-piece is attached. The latter is intended to prevent the expired air from passing into the apparatus. The valves *a* and **a*, are two disks of glass, each resting on a short piece of tube, and the whole contained in a larger tube, the opening to the mouth-piece being midway between the two valves. On inspiring, the lower valve opens and the upper one remains closed; on expiring, the lower one is closed, and the upper valve opens, and allows the expired air to pass out through the orifice *c*.

Inhalers are made on the above principle, but without the valved mouth-piece, in metal, and such are used for inhaling the vapour of hot water, acetic acid, &c.

In administering the vapour of ether, it is desirable to promote rapid vaporization and diffusion, and for this purpose a more extended evaporating surface is required than the stratum of liquid at the bottom of the bottle presents. This is provided by introducing into the bottle some pieces of sponge wetted with ether, as shewn in fig. 407. This apparatus is similar in principle to the preceding. The straight tube through which the air enters the apparatus is furnished with a stopper by which the loss of ether is prevented when the apparatus is not in use.

*Fig.* 407.



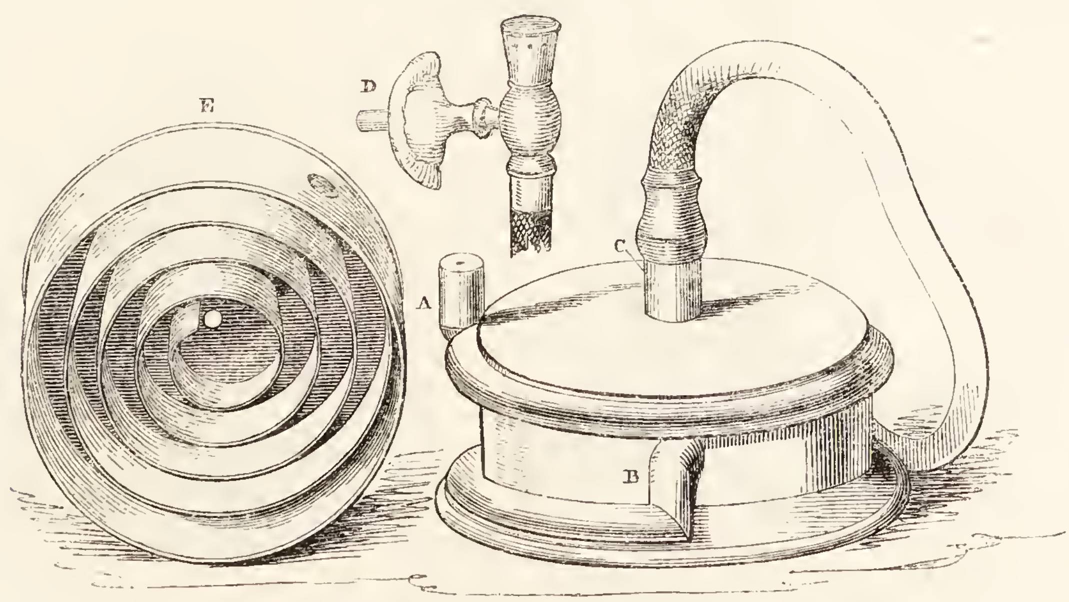
Ether Inhaler.

The valved mouth-piece, represented in figs. 406 and 407, was first made by Mr. Gilbertson at the suggestion of Mr. Bell. The valves, and also the mouth-pieces are made of glass, and the latter may be taken off and washed after using the instrument. There is a great advantage in the glass valves, which is, that the operator can judge, by the action of the valves, which are visible, of the quantity of vapour that the patient is inhaling. When the inhalation ceases, the valves, of course, remain closed.

Dr. Snow has recommended a form of apparatus for inhaling ether, which, in addition to an extended evaporating surface, offers facilities for regulating the temperature, and thus enables the operator to judge of the proportion of ether vapour contained in the inspired air. Fig. 408 represents this inhaler.

It consists of a round tin box, two inches deep, and four or five inches in diameter, with a tube of flexible white metal, half an inch in diameter, and about a foot and a half long, coiled round and soldered to it. There is an opening in the top of the vessel, at its centre, for putting in the ether, and afterwards attaching the flexible tube belonging to the mouth-piece. In the interior is a spiral plate of tin, soldered to the top, and reaching almost to touch the bottom. When used, the inhaler is to be put in a hand-basin of water, mixed to a particular temperature, corresponding to the proportion of vapour that the operator may desire to give; and the caps being removed, and the mouth-piece attached, when the patient begins to inhale, the air gains the desired temperature in passing through the metal pipe; it then comes upon the surface of the ether, where it winds round three or four times before entering the tube going to the mouth-piece, thus ensuring its full saturation, and preserving it at the desired temperature. There is no valve, or any other obstruction to the air, till it reaches the mouth-piece, which is of the kind used in other inhalers, and contains the valves necessary to prevent the return of the expired air into the apparatus.

*Fig.* 408.




ETHER INHALER.

A. Opening of pipe at which the air enters.
B. Termination of pipe in the tin box.
C. Point at which the flexible tube is removable by unscrewing.
D. Mouth-piece.
E. Tin vessel, with the bottom removed, to shew its interior.

Dr. Snow has published the following table, which indicates the proportions of ether vapour and air in saturated mixtures at the several temperatures named.

| Temp. Fahr. | CUBIC INCHES. | | WEIGHT IN GRS. | | Temp. Fahr. | CUBIC INCHES. | | WEIGHT IN GRS. | |
|---|---|---|---|---|---|---|---|---|---|
| | Ether. | Air. | Ether. | Air. | | Ether. | Air. | Ether. | Air. |
| 40° | 24·3 | 75·7 | 19·1 | 23·1 | 66° | 45·3 | 54·7 | 35·7 | 16·6 |
| 42 | 25·6 | 74·4 | 20·1 | 22·7 | 68 | 47·4 | 52·6 | 37·3 | 16·0 |
| 44 | 27·0 | 73·0 | 21·2 | 22·2 | 70 | 49·4 | 50·6 | 38·9 | 15·4 |
| 46 | 28·3 | 71·7 | 22·3 | 21·8 | 72 | 51·5 | 48·5 | 40·6 | 14·7 |
| 48 | 29·7 | 70·3 | 23·4 | 21·4 | 74 | 53·6 | 46·4 | 42·2 | 14·1 |
| 50 | 31·2 | 68·8 | 24·6 | 20·9 | 76 | 56·0 | 44·0 | 44·1 | 13·4 |
| 52 | 32·7 | 67·3 | 25·8 | 20·5 | 78 | 58·4 | 41·6 | 46·0 | 12·6 |
| 54 | 34·3 | 65·7 | 27·0 | 20·0 | 80 | 61·0 | 39·0 | 48·1 | 12·0 |
| 56 | 36·0 | 64·0 | 28·3 | 19·5 | 82 | 63·7 | 36·3 | 50·2 | 11·0 |
| 58 | 37·7 | 62·3 | 29·7 | 19·0 | 84 | 66·6 | 33·4 | 52·5 | 10·1 |
| 60 | 39·5 | 60·5 | 31·1 | 18·4 | 86 | 69·5 | 30·5 | 54·8 | 9·3 |
| 62 | 41·4 | 58·6 | 32·6 | 17·8 | 88 | 72·5 | 27·5 | 57·1 | 8·3 |
| 64 | 43·3 | 56·7 | 34·1 | 17·3 | 90 | 75·6 | 24·4 | 59·6 | 7·4 |

At about 45° the *weights* of vapour of ether and of air are equal, and at a little above 70° the *volumes* are equal.

The weights are calculated with the barometer at thirty.

For the inhalation of the vapour of chloroform, of which only a very small quantity is required to produce the desired effect, more simple forms of apparatus than those used for ether, are employed. A handkerchief, twisted into a hollow cone, moistened with a few drops of chloroform, and held over the mouth of the patient, is the usual method adopted for administering this vapour in Scotland by Dr. Simpson, and other eminent surgeons.

*Fig.* 409.

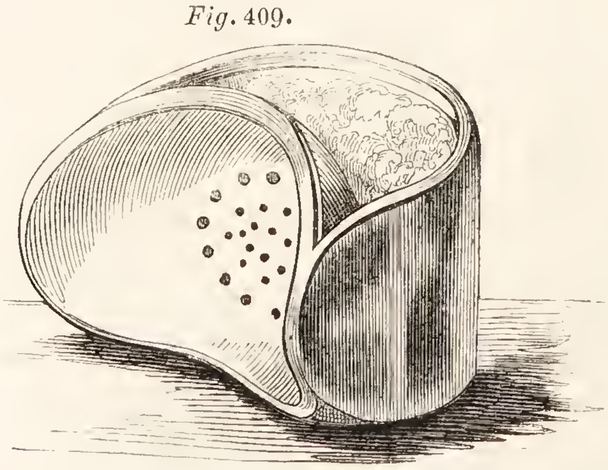
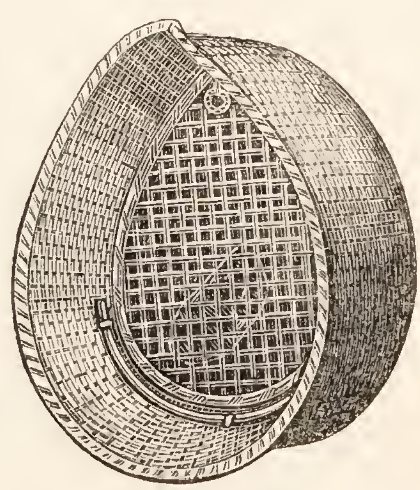


*Fig.* 410.



CHLOROFORM INHALERS.

Figs. 409 and 410 represent chloroform inhalers. The former consists of a perforated metallic plate, which is placed over the mouth of the patient, and in front of which there is a trough containing some sponge moistened with chloroform. This apparatus also answers very well for administering the vapour of ether. The apparatus fig. 410 is made of basket-work. A sponge, wetted with chloroform, is put into the inner part of the apparatus, and this is covered by a diaphragm, which intervenes between it and the mouth of the patient.

Dr. Snow uses an inhaler for administering the vapour of chloroform, which is constructed on a similar principle to that of his ether inhaler, so that a regulated temperature can be maintained during the process. He states that 100 cubic inches of air will take up the following quantities of the vapour of chloroform at the temperatures indicated :—

| Temperature. | Cubic inches. |
|---|---|
| 50° | 9 |
| 55 | 11 |
| 60 | 14 |
| 65 | 19 |
| 70 | 24 |
| 75 | 29 |
| 80 | 36 |
| 85 | 44 |
| 90 | 55 |

The vapour of tar has been administered by boiling common tar, together with some water, over a lamp or chaufer in the apartment occupied by the patient, and allowing the vapours to diffuse themselves through the room.

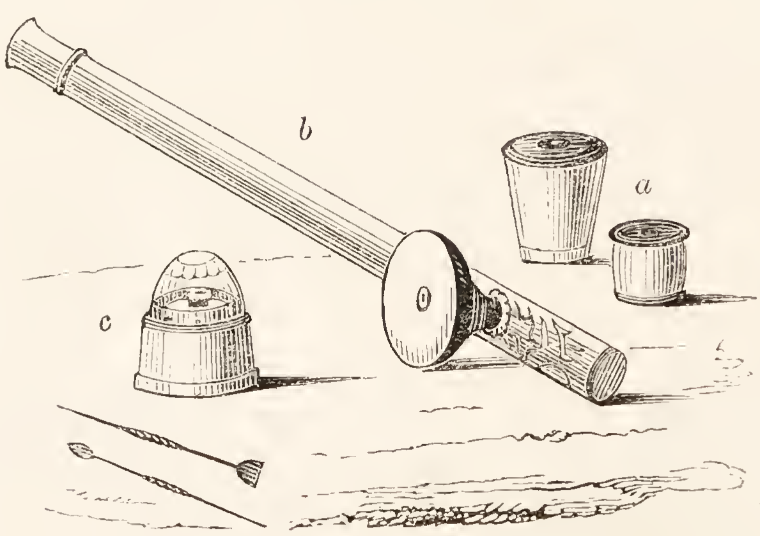
There are some substances which are occasionally administered by inhalation, but which cannot be introduced into the lungs as perfectly aëriform fluids, in consequence of their existing in that state only at high temperatures, and being incapable of diffusion. They are, therefore, inhaled as *fumes*, the vapours being more or less condensed, and the resulting solid or liquid particles being suspended in the air, and thus conveyed to the lungs. Sulphuret of mercury is sometimes administered in this way, and it is thus also that orpiment has been inhaled. The inhalation is usually effected in cases such as those named by sprinkling the substance, in powder, on to a hot brick or a hot iron, such as a shovel which has been heated to dull redness in the fire, while the patient inhales the fumes which are carried upwards in the current of heated air. Any attempt to convey the fumes through a tube, unless there be a current of air passing through it, would be ineffectual. There are some cases, however, in which a tube is used for inhaling fumes, as for instance, in smoking tobacco.

*The smoking of opium* is an operation in which an active medicinal agent is administered by inhalation in the form of fume or vapour. The great energy exerted by the active principle of the opium under these circumstances, seems to indicate that medicines, not usually accounted volatile, might be thus applied with advantage.

Fig. 411 represents the apparatus employed in China for smoking opium, and it may suggest the application of suitable means in other similar cases. The opium is not used in its crude state; an aqueous extract of it is carefully prepared, which is kept in small pots (*a*). The pipe (*b*) consists of a wooden tube, near to one end of which is fixed an earthen bowl, of a conical form, having a small aperture in the centre of the top. A lamp (*c*) is used in the process, and also the small iron instruments *d*.

The smoker having lighted the lamp, lays his head upon a pillow, and taking a small portion of the extract of opium upon the point of one of the instruments (*d*), he ignites it in the lamp, then introduces it into the bowl of the pipe through the aperture at the top, applies the bowl to the flame so as to heat it, and inhales the smoke at the open end of the tube. A whiff or two is all that is derived from a single charge of the pipe, and yet this is sufficient to produce the soothing effects of the narcotic drug.

*Fig.* 411.



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MEDICAL TUTOR IN UNIVERSITY COLLEGE, LONDON;

AND

A. B. GARROD, M.D.,

ASSISTANT PHYSICIAN IN UNIVERSITY COLLEGE HOSPITAL.


---

In introducing another work upon Materia Medica, in addition to those already before the public, the writers desire that it should be looked upon as strictly elementary; and, in so far as the description of the drugs is concerned, nothing more than a compilation. The necessity for this outline has been pressed upon them for some time by students with whom they are respectively connected, as well as by gentlemen in considerable practice, both of whom felt the inconvenience of reading through extended treatises, with a view to those essential points of instruction which might be conveyed in fewer words and be less encumbered with extrinsic matter. Without depreciating, then, the larger works in our language as books of reference, the present is intended to be one every word of which the student ought to read, and with whose entire contents he should render himself familiar.

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