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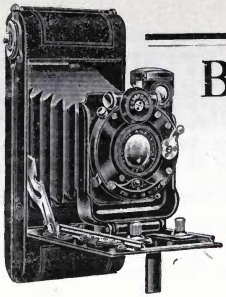

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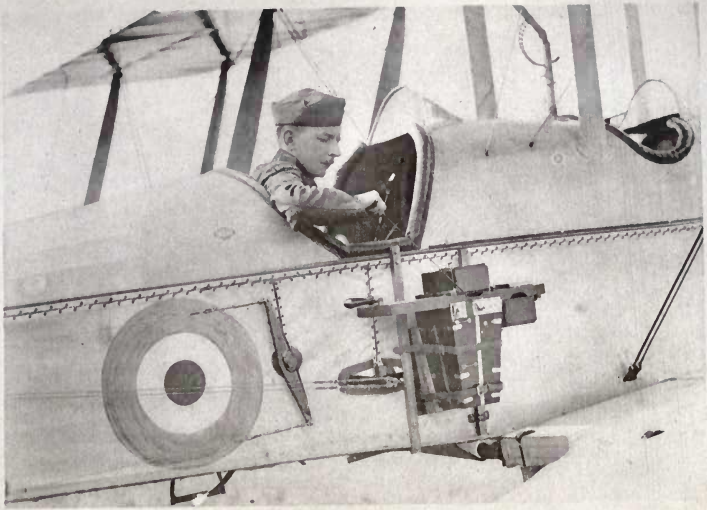

OPERATING AN AEROPLANE CAMERA

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PITMAN'S COMMON COMMODITIES
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PHOTOGRAPHY

AND ITS APPLICATIONS

BY

WILLIAM GAMBLE, F.R.P.S., F.O.S.

AUTHOR OF "LINE PHOTO-ENGRAVING"; EDITOR
OF "THE PROCESS YEAR BOOK"

LONDON: SIR ISAAC PITMAN & SONS, LTD.
BATH, MELBOURNE AND NEW YORK

Printed by Sir Isaac Pitman
& Sons, Ltd., London, Bath,
Melbourne and New York

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PREFACE

THE object of the author in writing the present book has been not to provide a guide or text book for those desiring to practise the art of photography, but rather to give in a popular manner an outline of its operations for the reader who seeks to know something about photography, without necessarily wanting to practise it. We believe there are many people who like to acquire knowledge of a subject simply for the sake of knowing in a general way "How it's done." It is for such people we have written this book, and we have endeavoured to divest it of detailed technicalities. The task has not been an easy one, and it would have been much less troublesome for the author to proceed on the usual lines of describing the processes with the completeness necessary to enable them to be worked from the instructions given. That would have meant a much larger book, for which probably there is no real need, as there are so many excellent treatises on the subject already published. The author has endeavoured to carry out the aim of the publishers of this series, and if the book should fall into the hands of some who are already well up in the subject, and who may consider there is little that is new in it, let them remember that there are many people who, not having had their advantage, may find such a book as this interesting and possibly useful.

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PHOTOGRAPHY

AND ITS APPLICATIONS

CHAPTER I

THE DISCOVERY OF PHOTOGRAPHY

If the average well-informed man were asked who was the discoverer of photography he would most probably answer by naming Daguerre, the inventor of the Daguerreotype. But though this famous Frenchman did a great deal for the advancement of photography he was not the actual discoverer of the photographic action of light.

The idea of forming an image in a camera originated long before photography, in the sense we know it, was thought of. It is probable, judging by the writings of the ancient philosophers, that the idea of forming an image in a darkened room by allowing light from the outside to pass through a tiny hole in a window shutter was known from the remotest period of civilization. This is the principle used down to the present day in the pinhole camera, though now employed only as a toy, or as a demonstration of the action of light, and it was on this principle also that the *camera obscura* was based. The words "*camera obscura*" are equivalent to "dark chamber."

Baptista Porta applied this principle in a practical way at Padua, in 1558. He replaced the dark chamber by a small box, and covered the tiny hole at one end of it with a lens, whilst at the other end was a screen

for receiving the image. Thus he had the elements of the modern camera. The apparatus was at first used merely as a scientific toy, but at a later date was used in a modified form for tracing the outlines of landscapes as a guide to artists.

An apparatus in the form of a table, with a glass top, underneath which was a camera having an inclined mirror to reflect the light upwards, is described in a book published in Paris in 1755. To work with the apparatus a sheet of tracing paper was laid on the glass top, and the lens of the camera pointed towards the view, so that the outline of the image could be then traced. Such a tracing-table is used at the present day by draughtsmen, and the inclined mirror is a feature of the Reflex camera, which is so largely used by press photographers.

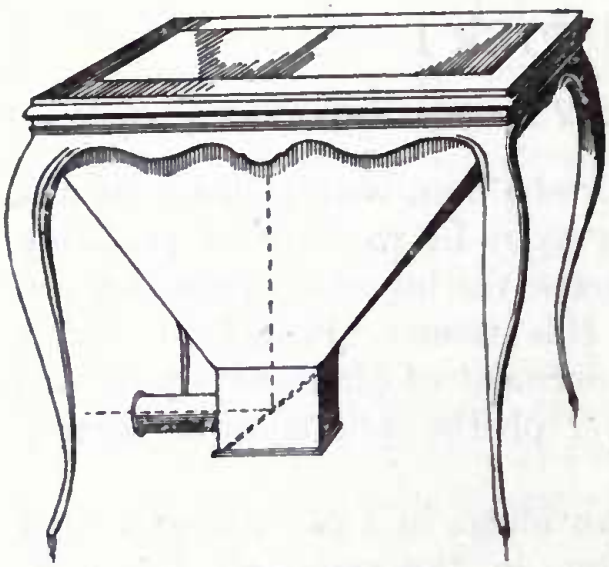

FIG. 1

TABLE CAMERA OBSCURA

It was quite natural when at a later date it was discovered that light could be made to darken paper coated with certain chemical compounds that efforts were made to fix the *camera obscura* image by receiving it on such sensitive paper.

These two things—the invention of the camera and the discovery of the action of light on chemically treated paper—constitute the genesis of photography, and all the advances to the present date have been in

the direction of improving the camera on the one hand and the sensitive surfaces on the other. It is noteworthy, that no difference in principle has been discovered—the camera still contains all the features of the *camera obscura*, and the sensitive surface is in the essential elements the same as when first discovered. The improvements have been in matters of detail, but the progress in that respect has been marvellous.

The principle on which photography is based is a combination of optics and chemistry. The optical side originated, as we have shown, in the *camera obscura*, and the chemical side of it was due to the discovery that light darkens silver compounds. This latter property was known as early 1556, in which year the old alchemist Fabricius records that he had observed the sun's rays had a blackening effect on horn silver—a crude form of silver found in the mines of Freiburg.

No practical deductions were made from this discovery until a much later period (about 1778), when Scheele, a Swedish chemist, entered upon a scientific investigation of this darkening action of light on silver chloride.

Other investigators confirmed the results of his experiments and extended the knowledge of the subject.

The earliest recorded attempt to produce a picture by means of this property of light and chemical action was by Professor Charles, at Paris in 1780. He caused a silhouette of one of his pupils to be cast upon a sheet of paper by means of a powerful ray of light. The paper, which had been treated with silver chloride, was darkened in the parts exposed to light whilst those portions which were in shadow remained white.

The first really practical and persistent efforts to make photographic pictures were by Thomas Wedgwood, a son of the famous potter. Working with the aid and under the advice of Sir Humphrey Davy he was

able to evolve a process which was published in the journal of the Royal Institution in 1802. It was described as "A method of copying paintings upon glass, and of making profiles by the agency of light upon nitrate of silver." The system employed was similar to that sometimes now used for obtaining prints of such objects as leaves, ferns, etc., by pressing them in contact with a sheet of sensitive paper and exposing to light. The result is a silhouette image in white on a dark background. Attempts were made by Wedgwood and Davy to obtain on the sensitive paper the image formed in the *camera obscura*, but these efforts met with no success, though some images were obtained in a similar way by means of the solar microscope. All endeavours to render the prints permanent were unsuccessful, and the experiments were apparently dropped.

A more definite step towards the realization of the idea of photography was taken by Joseph Nicephore Niepce, who began his researches as early as 1814, and to him much more deservedly than to Daguerre must be ascribed the lion's share of the honour of having discovered the first practical application of photography. Niepce wanted to apply the photographic image to stone for lithographic work, his idea being to supersede the tedious process of making a drawing on the stone. He was evidently aware of the previous experiments that had been made in photography, and his endeavour at first was to improve on them, but finding it impossible to render the image permanent he departed from the use of silver compounds and made use of Asphaltum, or bitumen of Judea as it was then called. Niepce found that if a thin film of this substance was exposed to light under any pattern which was in the nature of a silhouette or outline the parts which corresponded to the white or transparent patches became insoluble

in substances which dissolved bitumen. He coated pewter plates with bitumen and exposed them to light under paper prints. Then by flowing the plate with turpentine or similar solvent after exposure the soluble parts were washed away leaving the light-hardened parts which formed the picture. The image being a negative one the white lines were chemically blackened and then the bitumen ground was cleaned off, so that a permanent positive image was left on the plate.

Incidentally it may be mentioned that this was the foundation of the process of photo-engraving. The bitumen image being resistive of acids, the plate could be etched by applying an acid, and the result was the equivalent of the engraved steel and copper plates now used for printing etchings and engravings. A plate engraved in this way by Niepce in 1824 is still preserved in the museum of Chalons-Sur-Saone, France. Impressions from it are extremely good considering the early stage of the art when it was produced

Louis J. M. Daguerre, a scene painter, who invented a diorama in 1822, was smitten with the desire to fix the images of the camera obscura. He began his experiments in 1824, and his neglect of his scene painting and diorama business whilst devoting himself to photographic research led his wife to seek advice with regard to his sanity. Apparently he did not make much progress with his new idea, and having heard of the experiments of Niepce, which had been then going on for about fifteen years, joined the latter in partnership. The two worked together up to the time of Niepce's death in 1833, when the work was continued by his son. Five years after the death of the elder Niepce, Daguerre accidentally discovered the process which bears his name. It had been the practice of Niepce to darken his metal plates by the application of iodine, and this

blackening action only took place when the plates were exposed to light. Daguerre reasoned that if a silver plate treated with iodine was exposed in the camera an image would be obtained. This proved to be quite feasible, but the exposures were long and the image weak. One day Daguerre put in a cupboard a plate thus exposed, and forgot about it for a time; when he did chance to look at the plate he saw on it a strongly developed image, which he found to be due to the vapour from an open vessel of mercury in the cupboard. Soon after this it was found that the image could be fixed by the application of a solution of common salt.

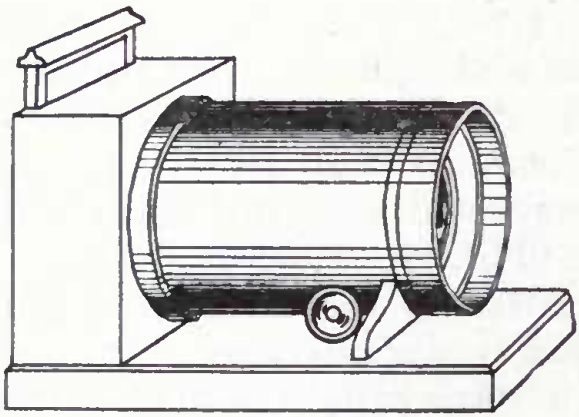

FIG. 2

DAGUERRE'S FIRST CAMERA

In 1839 Daguerre divulged the secret of his process and the French Government awarded him a life pension of six thousand francs (about £240), on condition that he did not patent his process. Apparently Daguerre concluded that this did not apply to England, and he took out a patent here, so that those who wished to work the process had to obtain a license to do so, paying a handsome sum for the privilege.

Long exposures, varying from 3 to 30 minutes, were required for making daguerreotypes, and various devices were adopted to get the best results. It was not an uncommon practice to whiten the face of the sitter in order to shorten the exposure for the face; and then in order to bring out the details of dark objects, such as the dress, a piece of black cloth attached to

a long stick was held in front of the sitter's face to prevent any further exposure of that portion taking place. Fig. 2 is a representation of Daguerre's first camera.

A contemporary illustration of a daguerreotype studio shows the sitter on a high platform under a skylight, and prevented from moving by head rest, back rest, and arm rests, showing that to have one's photograph taken in this way was a very trying ordeal.

An Englishman named Goddard found the means of reducing the exposure to a matter of seconds by making the iodized film more sensitive through the action of bromine vapour upon it. Chlorine vapour was found to have a similar effect. A further improvement in the process was toning or gilding the image by a solution of chloride of gold, which gave much greater brilliancy to the image.

This was as far as the daguerreotype was destined to go, and more rapid and convenient processes have relegated it to the limbo of obscurity. Recently an outfit for the process was sold in London for a few shillings.

Almost simultaneously with the work of Niepce and Daguerre a brilliant English investigator, Henry Fox Talbot, had been endeavouring on quite different lines to achieve photographic results, and his work embodies most of the basic principles of the photography of to-day.

Daguerre's process only yielded one picture for one exposure. Fox Talbot sought to obtain numerous prints on paper from the one exposure. By a process to which he gave the name of Calotype he made first a negative on paper by sensitizing it with silver iodide, afterwards treating it with a mixture of silver nitrate and gallic acid. The paper was exposed in the camera whilst still wet with the sensitizing solutions; the

exposure being greatly less than when the paper was dried. The image was then developed with a solution of gallo-nitrate of silver.

The negative image thus produced was used for making positive images by impregnating the paper with paraffin wax to render it translucent. It could then be placed in front of a piece of sensitive paper similarly prepared to that which was used for making the negative, and on exposure to light a positive image was obtained, the parts under the translucent portions of the negative darkening and so reversing the tones or shades. The process of making a print in this way could be repeated indefinitely, so that any number of copies of the original image could be obtained.

It was not long before the inconvenience of paper as a support for the sensitive film in making the negative was realized, and the happy idea of applying the sensitized coating to glass was formed in 1848 by Niepce de St. Victor, a nephew of J. N. Niepce, the pioneer of photography already referred to. In this method a glass plate was coated with a layer of albumen, containing iodide and bromide salts and this film was made insoluble by heat. It was then immersed in a nitrate of silver bath and exposed whilst wet, subsequently being developed in gallic acid and fixed. Positive prints could now be made by exposing through the glass negative.

A very important step which gave a great impetus to photography was made by the introduction of collodion as a vehicle for holding the sensitive compounds. For many years this process held its own for all classes of photographic work, even after the introduction of gelatine dry plates, and down to this day the process is very largely practised for making negatives for the reproduction of photographs, drawings, prints, maps,

etc. in the photo-mechanical processes so widely employed at the present day for illustration and other processes.

The first practical use of collodion was made by Frederick Scott Archer in 1850, though the idea was suggested earlier by others. We leave the details of this interesting process for a later chapter.

The Ferrotypes or Tintypes and the positives on glass, so extensively produced by itinerant photographers at sea-side and other holiday resorts, are modifications of the Collodion process, the negative image being simply made to appear whiter, so that it may show up against the black varnish on the metal or glass plate.

A modification of the Collodion process was that known as the Collodion Emulsion method which led directly to the invention of the modern gelatine dry plate. In the emulsion method the sensitive salts were mixed with collodion so as to save the necessity of bathing the plate in a silver solution. This enabled the plates to be dried (though they could be exposed wet by some modifications of the process.) It was thus possible with these dry plates to make pictures at any distance from the studio without the photographer having to take with him a portable dark room or tent for sensitizing and developing the plates on the spot.

Incidentally, it may be remarked, that it was found possible to make plates of much greater sensitiveness by the emulsion method than by the wet collodion. Very beautiful negatives were obtained by this process, but it had the drawback that the plates had to be prepared by the photographer himself, as the film was very fragile and the keeping quantities were doubtful. Several attempts to prepare the plates commercially met with little or no success.

The idea of replacing collodion with gelatine in the

emulsion process was the next in improvement ; and it has proved the most important advance in the whole history of photography, having been the means of bringing the process to its present pitch of perfection and to its universally popular application.

It was whilst the Collodion process was at the zenith of its success that many workers devoted their attention to the problem of finding a more convenient and less dangerous medium than collodion, which is very inflammable. To Dr. R. L. Maddox, of Southampton, belongs the honour of having, in 1871, first published particulars concerning the use of an emulsion consisting of gelatine and bromide of silver.

Other investigators pointed the way to practical improvements in the process, such as the method suggested by Mr. Charles Bennett for keeping the emulsion at a high temperature to increase its rapidity and that of Monckhoven of ripening it by the addition of ammonia, the latter process being more universally used, we believe by the plate makers.

By successive improvements in the manufacture of dry plates marvellous rapidity has been attained until exposures of $\frac{1}{1000}$ second are readily obtained under suitable conditions.

It only remains now to record the final step in the progressive improvement of the negative-making side of the process, viz., the use of celluloid in place of glass plates. This has rendered possible the marvellous achievements of cinematography.

The first celluloid roll film was introduced in 1889 by the Eastman Co., of Rochester, N.Y. Though not the first to conceive the idea of using celluloid film as a support for emulsion, credit must be given to Mr. George Eastman, the founder of the Kodak Company for the immense developments in film photography,

which have certainly been due to his patient and persistent efforts to popularize it.

Concurrent with these advances in the production of the negative there have been equally important improvements in the sensitive papers used for the production of the prints. These will be referred to in later chapters. Suffice it to say that there are now many other substances besides silver compounds which are sensitive to light and are now made use of in photographic processes. Salts of the metals platinum, chromium, and iron, in particular are largely used.

The improvements in the camera and its accessories can hardly be outlined here, and this part of the subject must be left for succeeding chapters describing the apparatus used.

CHAPTER II

THE CAMERA AND LENS

BEFORE proceeding to consider in fuller detail the various processes of photography, it would seem to be fitting at this point, to consider the optical means employed for taking the photograph, as it is obvious that the sensitive material for receiving the image is subsidiary, in so far that it would be useless without the means of employing it.

We have seen in the previous chapter that the most rudimentary form of camera was a mere box with a pinhole (Fig. 3), and that this was improved by replacing the pinhole with a lens.

The reason for this alteration was that the pinhole did not admit sufficient light. The image, whether produced by a pinhole or by a lens, is formed by reflection of light from the object which is being photographed. Each part of the object sends its ray of light in a straight line through the pinhole or lens, and the corresponding point is illuminated on the focussing screen. A light part of the object gives a light part on the plate. A dark print on the object reflects no light and therefore the corresponding point is dark on the screen. Points of intermediate brightness give corresponding points of shade, and thus the points of brightness or darkness collectively form the image.

Now a ray of light passing through a pinhole is diminished in intensity in proportion to the size of the pinhole—the smaller the pinhole the feebler the light which reaches the plate.

It might be thought that this difficulty could be

overcome by making the pinhole larger; so it would, but it would also result in the image being less sharp. The effect is expressed as "fuzziness."

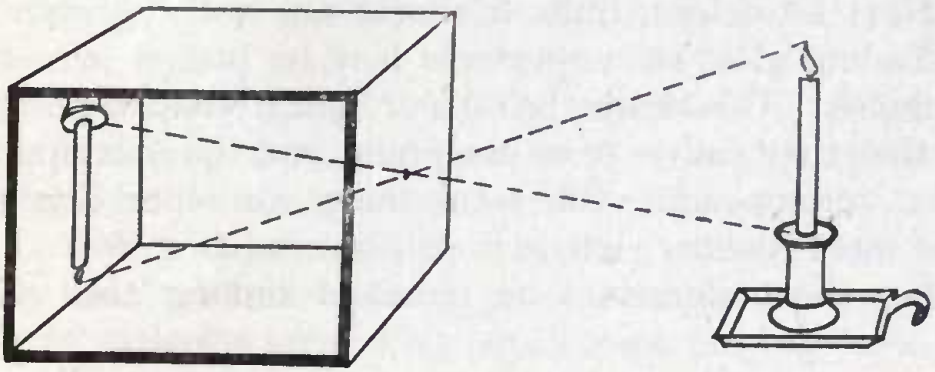

FIG. 3

THE PINHOLE CAMERA

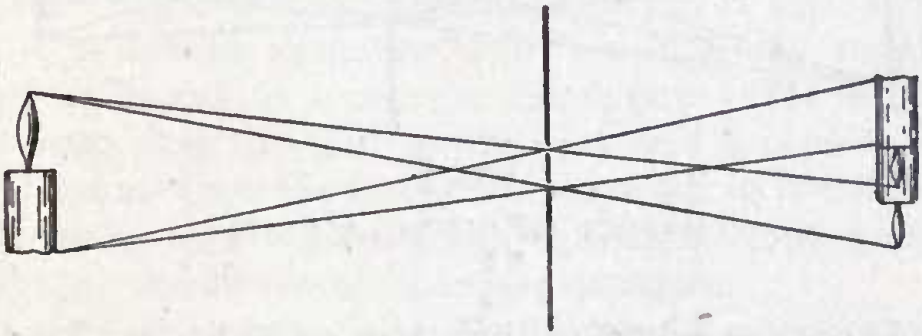

FIG. 4

EFFECT OF TWO PINHOLES

What would happen we may ask if a second pinhole were made a little distance from the first, say half an inch away? There would be two images formed overlapping each other, and where they overlap the image appears brighter (Fig. 4). Several further holes may be perforated between the two, until the circle of holes is like a pepper box lid. The images from the respective holes overlap each other, and it will be seen that there

is a brighter illumination over the whole screen, but the complete image is so blurred by the overlapping of the separate images that no picture can be distinguished.

Next let a lens, quite a simple one will do, such as a reading glass or a spectacle lens, be placed over the pinholes. This bends the rays of light from each pinhole so that they converge to one point, and the overlapping effect disappears. The total image becomes brighter and more distinct, but it is still blurred (Fig. 5).

Let the perforations be removed and replaced with

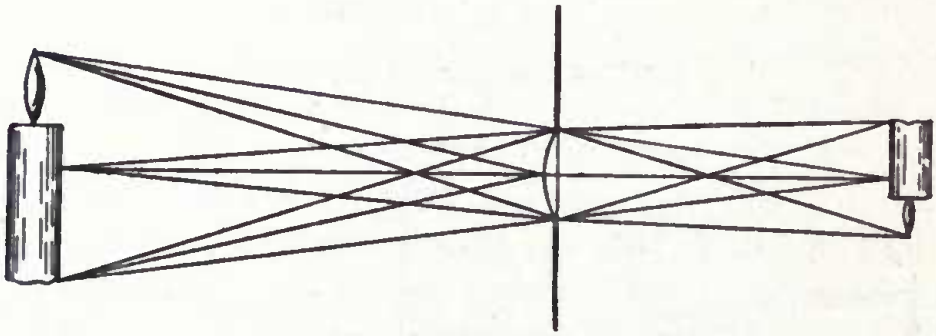

FIG. 5

EFFECT OF USING A LENS

a hole corresponding to their area so as to see that the lens will do alone. A brighter and clearer image is produced than with the pinholes, but still it is too indistinct.

What are the reasons for this ? One is that the image projected by a lens is not equally sharp for objects at all distances. In this respect it differs from the simple pinhole which focusses, though imperfectly, objects at all distances.

When using a lens the image must be "focussed," that is to say, the screen must be adjusted nearer to or further from the lens until a position is found where

the object to be photographed is defined most clearly. If there are other objects in the field of view, nearer to or farther than the principal object, they will not be in focus, and will be blurred.

Another effect produced by the simple lens is that only the central part of the image will be clear. The reason for this can only be fully explained by entering into the theory of lenses, but it may be simply explained by saying that a simple lens of the common type, such as is used in spectacles and reading glasses, does not bring the light rays which pass through the margins to a focus at the same distance as those passing through the centre of the lens.

We may overcome this disadvantage to a certain extent by reducing the size of the opening through which the rays pass before or after leaving the lens by inserting a piece of cardboard or metal with a hole in it of smaller diameter than the lens, this forming what is known as a stop, or diaphragm. The smaller we make this the sharper the picture will become, but at the same time the image will diminish in brightness, so that to take a photograph with a lens thus stopped down we should require a longer exposure.

A further drawback to the simple lens and camera is that if we attempt to take a high building and have to tilt the camera to get in the top of the picture the image will be distorted, the vertical lines converging to the top and forming a tapering picture. This is overcome by the use of the swing back.

Progress in the construction of cameras and lenses has accordingly been in the direction of devising means for overcoming these drawbacks. The simple box camera has been replaced by more or less elaborate arrangements for focussing, either by moving the back or front to and fro (or both alternatively, as in Fig. 7),

and the simple lens has been improved upon by adding to it other lenses for the purpose of correcting its faults.

Modern photographic lenses of the highest type consist of several simple lenses either in cemented combinations or with air spaces between them, the object being to secure the greatest possible rapidity, with freedom from distortion, sharp focus and covering power (Fig. 6).

Mechanical means have been devised for adjusting the aperture of the lens by means of diaphragms working on the iris principle, closing or opening by means of a milled ring or knob on the outside of the lens. This principle has been adopted in all modern lenses, the old method of using separate diaphragms, or a revolving plate with several apertures in it being entirely superseded.

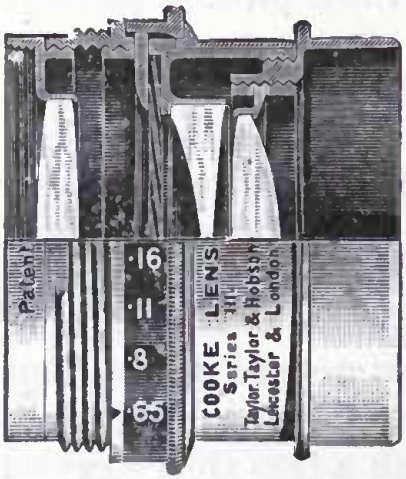

FIG. 6

A MODERN LENS

Owing to the increasing sensitiveness of plates it has been found necessary to provide means for readily and quickly uncovering and covering the lens to make the exposure. So long as lenses were slow working, and plates comparatively insensitive it was sufficient, to remove and replace the cap by hand, but such a method is obviously ineffective where the exposures are but a very small fraction of a second. Great ingenuity has consequently been expended on the construction of "shutters" for opening and closing the aperture of the lens (Fig. 8).

A further point which has given rise to much inventiveness is in the part of the apparatus which holds

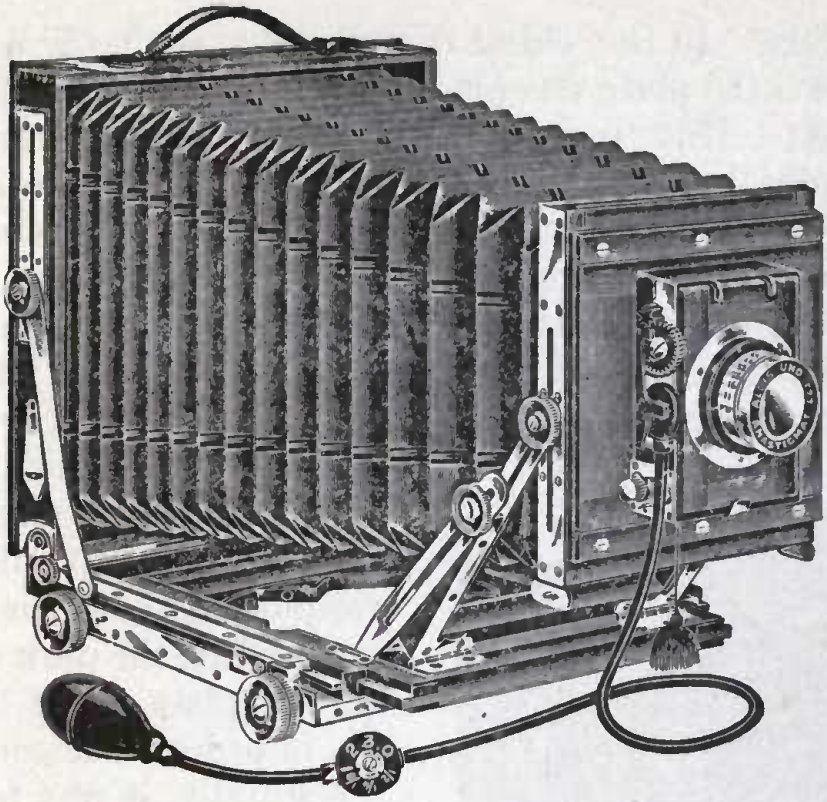

FIG. 7

MODERN CAMERA, BY BUTCHER & SONS, WITH FRONT AND BACK FOCUSSING PINIONS

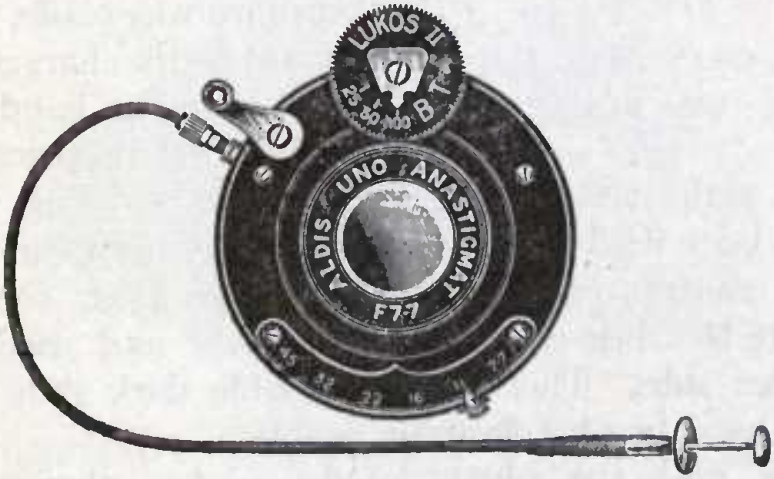

FIG. 8

LENS WITH SHUTTER AND IRIS DIAPHRAGM

the plate. In the oldest cameras it was simply a tray in which the plate was placed and closed up by a sliding shutter. This tray was attached to the camera, generally by sliding it into grooves—hence the name "dark slide," *i.e.*, a slide which keeps the plate in darkness before and after exposure. When the slide had been placed in the back of the camera the shutter was drawn so that the plate was exposed to the interior of the camera, until the moment arrived for uncovering the lens to allow the image to fall upon the sensitive surface. Then the shutter was pushed in and the slide removed to the dark room for the plate to be taken out in order to develop it.

FIG. 9

PLATE-CHANGING HAND CAMERA BY HOUGHTON'S

Naturally it was felt to be an inconvenience to have to go to the dark room to fill and empty the slide every time an exposure was made, unless several slides charged with plates were at hand.

The first improvement was to make the slide double, two plates being placed back to back with a light-tight separator between, and to have a shutter on each side, so that after the first exposure the slide could be turned over and used from the other side. This is the "double dark slide" still largely used in photographic practice.

When, with the advent of dry plates, photography began to be practised so largely for outdoor work the drawback of having to carry a number of slides was seriously felt, and efforts were made to construct

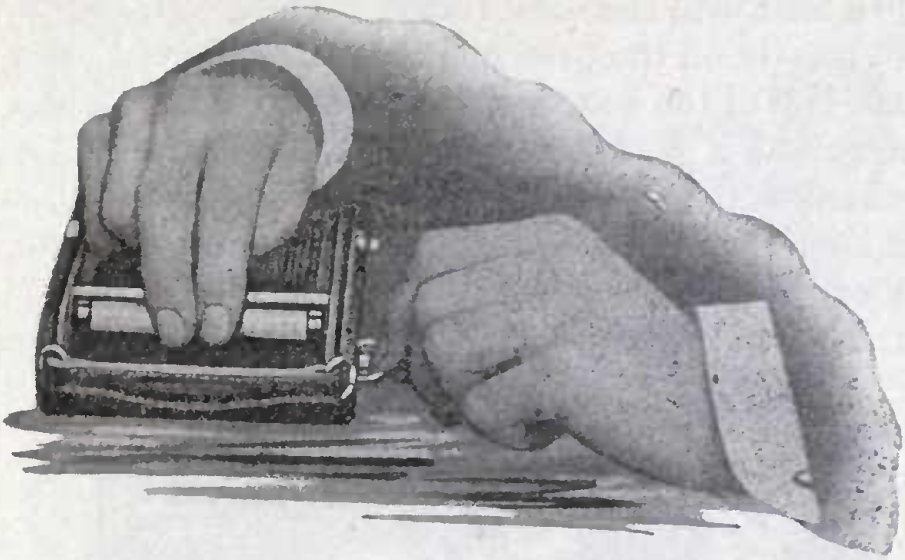

FIG. 10

REMOVING THE EMPTY SPOOL FROM A KODAK ROLL-FILM CAMERA

FIG. 11

INSERTING A NEW FILM IN A KODAK CAMERA

changing boxes to empty and refill the slides without having to return to the dark room. These changing boxes were mostly on the principle that the slide was attached to the top of the box, a shutter was withdrawn, and the plate allowed to fall into the box. There was some mechanism to enable the plate to be got out of the way and a new plate to fall into the dark slide by turning the box over.

Some of the boxes were, however, fitted with changing

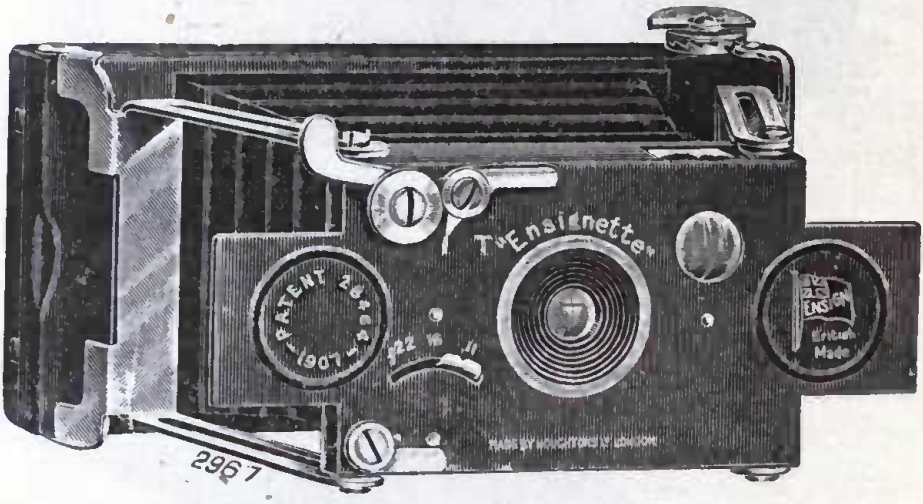

FIG. 12

THE ENSIGNETTE WAISTCOAT POCKET CAMERA

bags into which the hands could be thrust for manipulating the plate ; or the plate was drawn into the bag and the latter manipulated from the outside to push the exposed plate into a groove at the back of the box.

These changing boxes are now seldom used, the mechanism for changing the plates having been introduced into the back of portable cameras (Fig. 9). Moreover the roll film cameras have largely superseded plate cameras where extreme portability is demanded. Figs. 10, 11 show the extreme simplicity of the film-changing arrangements of a Kodak film camera.

The " Ensignette " (Fig. 12) is a type of waistcoat

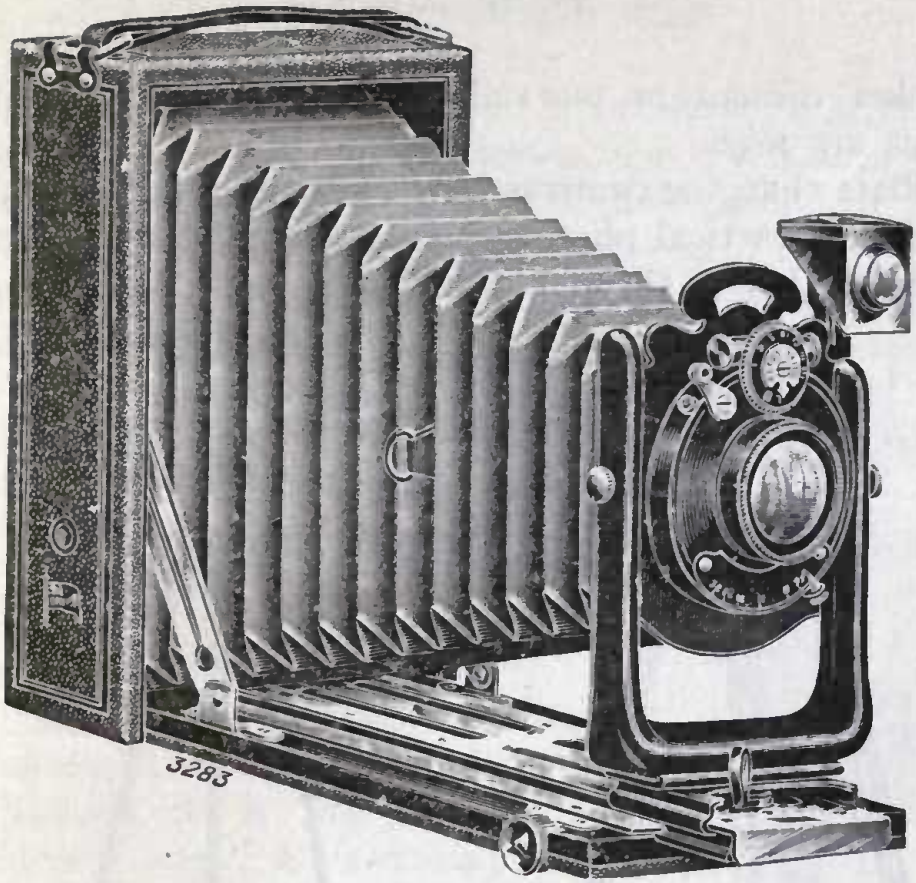

FIG. 13

A PORTABLE CAMERA BY HOUGHTON'S FOR METAL DARK SLIDES

FIG 14

A CHANGING BAG

pocket camera of marvellous compactness, in which films are used.

Plate changing cameras have really gone out of favour and the practical photographer has come back to dark slides, either of the single or double variety. In small

FIG. 15
HOUGHTON'S WOODEN FOLDING TRIPOD

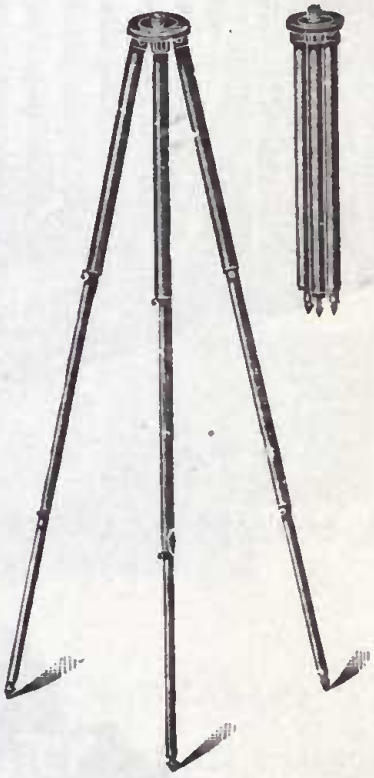

FIG. 16
HOUGHTON'S ALUMINIUM TELESCOPIC TRIPOD

cameras (such as Fig. 13) the single slides are often made of thin metal rendering them very portable, so that a number can be carried in the pocket and one slipped into the camera when wanted.

The changing bag is an expedient which can be usefully employed on tour or where otherwise the dark room

is inaccessible. It is simply what may be termed a sack of black cloth, with sleeves in it for inserting the hands, and a flap to put the dark slide and box of plates through. The operator soon gets into the way of manipulating the plates by feeling instead of sight, and the dark slides are readily emptied and refilled. Some changing bags are made with a window of non-actinic glass or fabric, and an aperture for looking inside, but experienced operators consider these additions introduce a risk of fogging the plates, and regard them as unnecessary complications (Fig. 14).

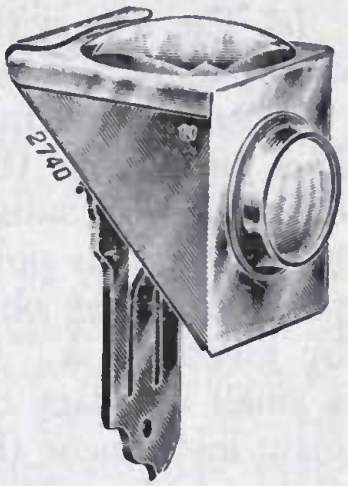

FIG. 17

A HOUGHTON FINDER

One other accessory of the camera should be mentioned, although it is not now considered such a necessity as formerly, viz., the stand on which the camera is placed to keep it steady for the exposure. This stand is usually in the form of a tripod, the three legs of which are made folding or sliding—or with both movements combined—so as to make it as portable as possible. The extreme of portability is reached in the aluminium telescopic tripods made for small hand cameras (Figs. 15, 16).

With increasing rapidity of plates and faster working lenses the tripod has become less and less a necessity, because small cameras can be held in the hand during the extremely short exposures required for instantaneous work, though, of course, for architecture, landscape and other kinds of work requiring careful adjustment of focus and exact position the stand has still to be used.

Whatever differences of detail there may be in various

styles of camera it will be found that each has the same fundamental features, viz. :

(*a*) The dark chamber either solid or formed partly with a bellows.

(*b*) The ground glass frame on which the image is focussed.

(*c*) The dark slide for holding the plate.

(*d*) A means of moving the plate or lens to and from each other to focus the picture.

(*e*) The lens, with which is usually incorporated the diaphragms and shutter.

Where a camera differs from these general features it is usually in the direction of dispensing with the dark slide by substituting a plate magazine or a film holder, and in omitting the ground-glass frame, the position of the object in the latter case being found by means of a "finder" which may be regarded as a small auxiliary camera on top or at the side of the main instrument (Fig. 17). The focus is adjusted to a scale, which enables the estimated distance of the object to be allowed for. In many of the cheaper cameras there is no focussing mechanism, these being known as "fixed focus" cameras. It is assumed that all objects beyond a certain minimum distance are in focus or approximately so. In some cases the lens is fitted in a focussing mount in the form of a quick thread screw or spiral in the tube, so that it can be adjusted instead of having to move the plate end or front of the camera.

CHAPTER III

THE DARK ROOM AND ITS EQUIPMENT

IT is, of course, essential that the photographer should have at his command some form of dark room, for though there were in the old days, portable developing tents or boxes and there have been various inventions brought out for developing without a dark room, the great bulk of photographic work is in fact done with the aid of this somewhat inconvenient but still very necessary adjunct.

The dark room may be any room or cupboard that may be darkened, or, correctly speaking, from which all white light can be excluded. This does not mean that the photographer works without light at all. He takes advantage of the fact that the sensitive plate is fully sensitive only to certain kinds of light. Such light is that of daytime, or the artificial light we normally use to see by.

Now the photographic plate of ordinary sensitiveness is not very susceptible to yellow light, and is much less so to a ruby red light. Consequently the photographer can safely illuminate his dark room with the latter kind of light, and, for less sensitive materials he can use a yellow or orange light. Thus his dark room can have a coloured window, or a lamp screened with a suitable colour. In such light he can see very well to put the plates into the dark slides and to carry out the operations of development.

If possible the dark room should have a sink (such as Fig. 18) with waste outlet and water tap, but amateurs often have to dispense with these conveniences, using a

jug for their supply of water and a pail for the waste. Photographic work on a limited scale can in fact be done with the very simplest means, even without a dark room, if one is content to wait until nightfall so as to secure natural darkness.

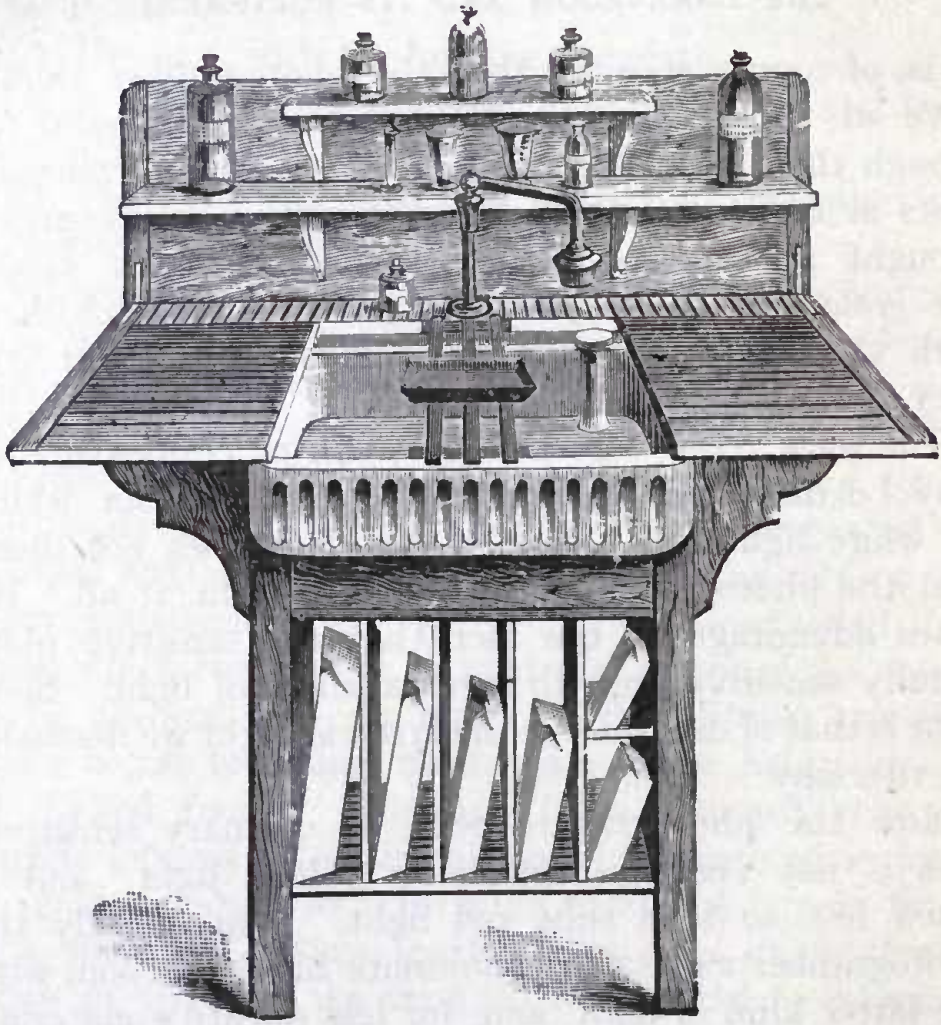

FIG. 18

A DARK-ROOM SINK BY HOUGHTON'S

Special forms of shallow trays or dishes to fit the standard sizes of plates are used for the development and other operations. These trays are either of porcelain, glass, papier-maché, vulcanite, enamelled steel, or other water-tight and chemically-resistive material.

Such trays are not an absolute necessity, but are a great convenience, and are economical by reason of entailing the use only of a minimum amount of solution.

Glass measures graduated in ounces and drachms are desirable for ensuring the correct proportions of the solutions being employed. A set of scales and weights is also regarded as a necessary part of the photographer's equipment. Such refinements of accuracy have, however, become less necessary since the introduction of "Tabloid" and "Cartridge" chemicals and ready-made solutions. Numerous articles more or less convenient for facilitating dark room operations are sold, but are not really essential, for plates can be developed, fixed, washed, and dried with no other aids than are usually found in the household. It would, though, be like carrying out chemical experiments with crude make-shifts and would not be conducive to the best results, nor to ease of working.

The extent to which the working apparatus is elaborated depends a good deal on the temperament of the worker. Starting as an amateur with the most elementary appliances the apparatus gradually accumulates if the early enthusiasm survives.

The worker who seeks to know the why and wherefore of the operations and who desires to achieve the best results naturally proceeds step by step trying every process and using every means offered. Thus we now find in the dark rooms of the most careful and advanced workers such things as special clocks for recording the time of development with means for arriving at the time factors suited for different makes and speeds of plates: also special thermometers for determining the temperature of the solutions. Such appliances are particularly necessary where the system of tank development (described in a later chapter) for plates or films is adopted.

Special attention should be paid to the illumination of the dark room. Instead of relying on the conventional ruby or yellow glass, various forms of " safe lights" are now available. These consist of a coloured film of gelatine or collodion between two glass plates bound together at the edges. The safe lights are best employed in a special form of lantern giving illumination by reflected light, instead of the light being directly behind the coloured glass.

The ventilation of the dark room is a matter to which little attention is paid as a rule, but it is important where much work has to be done in the dark room. Traps which allow air to pass whilst excluding light can be made, or special forms of metal cowls to fit on to ventilating pipes can be obtained.

Warming the dark room in winter time is not less essential, both for comfort and for ensuring uniform conditions of temperature for the working of the chemicals. Electric heating is ideal but expensive and not usually available. Gas stoves can be obtained which give off no light, but on account of the fumes they emit it is best to place them in another room and conduct the heat through an opening in the wall. A good way to secure heat with the additional convenience of being able to dry negatives quickly is to have a drying cupboard in the dark room.

CHAPTER IV

THE SENSITIVE PLATES—WET COLLODION PROCESS

THE photographer of the present day has become so accustomed to using, and hearing used, the term "dry plates" that he probably never gives a thought to what the name implies, viz., the contra-distinction to "wet plates," which as we indicated in our opening chapter was the older form of photography.

Now, although dry plates are used at the present time for all the ordinary purposes of photography, it is a fact that the wet collodion and collodion emulsion processes are still very largely used in reproduction work, and this book would not be a complete record of photographic work without at least an outline of these methods.

It may be perhaps a matter of surprise to the reader who is only acquainted with the modern dry plate that anyone should take the trouble to employ such apparently slow and tedious methods as wet collodion and collodion emulsion when dry plates are so ready to hand and seemingly so cheap. The fact is that much cleaner and crisper negatives can be obtained by these means than by the more modern methods. These negatives are much more suitable for the processes in which they are employed than are dry plate negatives.

The time taken to prepare the plates is set off by their cheapness compared with dry plates, especially in the case of large sizes, and the saving of time in development, intensification, fixing, washing, and drying, all of which operations are more quickly done than the corresponding ones for dry plates.

The slowness of the sensitive films compared with gelatine emulsion is not accounted any disadvantage, as the exposures are usually made with the aid of powerful electric arc lights, and a few seconds or minutes is not considered of any account in the kind of work done.

Apart from these considerations the "process" photographer holds that for certain classes of work he prefers to use the collodion processes on account of the better results obtained, and therefore it is useless to discuss the comparative merits of the two processes in regard to cheapness or ease of manipulation.

Another point in which collodion processes have always scored, is in respect to the great density of deposit obtained along with extreme clearness of the transparent portions of the negative. The grain of the image is also extremely fine, to the extent of being almost imperceptible, except under considerable magnifying power. On this account collodion negatives are particularly suitable for microscopic work and astronomical photography. The finest lantern slides are also done by collodion, and professional makers of such slides prefer to make them by these methods.

The improvements in dry plates in the direction of producing fine grain emulsions have to a large extent removed the disparity between the two methods, so that it is possible collodion will not permanently hold its place for all such purposes.

In the earliest days of photography the worker had to prepare for himself the pyroxyline with which the collodion is made. The method of preparation consisted in acting on cotton wool with a mixture of nitric and sulphuric acids. This had the effect of converting the cotton into a substance analogous to gun cotton, and it is often incorrectly described by that name.

Cotton treated in this way becomes soluble in a

mixture of ether and alcohol, forming a clear white fluid similar to a thin varnish.

The pyroxyline can nowadays be obtained as a commercial article, so that the worker who wishes to prepare his own collodion experiences none of the troubles of the old workers. The collodion can also be obtained ready made, either in the plain state or iodized as subsequently described, and the iodizer may be purchased separately for mixing with the plain collodion as required.

If the worker starts with the plain collodion the first step is to iodize it. This consists in adding an alcoholic solution of iodides to which is usually added some bromides, the latter having the effect of making the collodion more sensitive. The iodides give density and the bromides detail; otherwise expressed we may say that the iodide gives or promotes a heavier deposit of silver in the parts corresponding to the lights of the picture whilst the bromide ensures a more even gradation of the tones from light to shadow. The iodides and bromides of cadmium and ammonium are generally used. The proportions of iodide and bromide are varied according to the kind of negatives desired. After being iodized the collodion is allowed to stand for a few days, and is all the better for keeping for a limited period.

The glass plates on which the collodion is flowed have to be very carefully cleaned, both chemically and mechanically to ensure faultless work.

The plate is held by one corner, in a level position whilst a pool of collodion is poured on and allowed to flow by gently tilting the plate until the surface is covered, when the surplus is drained off. A few seconds are allowed to elapse for the film to set, but it must not be allowed to become dry before exposure.

The plate is then immersed in the "silver bath." This consists of a slightly acidified solution of nitrate of silver, contained in either a rectangular glass cell, standing nearly vertical, or in a shallow horizontal tray of glass, porcelain, or ebonite. The former kind, known as the dipping bath (Fig. 19) is mostly used for smaller plates but may be used for plates up to 24 × 20 in., and the latter kind is employed for large plates, above that size, though smaller ones are also largely sensitized in this way by many workers.

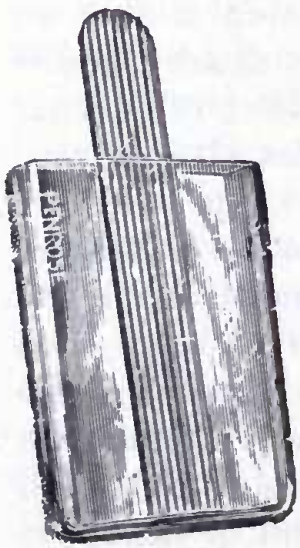

FIG. 19
A DIPPING BATH

The plate is lowered into the dipping bath with a suitable holder, and for the first few seconds is moved gently up and down to equalize the action of the solution. When the flat tray is used it is gently rocked to secure the same effect. The plate is allowed to remain in the bath for two or three minutes, then it is lifted out, drained, and placed in the wet state in a special dark slide which is provided with means for catching the drainings.

The exposure is made whilst the plate is in the wet state, and must be completed before the plate dries. The exposure, if daylight is used, will be much longer, probably twenty minutes at least, than for an ordinary dry plate. With the powerful electric arc lights used in process studios it is much less.

Development is not done in a dish. The plate is held by one corner between the thumb and finger in a level position and the developer is poured on. It is allowed to run to and fro by gently inclining the plate,

but must not be allowed to run off, or it will carry with it the silver which goes to form the image. The development is very quick, taking only a few seconds, and, after a rinse with water, the fixing solution consisting usually of cyanide of potassium (though hyposulphite of sodium will do) is applied either by flowing on or in a dish. The fixing is equally as quick as the development.

Usually there are operations of clearing and intensifying to improve the negative, and they are very quickly done, compared with the treatment of dry plates. A very short washing serves, and then the plate can be dried by the application of heat. If the negative is to be used for more than one or two prints or if it has to be preserved for future use it is varnished.

It may be mentioned that numerous attempts were made to prepare the collodion plate so that it could be dried for exposure at any future time. Although some of these methods were worked with some success none have come into practical use, and indeed they have all become obsolete and practically forgotten.

The collodion positive process used so extensively even now by the beach photographers is merely a slight modification of the negative process. It was found that a negative image could be made to assume the appearance of a positive one by whitening the metallic silver deposit. This was effected by using with the pyrogallic acid developer a small quantity of nitric acid. A better result was obtained by using ferrous nitrate with the ferrous sulphate developer, and later it was found that a still better method was to bleach the image with mercuric chloride. If the picture is taken on glass the whitened image may be made to stand out against a black velvet backing, or black varnish may be poured over the film

to give the necessary black background. Another way is to produce the picture on japanned iron plates, the results being known under the name of ferrotypes or tintypes.

Full instructions on the working of the collodion process will be found in Payne's *Wet Collodion Process*.

CHAPTER V

THE SENSITIVE PLATES—COLLODION EMULSION AND DRY PLATES

A REALLY practical advance on the wet collodion process was made by the discovery of the collodion emulsion method. To understand this process it is necessary to explain that in the wet collodion method the collodion merely acts as a film to hold the sensitive chemicals on its surface, whilst in the collodion process the sensitive chemicals are intimately mixed with the collodion before being spread on the glass plate.

In wet collodion the plate assumes its sensitive state when the iodides and bromides in the collodion come into contact with the nitrate of silver in the bath solution. The surface of the plate then has a coating of iodide of silver, or where bromide is present, iodobromide of silver.

Now in the collodion emulsion process the bromide of silver, or sometimes chloro-bromide of silver, where a chloride is present, is formed before being added to the collodion, and when the two are mixed together and thoroughly shaken an emulsion is formed, milk-like in appearance. This emulsion is spread on the plate in the same way as the collodion in the wet plate process. In one way of working the process the plate is placed in the camera in the moist state, being most sensitive in this condition. It has been found possible, however, by suitable modifications of the process to dry off the plates for use at any time.

Much excellent work was done by the collodion emulsion process in the days before the dry plate became

a commercial proposition; but whichever way the process was worked—moist or dry—it was a troublesome and none too certain method. Efforts were made to introduce commercial collodion dry plates, but just as these promised to be successful the gelatine dry plate came into vogue and swept away any chances the older process might have had.

At its best the collodion emulsion dry plate could not compete with the speed attained by the gelatine plate, so that whatever advantages the former possessed were neutralized by this factor. Besides the gelatine plates were cheaper and easier to manufacture.

Of late years collodion emulsion has been brought into use again by the developments of reproduction processes in the direction of colour work. It was found that the emulsion could be readily treated with dyes to render it more sensitive to particular colours or parts of the spectrum. When used moist in this way the sensitiveness was made equal to gelatine dry plates of medium rapidity.

No means have so far been discovered of making a highly sensitive collodion dry plate, and so long as this drawback remains the collodion emulsion process must have but a limited application.

We do not go deeply into the preparation of collodion emulsion and its working, as it is hardly likely that many readers of this book will be interested in it. Full details will be found in some of the older books on photography, and the modern applications of it are treated in *Collodion Emulsion*, by H. O. Klein.

The preparation of gelatine dry plates is similar in principle to collodion emulsion up to a certain point. There is the same process of mixing the sensitive salts with a vehicle to form an emulsion, but there is an important difference of result between using collodion

and gelatine. Whereas it is found that collodion had little or no effect on the sensitive salts held in suspension in it, the gelatine can be made to act upon them as to bring about increased sensitiveness. An action goes on which is termed "ripening." This action increases the sensitiveness of the plate, and though there is a limit to which it can be carried, it is possible to reach a point where plates of extremely high rapidity are obtained.

The ripening action can be brought about either by treatment of the emulsion with ammonia, or by raising the temperature of the emulsion. The former process is, we believe, most generally used now.

It is quite impracticable for a photographer to attempt making for himself gelatine dry plates, though some of the old workers used to do it, and it does not seem worth while to describe the method here. Those who are interested enough to pursue the subject further will find the process described in several photographic books, notably in Abney's *Photography with Emulsions.*

Films differ from dry plates only in the fact that the gelatine emulsion is spread on a film of celluloid instead of on glass plates. Sometimes the film is thick, so as to be used flat in dark slides, exactly as a glass plate, but the bulk of the photographic film used is employed in the form of long strips in special roll holders which enable the film to be wound from a spool at one side to a similar spool at the other side.

The photographer of the present day does not need to concern himself much as to what plates or films to buy. As a rule the advice of the photographic dealer, or of a friend already versed in the craft is taken, but even without this aid one cannot go far wrong since there is not much to choose between one make and another. It is only the expert amateur or experienced professional who can distinguish the subtle differences

of quality between the different makes. All reputable makers have to keep their plates up to an accepted standard in regard to speed, freedom from faults and uniform working qualities. As dry plate making is not a business which can be done by a small manufacturer, working to get business by the cheapness of his product, there is not much danger of poor plates and films getting on the market. The business is confined to a few well-known firms whose prices are equal for equal brands and sizes.

A good deal of confusion is caused in the minds of beginners by manufacturers printing on the labels of their plate boxes such terms as "Rapid," "Extra Rapid," "Extra Speedy," "Snapshot," "Flashlight," "Lightning," etc. These terms are really no guide except as indicating that the plate purports to be more or less "fast" in exposure.

In the early days of the dry plate the makers adopted three designations, which were generally understood, viz., "ordinary," "rapid," and "extra rapid." Of these terms the first only has survived. By common consent the "ordinary" is the plate for timed exposures, and it is with this plate that the beginner is advised to make his first efforts. Such a plate will give him the least trouble in exposure and development, owing to what is called its "latitude," which means the allowance of a considerable margin for errors of exposure.

The only reliable way of comparing the relative speeds of plates is by a system of testing which all dry-plate makers have adopted. This is known as the "H. and D." system, these letters indicating the initials of the names of the inventors of it, Messrs. Hurter and Driffield. These investigators based their method on the hypothesis that in a perfect negative the opacities of the different gradations in the negative were strictly

proportional to the light reflected from those portions of the subject which they represented when the plate had received the correct exposure, and that a true representation of the tones of the original was only possible when the density of the negative is proportional to the light intensity.

To compare plates of varying sensitiveness they adopted a standard light, an exposing instrument, and a photometer for measuring the densities. Test plates are taken from each batch of emulsion, and readings are obtained with the instruments, enabling a speed number to be obtained for each batch of plates tested. These speed numbers are marked on the boxes of plates sent out. The comparative plate speed is proportionate to the numbers. Thus 100 H. and D. is a comparatively slow plate, and 300 H. and D. is a fast one.

Exposure tables are based on these numbers and the relative time required for various plates can be calculated.

These calculations are made easy by the aid of exposure meters which are usually based on the exposure of a strip of sensitive paper through a small opening in the instrument. The time taken for the paper to darken to a standard tint is noted, and this figure is set on the scale of the instrument opposite to a figure indicating the sensitiveness of the plate. Then opposite the figure on another scale denoting the size of the diaphragm opening the exposure time will be found. Another scale is usually provided to give an indication of the variation to make for the class of subject that is being photographed—landscape, seascape, buildings, etc. The Watkins meters are popular types.

It is not absolutely necessary to use an exposure meter, and the majority of professional photographers ignore such aid, depending on the judgment gained by experience, but the advanced amateur largely employs this means and holds it to be a reliable adjunct.

CHAPTER VI

MAKING THE EXPOSURE

HAVING chosen a camera and procured the necessary sensitive plates or films, the would-be photographer sets forth to find his subject and expose his first plate. The amateur is usually ambitious to take portraits or groups of his friends in the home garden, but this is an essay not to be recommended. It is possible that by chance the first efforts in this direction turn out acceptable, but this is not invariably the case, and more often the results are disappointing and discouraging.

The photographic beginner will learn far more by taking a view of a house, or garden, or the perspective of a street. Alternatively if a marble statuette or a plaster cast is available that will give him much better experience than taking portraits. By practising in this way, taking views from different standpoints he will gain a knowledge of the way light falls on objects, and how this affects the results on the photographic plate.

By trying different times of exposure on the same subject, and by taking it at different times in the day, it will be seen how great are the variations that may be produced with the same appliances and materials.

Again, by directing the camera towards different points of view, and from varying distances it will be noted that widely different results are obtained, some being more pleasing than others.

Suppose the photographer has set up his camera directly opposite to a house, he may very likely find that he cannot get the whole of the subject on the plate

from the position where he is standing. Possibly the width of the house may come within the plate but not the height. Very naturally, he tilts the camera,, and gets in the top of the house, but then he finds that the view is distorted, tapering towards the top. If his camera has a swing back and rising front he will be able to correct this by raising the lens, and swinging inwards the plane

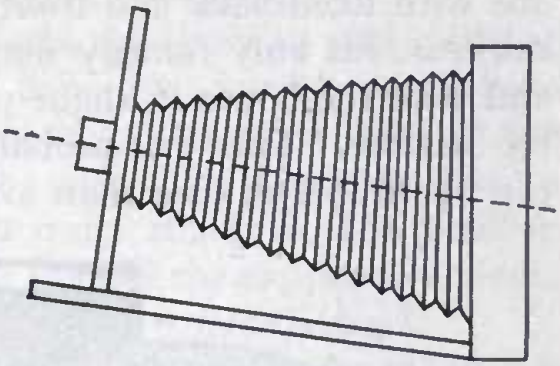

FIG. 20
SHOWING SWING BACK

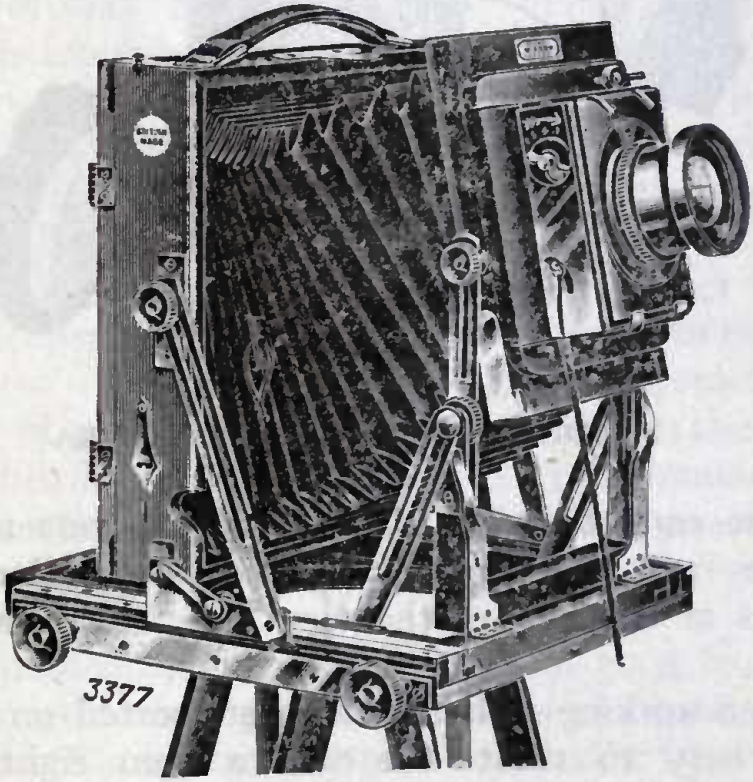

FIG. 21
HOUGHTON CAMERA WITH SWING FRONT AND BACK

of the ground glass so that it will be vertical notwithstanding the tilt of the camera (Fig. 20). The

same result may be attained if the camera has a swing front as in Fig. 21. Should, however, his camera be one with fixed back and front, as are most cheap hand cameras, his only remedy may be to get farther away and take the house in slight perspective if the street is too narrow. This will probably give a better view of the house in any case than a view broadside on.

FIG. 22

HOLDING A KODAK FILM CAMERA

Some cameras have a side swing movement, which enables a better perspective to be obtained when objects at one side of the view are much nearer than others.

When working with a camera supported on a tripod it is easy to rotate the camera from right to left or *vice versâ*, especially if the tripod is provided with a turntable so as to find out the best part of the view to form the central point of interest in the picture, and also to leave out unsuitable parts at one side or

other of the picture. A cross front which is usually fitted to stand cameras enables a similar result to be obtained, though to a more limited extent.

When using hand cameras the levelling and centring of the picture must be done by viewing the objects in the finder, and by watching the spirit level if the camera is provided with one. The beginner has to learn to hold the camera quite steady in the position determined, and to keep it so until the exposure is made. Fig. 22 shows how a Kodak film camera is held.

Where dark slides are used care has to be taken not to disturb the camera when inserting a slide, and if the slides are double ones means must be employed for knowing which plate has been exposed otherwise two exposures may be made on one plate. Usually the slides are numbered, and the exposures can be registered in a note book, or an indicator is sometimes provided to show the side which has been exposed. Some slides have a tablet on them for writing on with pencil any notes as to exposure.

Next to choosing the point of view, comes the important operation of focussing, which is not so easy as it may seem. The beginner has to get accustomed to the novelty of seeing the picture upside down on the ground glass; then he must also get used to the dimness of the picture, subdued as it is by the grain of the ground glass, and having to be examined with the head under a focussing cloth.

The photographer racks the ground glass to and fro until he gets what appears to be the sharpest possible result for the central features of interest in the view. He will find that it is not possible to get all objects equally sharp, and he must decide which are most important to be most clearly defined.

Another point which will trouble the beginner is

that there is a falling off in sharpness towards the edges of the plate, and if the character of the view is such that sharpness all over is essential, resort must be had to what is termed "stopping down." This means regulation of the aperture of the lens by means of the diaphragm. A change from full aperture to the next size smaller will produce the desired result with many subjects, but if still greater sharpness is desired (and possibly because the lens is a poor one not giving sharpness at a large aperture) a still smaller diaphragm must be used. Excessive sharpness is not, however, a quality to be uniformly aimed at. Some subjects may be better for being taken slightly unsharp, the result being softer.

In "stopping down" it must not be forgotten that the exposure is increased as the aperture gets smaller. It will be noted that the diaphragm openings are numbered 8, 11, 16, 32, 45, 64, in an ordinary lens, though some modern lenses of high quality have numbers beginning, 4·5, 6·5, or 7·7. In books of instruction and in exposure tables these numbers are preceded by F/. This means that the focus of the lens (the distance from the ground glass when objects are at a great distance, termed "at infinity") is divided by the number representing the aperture.

For example, suppose the number is 8 and is expressed F/8, this means that the focus, whatever it may be, is divided by 8, and the quotient is the diameter of the aperture. Suppose the focus is 8 in. then 8 divided by 8 gives 1, so that the aperture is 1 in. in diameter. Now F/16 would similarly give $\frac{1}{2}$ in., but it must not be supposed that the exposure will be simply doubled; as a matter of fact it will be quadrupled. The numbers of the diaphragms are actually arranged so that each step smaller doubles the exposure. Thus, if the correct

exposure for F/8 is 1 minute the exposure for F/11 will be 2 minutes, other things being equal.

The diaphragms are also used for regulating the exposure as well as for securing sharpness. It may happen that the light is so brilliant that if the exposure was made with full aperture the plate would be over-exposed. By stopping down to the next size, or to

FIG. 23

ROLLER BLIND LENS SHUTTER

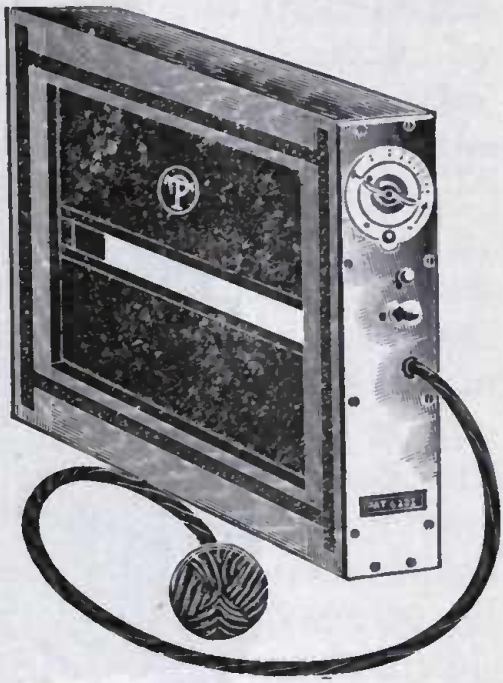

FIG. 24

ROLLER BLIND FOCAL PLANE SHUTTER

some smaller size, the exposure can be controlled. This method has to be adopted when working without a shutter, and time exposures have to be given.

If the camera is provided with an automatic shutter then the photographer sets it for the exposure time determined upon, either by judgment, or with the aid of an actinometer, or by reference to an exposure table. A shutter is absolutely necessary for instantaneous exposures of rapidity which varies in fractions of a second.

The shutter may be a separate piece of apparatus attached to the front of or behind the lens (Fig. 23), or can be what is called a focal plane shutter which is in the form of a curtain with a slit in it (Fig. 24) immediately in front of the plate.

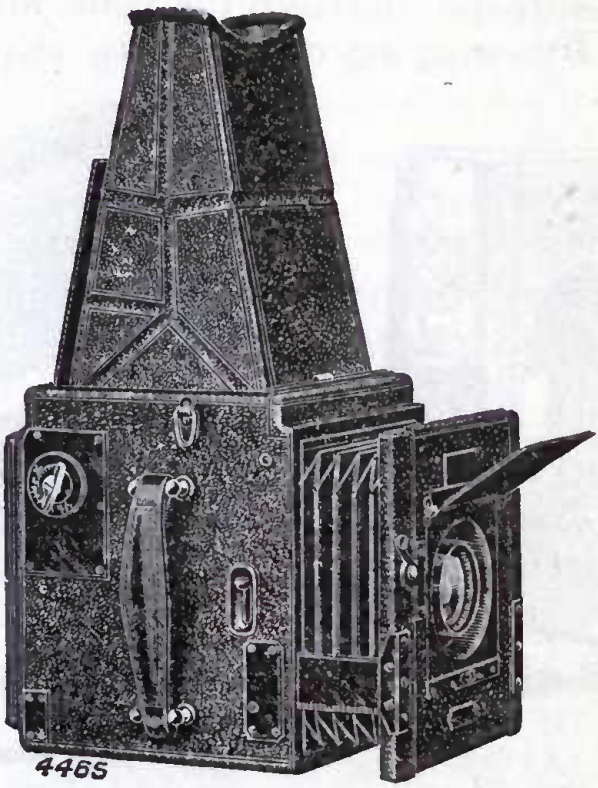

FIG. 25

A REFLEX CAMERA BY HOUGHTON'S

A form of camera which is largely used for press photography is the "Reflex" type (Fig. 25). It is provided with a mirror inclined at 45° to the axis of the lens. The mirror reflects the image upwards to the ground glass which is laid horizontally on the top of the camera. On looking down the hood, the image is seen and can be kept in view until the moment of exposure. When the trigger is released, the mirror swings up out of the way and the plate in the dark slide at the back of the camera is exposed, the shutter

operating simultaneously with the movement of the mirror.

Although good daylight is the essential for photography in general there are occasions when it is not available, and much successful work is done by means of artificial light. In portrait studios electric light is largely used either in the form of the electric arc lamp, the mercury vapour lamp, or groups of incandescent lamps, and gas light has been used to advantage by employing clusters of burners with incandescent mantles. For the professional, who has to work away from the studio, taking groups in public buildings or " at home " portraits, resort is made to the flash light produced by burning magnesium powder, or sometimes aluminium powder. The means for firing the powder are quite simple, generally consisting of a bulb and tube to blow the powder through a spirit flame. It is also possible to obtain cartridges of the powder mixed with chemicals which facilitate ignition. Flashlight photography presents no difficulties to the amateur, though it requires experience in arranging the lighting to get the best results. Instantaneous exposures are obtainable by this method but where a long exposure is required in a dark interior it is often the practice to use magnesium ribbon, which has simply to be lighted at the end. There are lamps for mechanically unwinding the ribbon as it burns away.

CHAPTER VII

DEVELOPMENT AND AFTER-TREATMENT OF THE PLATE

WHATEVER form of sensitive plate is employed, whether collodion or gelatine emulsion, it must be understood that no visible image is obtained by exposure in the camera, so that there is nothing in the appearance of the plate to denote that it has been exposed.

The plate must be removed from the dark slide in the dark room, and must then undergo a process known as development. This consists in applying a chemical solution which will act on the silver which has received the light action, that is to say, the parts represented by the light reflected from the object which has been photographed. The darkest shadows of the object will reflect no light, or at any rate none sufficient to affect the sensitive surface. Thus there will be no developing action on these parts, but on the other portions the silver compound in the film will be darkened by the developer and the amount of darkening will be proportionate to the amount of light which has reached the different parts of the plate.

A little consideration will show that the result must be a negative one. The white parts of the subject will have reflected the most light, and consequently the greatest darkening action occurs in corresponding parts on the negative. The white face of a portrait subject will be represented by a black face on the negative. This is well illustrated by the reproduction of a negative given on the opposite page.

It will also be noted that the tones of the picture

NEGATIVE

POSITIVE

THE LATE MR. UPENDRAKISOR RAY,

A well-known Indian Photographic Process Worker and Author

(*To face page* 18)

are formed by patches of varying density, so that when the negative is subsequently printed there will be the same variation of tones on the paper picture.

This darkening action of the developer is brought about by a chemical process described briefly as reduction of the silver to the metallic state. It is not possible here to describe the chemical reactions in a simple way. Sufficient to say that the greyish white granules of silver compound are blackened by the action of the developer. Let us say that the action is analogous to the tarnishing of bright silver articles exposed to the atmosphere, and especially when sulphur fumes are present, as from gas. Though not a correct chemical explanation it will serve as a popular illustration.

In the case of wet collodion the developer usually employed is an acidified solution of sulphate of iron. Collodion emulsion is commonly developed with hydroquinone, which complex chemical is one of those numerous substances derived from coal tar products. This developer is also very suitable for dry plates, though it has been largely superseded by a variety of other compounds also derived from coal tar products, and introduced by the Germans under such fancy names as Metol, Rodinal, Amidol, Glycin, etc. Chemically they are all of the same family group, but their action on the sensitive film varies, some being more powerful than others. During the war efficient British substitutes for these chemicals have been introduced, under various names, such as Monomet, which is the equivalent of Metol. Hydroquinone is sometimes employed in conjunction with Metol, and then forms a faster developer.

A developer much favoured in the early days of photography, and which is still used largely by professional photographers, is pyrogallic acid, commonly known as "pyro." This has been used with advantage

on wet collodion, and collodion emulsion, as well as on gelatine plates, and yields excellent negatives. It is out of favour with amateurs because it stains the fingers, and unless carefully used is apt to give yellow stained negatives which are difficult to print. Whatever developer is used the compound is dissolved in water and diluted to a suitable strength, the formula for mixing the developer being always given on the boxes of dry plates. It is best, for beginners at any rate, to follow the makers' instructions.

FIG. 26

DEVELOPING A STRIP OF FILM

Except in the case of wet plates, which are developed by pouring on the developer whilst the plate is held level, the plates are laid in a tray of porcelain, ebonite, or other material, the developer being poured on, and the dish rocked to and fro to ensure development.

Celluloid films are developed in the same way if of the thick kind, or in strips which are drawn to and fro through the developer if the film is of the thin kind used in roll film cameras (Fig. 26). Various special trays and tanks are also employed for the development of films (Figs. 27 and 28 show one form of these tanks).

In this apparatus the film spool, after removal from the camera, is put into the winding box, and re-wound

in contact with a corrugated waterproof apron, which enables the developer to reach every part of the film. The roll thus formed is put into the cylindrical tank and is raised two or three times with the wire hook, shown in the illustration, so as to expel air bubbles.

The effect seen after applying the developer is that after a few seconds or a few minutes—the time depending

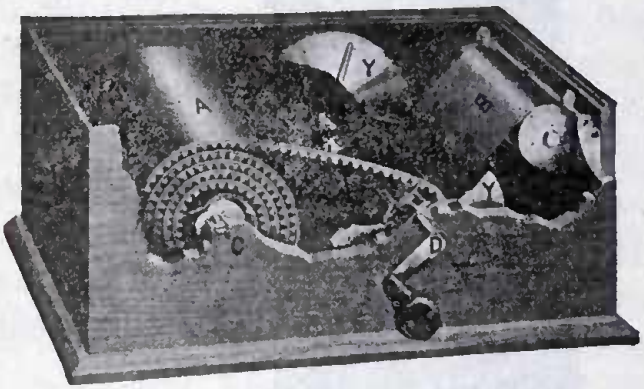

FIG. 27 FIG. 28

KODAK DEVELOPING TANK AND WINDING BOX

on the exposure, the temperature, and the strength of the developer—parts of the plate will darken, which can readily be seen in contrast with the creamy white film, even in the dim light of the dark room In the case of a portrait the parts which darken first will be the whites or very light parts of the subject—technically called the "high lights." In the case of a portrait the parts which will darken first will be a white collar or white lace on a dress, and in the case of a landscape the sky will come out first. The other parts will appear more slowly, and are less readily seen. The completion of development is generally determined

by holding the plate up to the lamp, so that light is reflected through the film and enables the worker to determine whether all the detail of the picture has been brought out.

FIG. 29
DEVELOPING TANK

It is a matter of judgment, only acquired by experience to decide when a negative is fully developed. Usually the amateur is told to develop until the plate is almost darkened all over, or until the darkened parts show through at the back of the plate. In this condition it will be difficult to see the detail when the plate is held up to the lamp, but such detail will become visible in the subsequent operation of "fixing."

Of late years a method known as "tank" development has been much used. The developer is diluted so as to weaken it and thereby prolong the operation. Several plates are immersed in the developer in a tank which is closed by a light-tight lid (Fig. 29), and they are allowed to remain for a determined time, depending on the particular make of plate, the exposure, and the nature of the developer. No examination of the plates during development is needed, and when taken out they are ready for "fixing" after a slight rinse.

This latter operation consists in immersing the plate, after rinsing off the developer, in a bath of hyposulphite

of soda, usually called hypo, which has the effect of dissolving out all the silver that has not been acted upon by light, leaving the plate transparent in these parts. It is quite a simple operation requiring practically no experience. When fixing is complete all the whiteness shown at the back of the film disappears, and the plate looks black.

Wet collodion and collodion emulsion can also be "fixed" by means of hypo, but it is generally preferred to use cyanide of potassium, which is more effective, and is less trouble to wash out. This chemical cannot be used for dry plates, as it has a solvent action on the gelatine.

An important step is next to get rid of the fixing solution which has soaked into the film. If the fixing chemical is not entirely eliminated stained negatives result, either in the subsequent processes, or after the negatives have been kept for some time. This elimination of the fixing salt is simply done by thorough soaking and washing with water. "Hypo eliminators" are sold by dealers, but are not much favoured by advanced workers.

The next step is the drying of the films, which is done by placing a plate in a rack to drain, and if time allows to let it remain long enough, say overnight, it will dry spontaneously. Professional workers sometimes hasten the drying by gentle heat, or with an electric fan, a drying cupboard being employed where a large amount of work is being done. Drying may also be hastened by immersing the plate in methylated spirit.

If the original exposure was properly timed, the operations described, if carried out correctly, will result in a good printable negative, but as exposure is the most uncertain factor in the photographic process, the amateur generally finds that good negatives are a matter of chance. The negative may have been

under-exposed, in which case the image will be " thin," that is to say, with very little density in the tones. Such a negative would yield a dark print with little contrast. On the other hand the negative may have been over-exposed, when it will either be " flat," or very dense, A " flat " negative will yield a weak print, whilst a dense one will probably show great contrasts of black and white.

The question arises whether such faults can be remedied. They can if the defects are not too pronounced. In the case of an under-exposed negative the remedy is to apply an intensifying solution, which will darken the image ; and in that of an over-exposed negative to apply a reducing solution.

The process of intensifying consists in applying chemical solutions which will still further darken the silver particles forming the image. Numerous chemical compounds will do this, but the most simple to apply in the case of dry plates is bichloride of mercury. Where a solution of this salt is applied to the plate the dark image on the negative is bleached white, but it is blackened after a brief washing by next flowing over it a very dilute solution of ammonia. It will then be seen that the dark parts of the negative are much intensified and details in the shadows which were not previously very visible, become much more pronounced. Such a plate after being washed and dried will yield a much better print, and often this process is a means of saving a negative which could not be taken again.

The process of reduction is a reversal of the preceding method. The solution applied makes the negative less dense by removing some of the darkened silver in the image, and clears away deposits of silver particles in the transparent portions. Various chemicals will effect this reduction, but the simplest is a solution

of ferricyanide of potassium to which is added a solution of hyposulphite of soda. This solution acts very vigorously on the image, and if allowed to stay on too long may overstep the desired effect. Its action is stopped by simply rinsing the plate.

Similar processes are used in wet collodion and collodion emulsion work, but in these processes there is also a method of intensification which partakes more in the nature of re-development. This is done with a solution of pyrogallic acid and nitrate of silver, with the addition of citric acid.

The only other treatment the negative receives is in the case of plates which have to be extensively printed from and preserved, as in the case of professional negatives which are varnished to preserve the films.

Portrait negatives are invariably "retouched," an operation which consists in applying a slight coating of varnish of such a nature that the surface is roughened slightly, so as to take lead pencil marks. The retoucher stipples or shades the light parts of the negative so as to soften what would print as shadows, say under the eyes or where the cheek bones show prominently in portraits. In some cases instead of pencilling a process of light scraping of dark parts is resorted to so as to cause the negative to be more transparent in these parts and consequently to print darker.

In the case of landscape negatives the corresponding operations are usually performed by coating the plain glass side of the negative with a matt varnish which when dry will take pencilling or stumping with black lead, whilst at the same time the varnish holds back printing of the shadows. Sometimes a sky or an objectionable background is stopped out with an opaque paint, and occasionally clouds are printed in by a second exposure. A new background can be applied in the same way.

CHAPTER VIII

PRINTING PROCESSES

MAKING prints from the negative is relatively a more simple matter than the making of the negative, and there is an extensive choice of sensitive papers for producing varied effects.

The oldest method, now practically discarded, was the use of a plain paper inpregnated with silver chloride. The paper was first soaked in a solution of a chloride salt and then floated on a bath of silver nitrate. When dried this paper was exposed under the negative and a visible image was obtained. The portions under the most transparent parts of the negative darkened most and quickest, the other portions in a varying degree corresponding to the density of the negative in its respective tones. The print was made darker than the finished print was desired to be, as there was a loss in fixing. The latter operation simply consisted in immersing the print in a solution of hypo. The print was then washed, and having been dried was complete.

The results of such a process were usually flat and unsatisfactory owing to the action of organic compounds in the paper, and it was found desirable to "size" the paper. The sizing was usually done with a weak solution of arrowroot, though starch or gelatine would serve the same purpose. The treatment of the paper with chloride and silver nitrate was as before described. The result of this improvement was that the prints were cleaner and brighter. This was due to the formation of a new silver compound, and to the image being kept to the surface of the paper.

This process can be applied to fabrics and to wood, leather, or any other organic material that can be " sized.

A further improvement on this method was the albumen process. This consisted in applying a coating of egg albumen to the paper. The albumen was mixed with ammonium chloride before being applied to the paper and by drying at a high temperature a glossy surface was obtained. This paper was liable to deterioration, becoming discoloured and yielding prints that were weak and flat. To avoid this trouble it was customary to fume the paper by placing it in a cupboard with a basin containing strong liquor ammonia. Other methods were employed with the same object, such as pressing the paper between sheets of blotting paper soaked in citric acid or other chemicals.

The prints yielded by this process are of a reddish brown colour which would not be pleasing if they were finished in this state, and it was therefore found desirable to apply a further process known as "toning." This consisted in immersing the print in a solution of chloride of gold or platinum, but usually the former. Chemically the result was to change the colour of the metallic silver by the substitution of the gold or platinum, and the effect is to give the print a pleasing tone. According to the composition of the bath and the time of immersion various shades are obtained from a rose tint to a copper red, purple, or chocolate, and even to a black. The platinum bath was especially suitable for shades of sepia brown. To produce the best results the process of toning required considerable care and experience, and the process was not one in which an amateur was invariably successful. Moreover, the character of the negative and the intensity of the light during printing had an important influence on the tone. These uncertainties coupled with the difficulties of preserving the

paper in good condition led to the process falling into disfavour when the later processes of printing-out and development papers were introduced.

The "printing-out paper," commonly known as P.O.P., is the outcome of the gelatine emulsion process used for dry-plate negatives. The emulsion used for the latter purpose would not print out, *i.e.*, give a visible image, but it was found that by using a gelatino-chloride emulsion this property could be obtained. The gelatino-chloride emulsion is applied to a paper

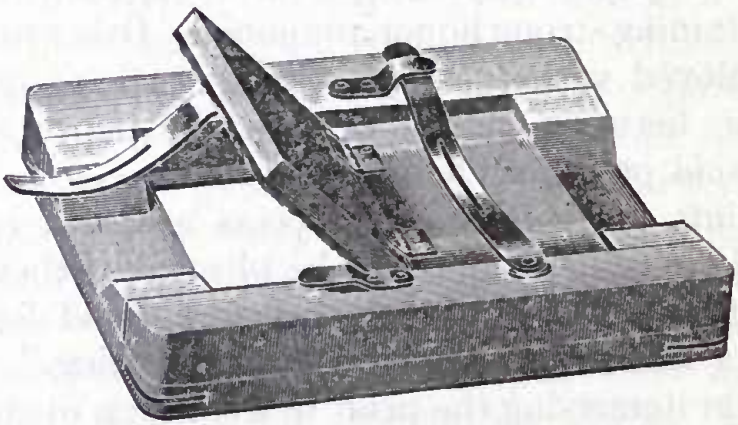

FIG. 30

PRINTING FRAME

of good strength and opacity, a thicker and better one in fact than that used for the albumen process.

Two varieties of P.O.P. are made—"glossy" and "matt." The principle of manufacture is the same, the difference of surface resulting from differences in the emulsion and from the surface of the paper used. This emulsion has also been applied to glass and opal plates giving very pleasing effects, though such materials have never been popular.

P.O.P. is made on a large scale by manufacturers employing special coating machinery, and is usually supplied in packets cut to standard sizes.

The printing of this paper is done in the same way as for the albumen process, exposing the paper under the negative in a printing frame (Fig. 30), and examining the image to see when the printing is finished. The print is usually made darker than it is ultimately desired to be, so as to allow for loss in toning and fixing.

The toning is done with a solution of chloride of gold, made up differently to that used for albumen paper. Usually the bath contains sulphocyanide of ammonium. On matt paper platinum toning is often employed, giving warm brown and sepia tones or a black if desired. Other substances have been employed for toning, among which may be mentioned uranium, palladium, lead, osmium, iridium. In fact, practically all salts of the metallic elements may be employed.

After toning the prints are fixed and thoroughly washed and dried. If an extra glossy surface is required the prints are pressed (or, as it is usually termed, "squee-geed") whilst wet into contact with a well cleaned glass plate, ferrotype plate, or paper-mache slab. To prevent adhesion the plate is often polished with talc powder or rubbed with a wax solution. When dry, the prints strip off with a highly glazed surface.

There are "self-toning" papers, which are similar to P.O.P., except that the emulsion contains some salt of gold, which is reduced in the fixing bath and thus tones the image, so that the necessity of toning the image is avoided. The range of tones that can be obtained on such a paper is more limited than with the separately toned P.O.P.

Another kind of printing-out paper is that produced by the collodio-chloride paper. After enjoying some popularity on its introduction it became practically obsolete, probably owing to difficulties of manufacture,

but of late it has been revived, and the paper is now produced by several firms on a commercial scale by means of modern coating machinery. The essential feature of this paper is that collodion is used instead of gelatine as the vehicle to hold the silver chloride. A highly glossy surface is produced by natural drying, and an advantage is that the water can be blotted off

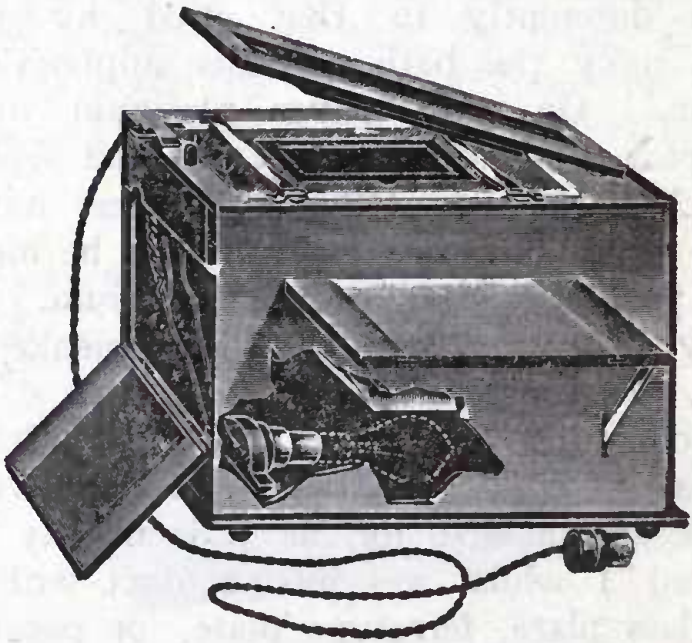

FIG. 31

BUTCHER'S BROMIDE PRINTING BOX

on the prints coming from the washing tank, and the paper dried with gentle heat.

So far we have dealt with papers which yield a visible image by exposure to daylight under the negative, the image being completed by toning and fixing. We now proceed to consider another class of paper which is very extensively used, viz., bromide paper.

The important difference in using this paper compared with printing-out papers is that the exposure is made with artificial light, and the image has to be brought out by development.

The paper is coated with gelatine containing silver bromide, the emulsion being similar to that for making plates but considerably slower. Unlike the printing-out papers the bromide paper must be handled entirely in the dark room.

The chief advantage of the process is the rapidity of production, and on this ground the bromide prints are preferred when large quantities have to be turned

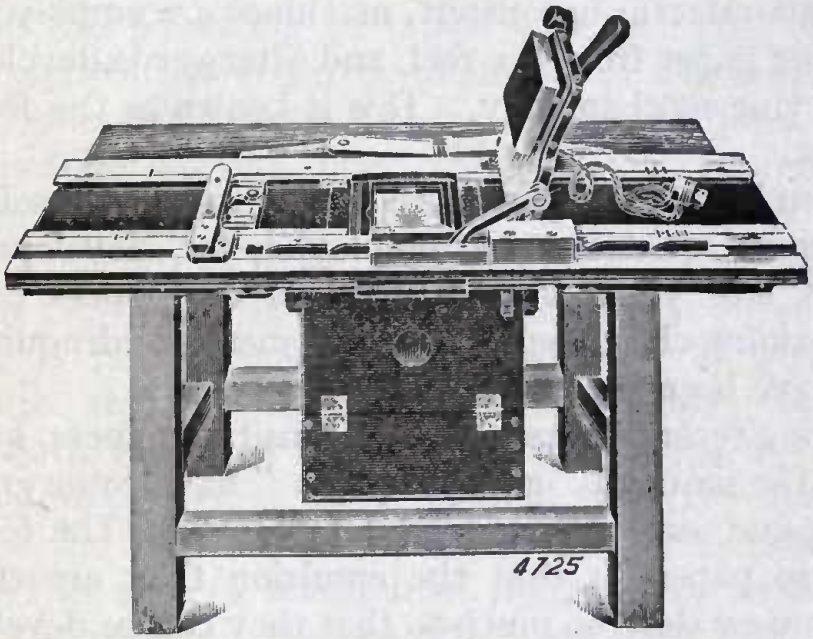

FIG. 32

STRIP PRINTER BY HOUGHTON

out quickly. It has been found possible to apply mechanical aids to increase the output of prints by this process. The chief features of such methods are that means are adopted to quicken the handling of the paper and the making of the exposure. Quite simple apparatus is offered, which is well within reach of the amateur. The most usual form is what is known as the bromide printing box; this consists of a box enclosing an electric lamp, a transparent pane in the top to lay the negative and paper on, and a hinged lid to press the paper into

contact (Fig. 31). The operation of applying the paper, switching on the light to make the exposure, and replacing the paper with another piece is done very quickly. A more elaborate form of apparatus used by the professional is known as the "strip printer," in which long strips of paper are placed in a special frame at the top of the exposing box, and a slide is moved along to make the successive exposures (Fig. 32). For a large manufacturing output, machines are employed for exposing paper from the reel, and afterwards developing and drying mechanically. This is known as the Rotary process.

When bromide papers were first introduced a solution of ferrous oxalate was employed for development, but of late years various modern developers of the non-staining class, such as amidol, metol, hydroquinone, etc., have been successfully used.

During recent years a class of sensitive papers, known under the name of "gaslight paper" have come greatly into vogue, especially amongst amateurs. The feature of these papers is that the emulsion they are coated with is very slow, so much so that they can be developed with safety a yard or two away from the gas light used for exposing. A more energetic developer has to be employed than for bromide paper, and development usually takes longer to complete. The paper must not be unduly exposed, nor remain too long exposed to the light. What is implied by the gaslight method is that a short exposure to the light has little effect on the paper, and as development should be completed quickly there is no danger of fogging under normal conditions. These gaslight papers give pleasing tones, by varying the exposure and time of development, without the aid of a toning bath, though by use of the latter a still greater range of colours can be obtained.

Finally, we must mention the platinum process which yields very beautiful prints, but which is a method usually considered too expensive and difficult for the average amateur. The salts of platinum are too insensitive to be used for obtaining a direct photographic image, but Mr. W. Willis, the inventor of the platinotype process, discovered that it was possible to first produce an image with the salts of iron, and build up on this so strong an image with platinum that the iron compounds could be removed in the subsequent developing operation without apparent loss. The platinotype process may therefore be regarded as a method of toning iron prints. The paper is coated with a mixture of ferric oxalate and a salt of platinum. When exposed to light a faint image is produced. The print is then immersed in a solution of potassium oxalate, and development is instantaneous. Formerly this bath was used hot, but the paper will develop in a cold bath though it is generally preferred to slightly warm the bath. After development the prints are placed in a weak solution of hydrochloric acid which has the effect of dissolving out the faint iron image. The iron must be thoroughly removed or the whites of the paper will turn yellow. A final washing completes the operations. The prints obtained are a rich black, but it is possible to obtain sepia tones by a modified treatment. The best negative for this process is one with a fair amount of contrast and good gradations. If, however, the negative employed is not quite suitable, a method of local development with a brush may be used. Glycerine is applied to certain portions to hold back the development by preventing the developer sinking in.

CHAPTER IX

PRINTING PROCESSES—CARBON AND OTHER METHODS

THE processes of printing we have described in our last chapter depend as will have been seen on producing a change of colour or tone in the metallic compound by chemical means. We have now to describe a method which depends on a totally different principle.

Investigations made by Mungo Ponton in 1839 revealed the fact that when salts of chromium were mixed with gelatine, with which paper or other material was coated, exposure of the prepared surface to light resulted in the gelatine being hardened, so much so indeed as to resist the action of even hot water.

Starting from this fact paper coated in this way was exposed under a negative, and it was then found that the hardening action was proportional to the amount of light which had got through the various parts of the negative. It is obvious that the hardening action would be the greatest in the parts corresponding to the transparent patches on the negative and least where the negative was densest. Thus it was found that if the print so obtained was washed with hot water the unaffected portions were dissolved away, and the picture was left in a slight relief.

The image was, however, hardly visible, and the early experimenters sought to make it so by mixing black or coloured pigment with the gelatine. This pigment dissolved away with the gelatine where the latter was soluble, and remained held where the gelatine was hardened. A difficulty was met with in the circumstance that the light did not penetrate completely through the layer in the denser portions, so that there was

a soluble layer under, which dissolved away and caused the image to lift off the paper. Attempts were made to overcome this trouble by exposing from the back, but it was not until J. W. Swan, in 1864, brought forward a process of transferring the film that the carbon process became successful.

Swan coated the paper with pigmented gelatine and exposed under the negative as usually, but instead of proceeding to develop the paper in the old way, he pressed the coated side on to another surface-paper, glass, porcelain or metal, it was immaterial which. By pouring hot water on the back of the print the original paper backing was released and stripped off through the gelatine next the paper being dissolved. It was then possible to develop the print from what was originally the back. The hardened surface being next the support was held firmly, whilst the soluble portion was washed away and a good print was thus developed.

Two methods of transfer are employed, known as "single" and "double" transfer. In the "single" transfer process the transferred image remains on the transfer paper after development. The only disadvantage is that from an ordinary negative the image is reversed from left to right, so that the picture is as if seen in a mirror. This difficulty can be overcome by using a mirror in conjunction with the lens when taking the photograph, so that the lens receives a reflected and therefore reversed image ; or a reversed negative can be made from the original one by copying in a transparency camera, the negative being turned round to face the opposite way when making the transparency from which the final negative is made.

The first method is not convenient in the case of outdoor photography, and the second method is

a roundabout one. Hence a method was adopted of developing on a temporary support, and then transferring the image to a final support. If this final support was to be paper or any other flexible material it was possible to use glass, opal, or metal as the temporary support. In this case the surface was waxed so as to ensure the image coming away easily after development. The final support was pressed into contact with the image on its temporary support, allowed to dry and then stripped off.

Where it was desired to transfer the image to a rigid final support, such as ivory, porcelain, glass, metal, wood, etc., the use of a temporary support was impracticable. For such work the "double" transfer process is used. A stout paper was coated with insoluble gelatine, so as to stand the operations of developing the image on it, and before the image is put down the surface is waxed to prevent permanent adherence. The transfer paper after development is pressed into contact with the final support, allowed to dry and then stripped off.

The pigmented paper can be obtained in a great variety of colours, together with the special transfer papers, from the Autotype Co., who were the original licensees of the process, and who have perfected and standardized the process so that it can easily be worked even by amateurs.

A number of processes having some similarity to the carbon process have been put forward from time to time, but without coming into any general use. These processes are based, as in the carbon process, on the oxidising action of the chromium salts, and the principal advantage claimed is that they can be worked without transfer. Such methods are those known as Gum bichromate, Artigue, Carbon Velours, and Ozotype.

In the gum bichromate process a sheet of drawing paper is sensitized by immersion in a solution of potassium bichromate, and dried. It is then coated with a mixture of gum and pigment, and exposed under a negative. To develop the print it is floated face downwards in a deep dish of cold water, which has the effect of causing the gum and pigment to soak out of the unexposed portions. Development may take hours to complete in some cases, but it can be hastened by laving with water and by gentle application of a camel hair mop. The print is fixed with a solution of common alum, or with hypo or sodium sulphite. The method is favoured by photographers who wish to produce broad artistic effects, the process lending itself to skilful manipulation.

For the Artigue process the paper is coated with a mixture of pigment and some organic substance, and is sensitized with potassium bichromate. Drying and printing is done as in the usual carbon process, but the development is somewhat unique. A mixture of fine sawdust and water is prepared, and this is poured from a jug on to the surface of the print, which is supported on a sheet of glass. The idea is that the sawdust picks up the soluble gelatine, or whatever else may be the colloidal coating, causing it to leave the paper more readily.

In the Ozotype process the ready prepared and sensitized paper after exposure under a negative is immersed in a dilute gelatine solution, and then a sheet of pigmented paper, such as ordinary carbon tissue, after immersion in a solution of hydroquinone, acetic acid and ferrous sulphate, is squeegeed down on to it. The two are allowed to dry and are then developed together in the same way as a single transfer carbon print.

Another method having an analogy to the carbon process is the "dusting-on" or "powder" process. The sensitized coating is a bichromated colloid, usually gum or dextrine which is mixed with sugar, with the object of producing a surface which will be sticky in the presence of a slight amount of moisture. The surface is dry and hard before and during printing, but in the damp atmosphere of the dark room soon absorbs moisture. The absorption is proportional to the action of the light which has passed through the negative. Thus in the parts which have not been acted on through being protected by the opaque parts of the negative the film will become most tacky whilst in the other parts the tackiness will be in a varying degree. If a suitable powder colour is lightly brushed over the surface this powder will adhere in proportion to the tackiness and thus a picture will be formed.

A process of this kind is used for photo-ceramics, the powder employed in this case being of a vitrifiable nature, so that it can be fired into the porcelain or other material.

One other process should be mentioned to complete our survey of the methods based on the salts of chromium, viz., the Oil Process. For this method drawing paper is sized, sensitized with a bichromate solution, and printed under a negative. In development the paper is soaked in water, the surplus blotted off, and printing ink thinned down with oil is applied by dabbing with suitable brushes. The effect is that the ink takes to the print in proportion to the light action forming the tones of the photograph.

CHAPTER X

ENLARGING, COPYING, AND LANTERN-SLIDE MAKING

THE matter of portability of the apparatus usually decides the question of the largest size negative it is practicable to make by direct exposure. The tendency of late years has been to make comparatively small sizes of negatives, and resort to enlarging where increased dimensions were desired.

The enlarging may either take the form of making an enlarged negative, and printing from it in the usual way by any of the processes already described, or of making an enlarged print from the original negative.

The process of enlarging is based on the same principles as the microscope and the magic lantern, and may perhaps be best understood by considering the latter. If a slide, which is usually 3¼ in. square, is put in the lantern and focussed on to a distant screen we know that we obtain an enlarged image. The degree of enlargement depends on the distance of the screen from the lens.

The enlarging lantern is practically the same as the optical lantern used for projecting pictures, with the exception that the stage for holding the slide is enlarged to take the commonly used sizes of negatives, and the condenser is increased in size to cover them, whilst there is a greater degree of adjustment of the projecting lens, so as to focus it at the proper distance from the negative to serve the relatively smaller pictures required in photographic enlarging (Fig. 33).

It is not absolutely necessary to have a projecting

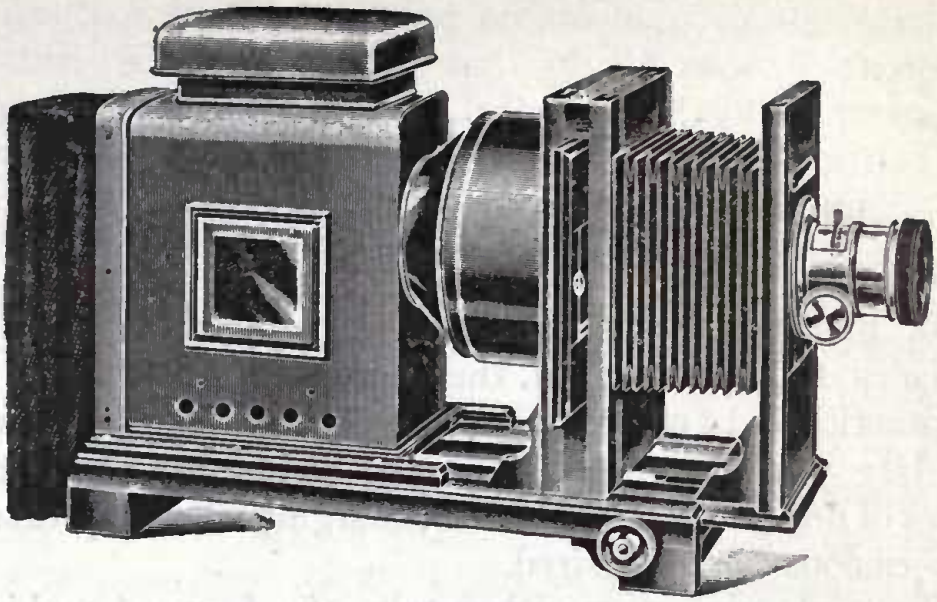

FIG. 33

ENLARGING LANTERN BY BUTCHERS

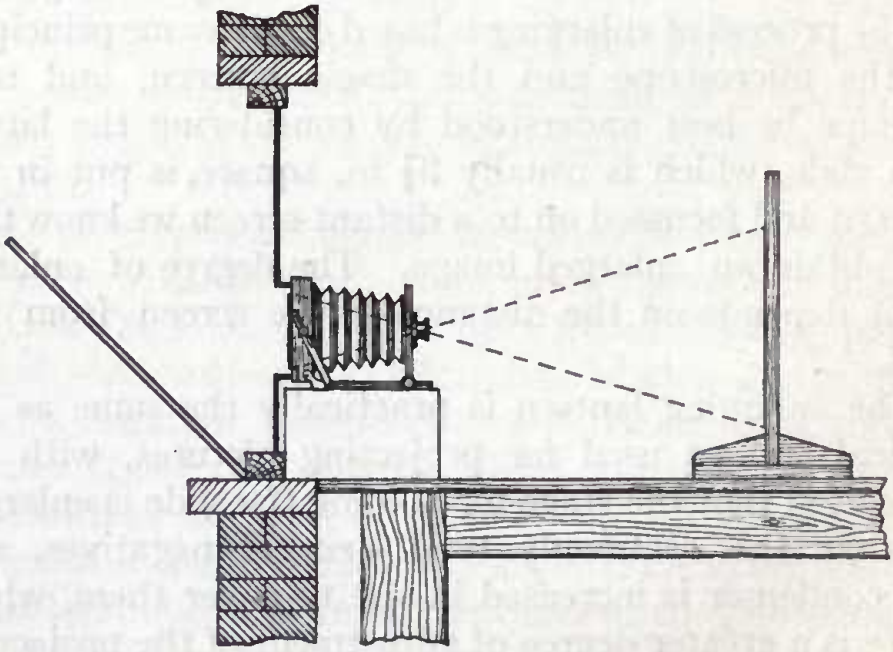

FIG. 34

CAMERA ARRANGED FOR ENLARGING

lantern for enlarging. A rough box holding the negative at one end and an ordinary camera lens at the other may be placed over a hole in a window-shutter, and so project the image into the darkened room, where it can be received on the sensitive paper pinned to a drawing board. Such an arrangement would have the drawback of there being no means of focussing, but this could be remedied by a little ingenuity, say by having two boxes sliding one within the other.

Still better is it to make a frame to enable the rear end of the ordinary outdoor camera to be attached in front of a hole in the window shutter. Then the ordinary focussing adjustment of the camera can be used (Fig. 34).

When it is desired to be independent of daylight the box or camera may be attached in front of some form of lantern, or placed in front of an opening leading to another room, where the light for illumination can be placed.

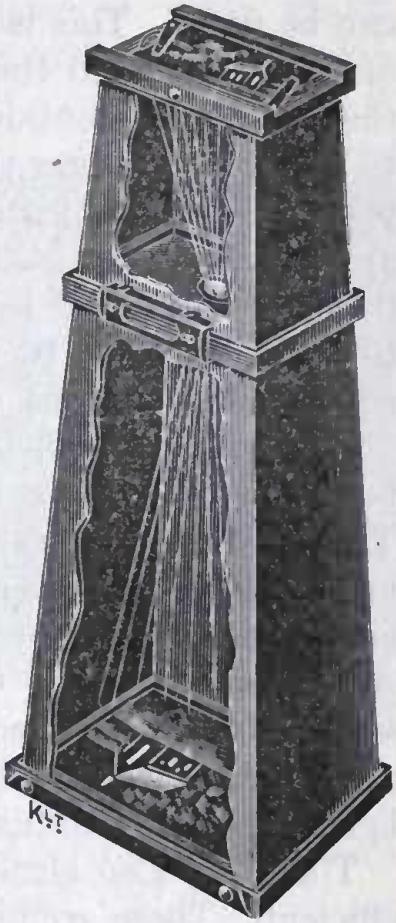

FIG. 35

KODAK DAYLIGHT ENLARGER

A condenser is not a necessity. A sheet of ground glass placed behind the negative will diffuse the light so as to equalize the illumination, the only drawback being loss of light, causing longer exposure.

Various means can be employed for increasing the illumination, such as the placing of a suitable reflector

behind the negative and throwing the light on to it instead of using the light direct. In this method it is best to have two lights, one on each side.

For amateur work, where it is only required to enlarge from one definite size to another, a fixed focus enlarger can be used. This is simply a tapering box at one end of which is placed the small negative and at the other, the dark slide containing the sensitive plate or paper to receive the larger size. Inside the box is a partition placed at a suitable distance for holding the lens. This apparatus is often called a "daylight enlarger," as it is generally used by placing it, negative end upwards towards the sky to receive illumination, but it can equally well be used with artificial light (Fig. 35).

All forms of artificial light can be used for enlarging, but gas or electric light are the most used means. The latter is preferable by reason of its brilliancy and uniformity, but quite good work is done by gas, and even oil lamps are used successfully when neither gas or electric supply is available. Oil is, however, a weak and troublesome illuminant, and some form of acetylene light arrangement is usually adopted where neither electric light nor gas is obtainable.

There are also alcohol vapour lamps which are quite efficient. These are used with the Welsbach type of gas mantle, and the alcohol vapour is caused to ascend to the mantle by a preliminary heating of a part of the apparatus with a spirit lamp. The vapour can then be lighted and gives the necessary heat to maintain the mantle in a state of incandescence.

The paper used for enlarging is the ordinary kind of bromide paper already described for contact printing. For large work when broad treatment is desired matt or rough surface papers are used.

It has not been found practicable to enlarge on to

Printing-out or Platinotype papers owing to their relative slowness. The same remark applies to carbon tissue, though successful enlargements have been made on it by using a very powerful electric arc light and by modifying the sensitizing bath.

Where enlargements are desired on such papers the procedure is to make an enlarged negative. This

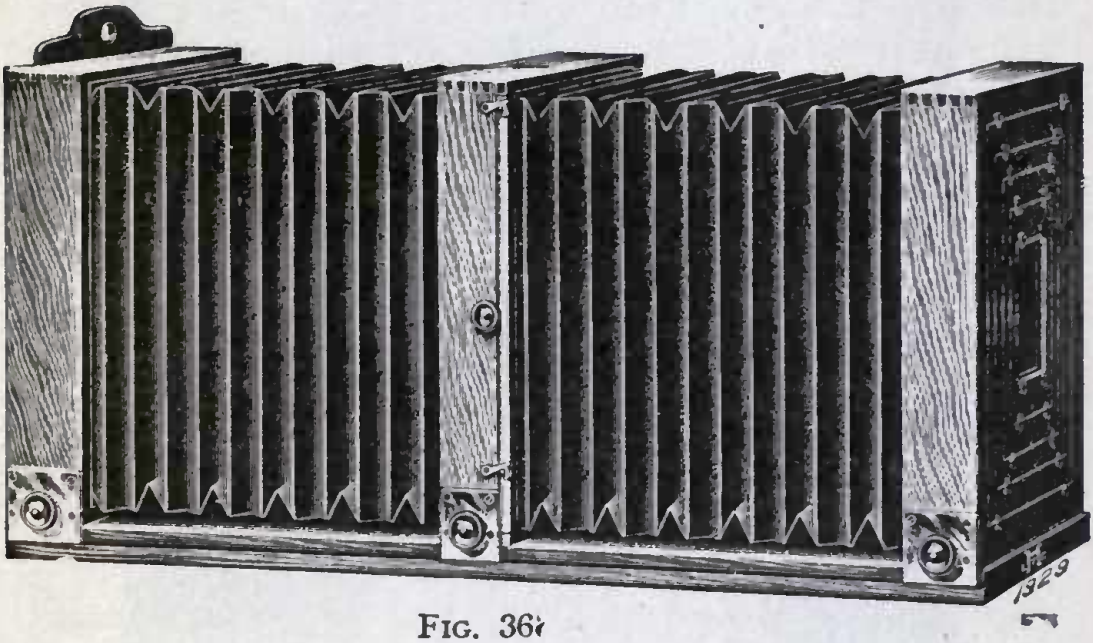

FIG. 36.

TRANSPARENCY CAMERA

is easily done by using a dry plate in place of the bromide paper and giving a suitable exposure.

When much work has to be done in making enlarged negatives it is best to have a transparency camera. This is practically the equivalent of two cameras placed end to end (Fig. 36). The lens is between, and the back of one camera is used to hold the negative to be copied, whilst the other holds the dark slide with the sensitive plate. This avoids the necessity of having to make the exposures in a dark room.

Enlargements usually require some retouching or working-up, as faults which are not apparent in the

small original negative become glaring in the enlargement. The retouching may consist merely of spotting, which is a method of applying water-colour with a fine brush to correct small specks of white or black ; or it may

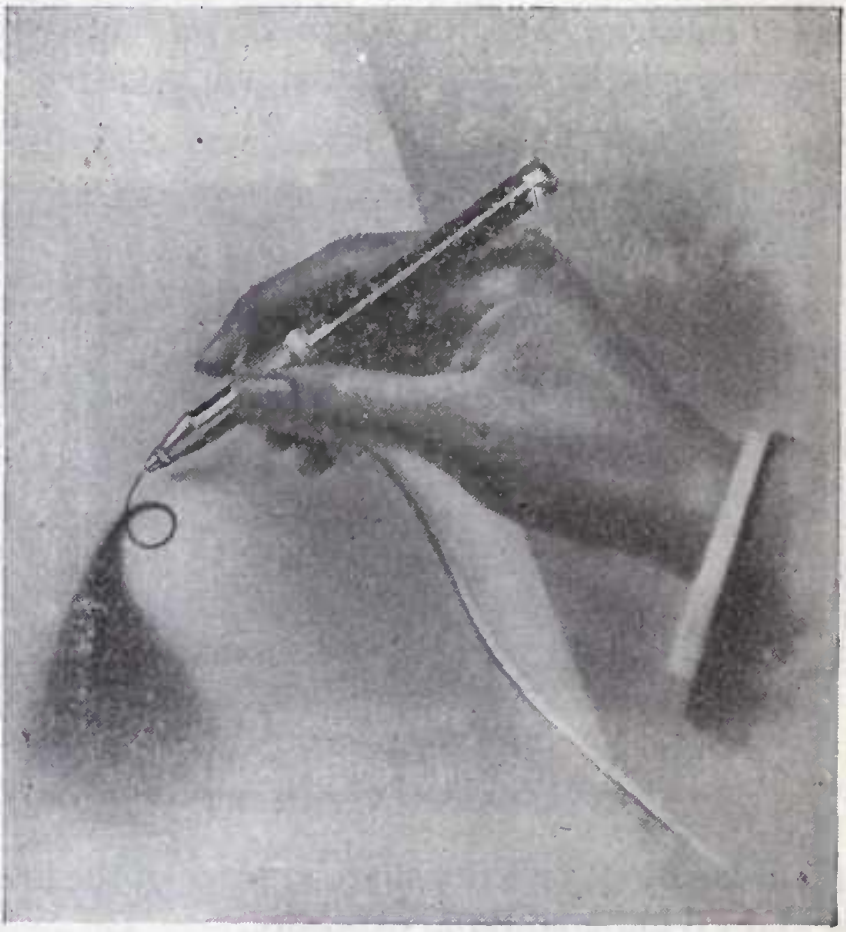

FIG. 37
THE AEROGRAPH

be elaborate working up by introducing a new background, strengthening shadows, or increasing the brilliancy of the lights. Such working up is generally done professionally by means of the Aerograph, which is an instrument for spraying water-colour on to the surface (Fig. 37). The spray can be regulated so as to produce a very dark or very light effect, and parts of the picture

where no alteration is required can be marked out with tracing paper stencils.

More elaborate retouching may be done with crayons and by stumping in black or colour. The Aerograph may also be used for applying colour, and of course the colour may be also applied by brush work.

Enlarging may be done by direct copying within certain limits. The degree of enlargement is governed by the focus of the lens, and the extension of the camera available. To copy same size requires a camera which will extend to double the focus of the lens, for twice the size three times the focus, for three times the size four times the focus. It is obvious, therefore, that for any considerable degree of enlargement the camera would become unwieldy on account of the length required. Hence it will be seen that the lantern is much more convenient, as it can be placed any distance away from the sensitive surface that the dimensions of the room will allow.

Copying is most generally used for same size reproduction or reductions. It can be done with the ordinary landscape camera, provided it has sufficient extension (double the focus of the lens for same size reproductions). Naturally if a shorter focus lens is available a greater range can be obtained, provided the lens will cover the plates. It is difficult, however, with an ordinary camera on a tripod to secure parallelism between the copy and the plate. Various expedients such as levelling and measuring with string or tape may be adopted to bring about the desired parallelism but it is best accomplished by having the camera arranged to run between guides on top of a bench, and a copyboard mounted on an easel fixed exactly parallel to the camera.

For large work very rigid cameras and copying stands (Fig. 38) are made in which every provision is made to

secure parallelism and freedom from vibration, which is also a very essential condition where fine detail is being copied.

Copying is best done on slow plates. There are plates made specially for the purpose, known as "process plates," and these give a very clean image with maximum density and freedom from grain. Process workers prefer to use wet collodion for copying, being cheaper and giving other advantages over the dry plate.

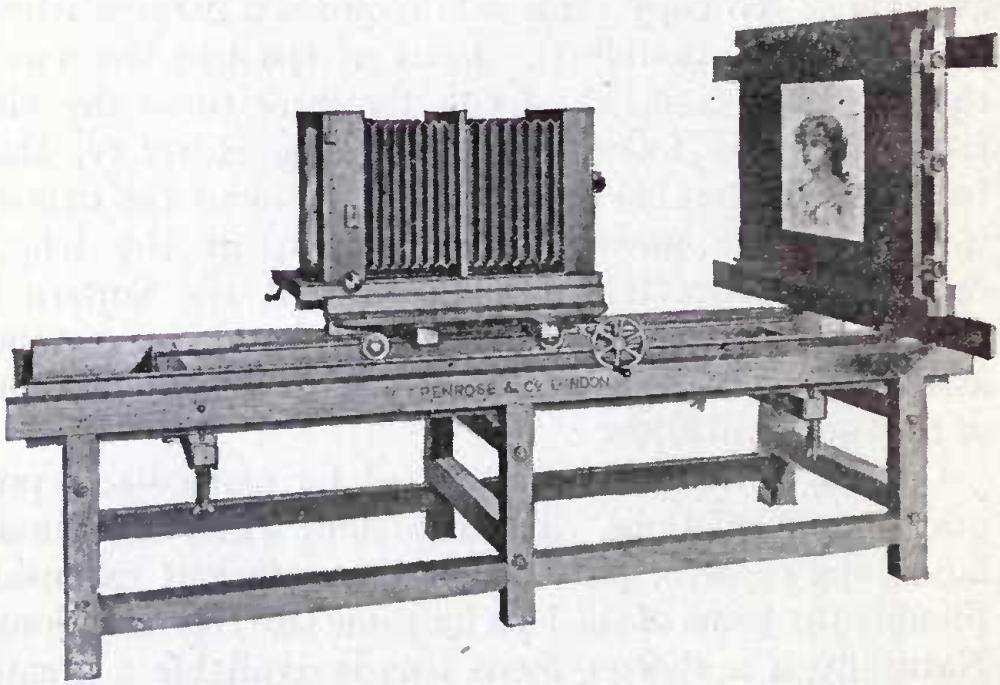

FIG. 38

CAMERA ON COPYING STAND

Copying may be done in good daylight, but professionally it is preferred to use electric light, the best arrangement being a pair of arc lamps, with suitable reflectors, placed at each side of the copyboard. For occasional work of small size it is possible to use the light of burning magnesium ribbon. Incandescent gas or acetylene is also suitable.

The development of the negatives in copying proceeds on much the same lines as for ordinary work. except

that it is desirable to use a non-staining developer, such as metol or hydroquinone. The developer must be well restrained with bromide. Negatives of line subjects where great clearness and sharpness of lines and density of ground is necessary are cleared with ferricyanide and hypo reducer, and intensified with silver cyanide.

Lantern slides may be made by direct contact with the original negative, if the latter is of such size as to come within the dimensions of a lantern slide ($3\frac{1}{4} \times 3\frac{1}{4}$ in.) For negatives of larger size or where a portion only of the negative is required on the lantern slide the transparency camera similar to that already described for making enlarged negatives is used. For lantern-slide making the end of the camera which holds the negative must be made to give a long extension, as it is often necessary to considerably reduce the image, and this requires a long distance from the lens.

The remarks we have made as to copying, with regard to securing parallelism, the illumination, development, clearing and intensifying apply almost equally in the case of lantern slides, but it should be added that special lantern dry plates are obtainable and should be used. It is possible to obtain very pleasing effects of tint by toning the slide with suitable solutions. Instructions furnished with the plates usually give formulae for toning.

When finished the transparency is bound up with a cover glass by means of gummed paper binding, so as to secure protection in handling.

The same process as for lantern slides can be applied to the making of transparencies for window decoration.

When making lantern slides and transparencies in the camera, the illumination of the negative is best obtained by indirect illumination. This is usually obtained by illuminating a white surface placed behind the negative. It is best to use two arc lamps so placed

that one lamp is on each side, thus securing uniform illumination. Where it is not possible to have arc lamps the same result may be obtained with several incandescent lamps, or even with incandescent gas-burners. High power types of the latter are quite efficient for enlarging, copying and lantern-slide making, and are much cheaper to run than electric light.

CHAPTER XI

COLOUR PROCESSES

It is not possible in the space of a single chapter to do more than give a brief outline of the colour processes that have survived the experimental stage, and for which the materials for working them are obtainable. We do not describe such methods as the Lippmann interference process, or the Wood diffraction method, beautiful as are their results, because the means for working them are not available commercially.

The most notable colour process of the present day is the Autochrome process, invented by the Brothers Lumière, of Lyons, who prepare the special plates required. These plates are formed with a colour screen between the glass and the emulsion. The method of making this colour screen is very ingenious. Starch granules, as far as possible of uniform size, are dyed red, green and blue violet, and are mixed and sifted on to a glass coated with a tacky varnish. The grains are pressed or rolled flat, and the interspaces filled with a black pigment. The screen plate thus formed is coated with a panchromatic emulsion—that is an an emulsion which is sensitive to all colours in an almost equal degree.

The plate is placed in the dark slide so that the glass side faces the lens, and the exposure made as usual, though the time is relatively longer than for an ordinary plate. A yellow filter is employed on the lens to retard the excessive action of the blue and blue-violet rays. Development follows on the usual lines, the developer recommended by the makers being employed. As

the plate is sensitive to all colours, and would therefore be fogged by the red light of the dark room, it is desirable to develop in total darkness, though a feeble green light is allowable if the plate is exposed as little as possible to it.

When the development is finished the plate is rinsed and then immersed in what is termed a reversing bath, which dissolves out the image first formed. The plate is next exposed to white light, and then redeveloped, when the image shows up in colour. No fixing is required. The plate is simply washed and dried. On examination by transmitted light a beautiful transparency in colours is seen, provided the operations have been carried out successfully.

Many amateurs have obtained excellent results by this process, and it has been applied to all classes of subjects, including portraiture and the copying of pictures. The plates can be used as lantern slides provided a sufficiently powerful light is used in the lantern.

Another method which has come into considerable favour is the Paget process. In this case the colour screen is separate from the sensitive plate, and consists of small square elements of red, green and blue violet arranged in a sort of plaid or chequer pattern. This screen is placed in the dark slide in front of a panchromatic plate, and the exposure made through it, a yellow filter being used in conjunction with the lens. Development is as usual, and there is no reversal process as in the case of the Autochrome. Instead of this a positive is made by a contact exposure, and this positive is mounted in contact with what is termed a viewing screen, which is similarly patterned to the taking screen, but is differently coloured. The positive then shows the colours of the object. One advantage of this process

is that it is easily possible to make duplicate colour transparencies from the original negative.

The Dufay Dioptichrome process is somewhat similar in principle to the Paget, but the screen is differently formed (two of the colours being in parallel lines and the third colour in lines at right angles to them), and is

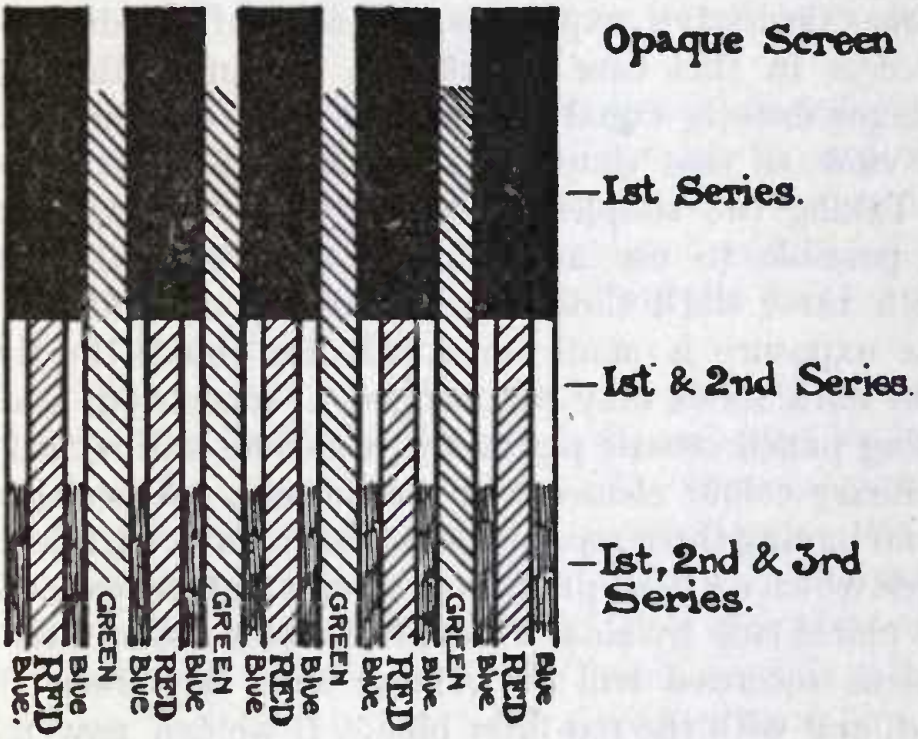

FIG. 39

THE WARNER-POWRIE SCREEN

fitted into a frame which allows of its complete registration with the positive. A method reversal by redevelopment as in the Autochrome process is adopted.

In the Omnicolore method the screen plate is very similar to the Dufay in the arrangement of the coloured lines. In this process also there is a reversal of the image by bleaching and redevelopment.

The Warner-Powrie process comprises the employment

of a screen of parallel lines, alternately red, green and blue (Fig. 39). A similar kind of screen is used in the Krayn process.

A number of colour processes are based on what is known as the indirect method. In this case three negatives are made by photographing through screens of red, green and violet, either simultaneously or by three successive exposures. The chief condition for success in this case consists in obtaining the three images exactly equal in size and from the same point of view, so that they will register when superimposed.

Taking the simplest case we may suppose that it is possible to use an ordinary camera rigidly fixed, with three dark slides, and three coloured filters. If the exposure is made on a still life object the filters and dark slides may be changed in succession, and by using panchromatic plates the negatives will record the primary colour elements of the picture. A better way than having three separate slides is to have a triple dark slide which carries a plate long enough for three exposures, or plates side by side. Through the blue-violet filter the colour recorded will be yellow; with the green filter red, and with the red filter blue. If we can now make the three prints in these colours and superimpose them it is obvious that if the conditions are correct we ought to get a blending of the three colours to produce a composite picture in natural colours.

The simplest way of attaining this result would appear to be by means of three transparent coloured films registered together. This method, invented by Ducos Du Hauron and elaborated by F. E. Ives, was put on the market by Sanger Shepherd.

The prints are made by exposing in contact with the original negatives celluloid films coated with bi-chromated gelatine containing a little silver bromide,

developing, staining to suitable colours, and superimposing the results. These are used as transparencies or lantern slides.

A film method which dispensed with the necessity of dyeing the prints consisted in coating transparent celluloid with pigmented gelatine as in the carbon process, the prints being developed with warm water as in the latter method. These films are not we believe at present or the market.

It is possible to obtain carbon tissue coated with red, yellow and blue pigments. This can be exposed under the colour negatives, developed on a temporary support and the three images transferred on to a single glass plate in superposition. Good results have been obtained by this method.

Another way is by the Polychromide process, successfully exploited by Mr. A. Hamburger, and used by him extensively for colour portraiture. The three negatives are printed on to a special kind of bromide paper, which is developed and toned by special chemical treatment to secure the three colours. The first print is the yellow backing. The second print is red, and is transferred on top of the first ; the paper being drawn away. The third print is blue and the film is transferred to a sheet of glass. The yellow print with the red film superposed on it is laid in register on the blue film, and forms the final support for the two other prints, the blue film being brought away from the glass. Thus a print on paper is obtained.

A great many efforts have been made to evolve a reliable method of making colour prints on paper, but it cannot be said that there is any really successful method.

The brothers Lumière worked out a process by which these prints were made from the respective colour

negatives on to bichromated gelatine coated on paper which is previously made non-expansive by a preliminary coating of collodion and spirit varnish. This ensures against the danger of the images not registering owing to unequal expansion of the paper. After exposure the films are transferred to a temporary glass support and developed with warm water as in the carbon process. The gelatine reliefs thus obtained are stained with suitable dyes. The films have finally to be transferred one over the other and in register on to a final paper support. This is by no means easy, and the process has consequently not been applied much to the production of paper prints, though excellent transparencies on glass have been made.

Messrs. Sanger Shepherd & Bartlett patented a process for obtaining prints on paper by taking three celluloid films prepared and dyed as for the transparency process already described, and whilst the films are still damp bringing them into contact with a soft gelatine film on paper. The dye is sucked out of the film into the paper, and an image is thus left on the latter. A second and third film are laid down successively in register, and the final result will be a combination print of the three coloured images.

The Pinatype process achieved some popularity, having the merit that the colours in the final result are all on the same principle as the Sanger Shepherd & Bartlett process just described, but instead of making the three prints on paper they are made on glass plates coated with bichromated gelatine. Three of these print plates are made, and suitably dyed; then a piece of damp gelatined paper is brought successively into contact with the glass plates so that the dye is absorbed from them. The chief condition for success is to secure the three prints being in register on the final support.

A process which may eventually come to the front for paper prints, though it has not so far been very successful, is known as the bleaching-out method, patented by Jan Szczepanik, of Vienna. Paper is coated with three dyed films one over the other, the resulting appearance of the surface being black. This paper is exposed under a coloured transparency and the effect is that the colours on the paper are successively bleached out, leaving only those which constitute the picture. To understand the action better, suppose the uppermost layer is blue, the layer beneath it red, and the layer next the paper yellow. If the action of the light is such as to bleach away the blue layer in parts, such parts will reveal the red and yellow films and their combination will produce orange. If the action is such as to bleach away both the blue and the red the resulting colour will be yellow. Other colours will be produced by mixtures due to more or less bleaching.

Various processes have been proposed for producing colour prints on bromide paper by successive development or toning. In this way it has been found possible to obtain pictures of crude colour, giving in a landscape green grass, a blue sky, and brownish tree shadows. Such processes have not proved reliable, but have lent themselves to some "faked" colour work, the tints having been produced probably by local treatment.

A promising method of recent introduction, and for which the materials are on the market is the Raydex process. The first step is the production of three separate colour negatives through red, green and blue filters. Positive prints on bromide paper are made from these negatives, and then what are termed "Colour sheets" are squeegeed into contact with them. After remaining in contact for about 15 minutes the colour sheets are stripped off the bromide prints and applied

to waxed celluloid supports; then they are placed in hot water when the paper backing can be stripped off, and all the gelatine that has not been rendered insoluble by the silver bromide gradually dissolves away. When development is complete the positives are set aside to dry. It now only remains to combine the three positives into a finished picture. This is done by soaking the positives and squeegeeing to contact with a transfer paper. The yellow print is put down first, and the celluloid support stripped off. The red and blue positives

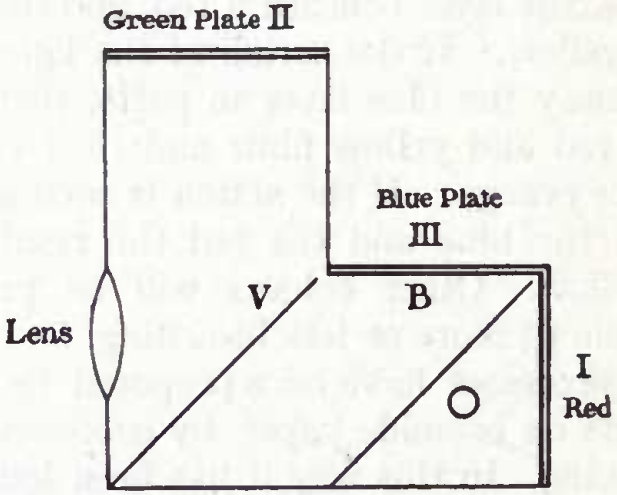

FIG. 40

THE BUTLER COLOUR CAMERA

are successively applied in a similar way. Thus the final coloured picture is obtained.

Numerous forms of special cameras for the three-colour processes have been devised, aiming at the idea of making the three exposures simultaneously. Some achieve this result by mirrors, others by prisms diverting the images in different directions. A good type of the mirror camera is that by Butler here illustrated (Fig. 40). Prism cameras have not got beyond the experimental stage.

Mr. F. E. Ives has devised several forms of cameras,

notably the Kromskop, and has also exploited numerous colour processes. His latest seems the most promising. Briefly stated it consists in placing in the path of the rays from the lens a mirror inclined at 45°. This mirror is semi-transparent, so that whilst reflecting the light in one direction it transmits light in another. Thus two images are obtained, one representing the red and the other the green component. By placing a film in front of one of the plates, a third (blue) component is obtained. These negatives are used for producing stained films.

An ingenious method, based on an idea first proposed by Ducos du Hauron in 1862, and more recently revived by W. Bennetto, consists in having a camera with a single reflector inclined at an angle of 45°, this reflection being transparent but tinted red. One plate is at the back opposite to the reflector, so that it receives the direct image through the reflector, whilst at the top (or bottom, it is immaterial, depending on the way the reflector is inclined) are two plates or a film and plate placed with their coated sides in contact with each other. The image is reflected from the surface of the reflector, and the first plate or film is sufficiently translucent to allow the light action to penetrate to the plate underneath. Thus three negatives are obtained with one exposure. This method has been further developed by O. Pfenninger and others, and would be a most effective way of obtaining colour negatives if plates of the right colour sensitiveness could be obtained commercially for the purpose.

CHAPTER XII

SCIENTIFIC APPLICATIONS OF PHOTOGRAPHY

ONE of the earliest applications of photography to science is its utilization as an aid to astronomical observations. Even in the earliest days of photography when only the wet collodion process was available most interesting and useful photographs of eclipses and other celestial phenomena were obtained, as well as photographic charts of the heavens. Since the introduction of the dry plate, and owing to the progressive improvements in its sensitiveness the achievements of photography in astronomical researches have been more and more remarkable.

The method of making photographic observations is quite simple. The camera occupies the place of the eyepiece of the telescope, and it is fixed for parallel rays, in other words, the camera lens is focussed for infinity, and it is placed so that it is one or two focal lengths away from the image formed by the telescope objective. The position is obtained by means of a telescope finder, which is a smaller telescope attached to the larger one. Except for photographing the sun and moon the fastest plates obtainable are preferable so long as they do not give a too prominent grain, which is characteristic of fast plates. In photographing stars and the very distant planets whose light is relatively feeble the exposures may extend to hours. If the telescope with its camera attachment were kept stationary the images on the plate would be lines instead of dots, due to the earth's rotation. Clockwork mechanism is, therefore, employed to rotate the telescope and its

camera at an equal angular rate in the same direction as that in which the celestial bodies are apparently moving.

Development follows on the usual lines of ordinary photography, clear crisp negatives being the aim, and for the positive copies either prints, transparencies or lantern slides are made.

Spectro photography is largely employed for astronomical observation, and colour sensitive plates are employed where accurate colour records are important.

The spectrograph is employed in many other departments of science, and has come to be regarded as a very reliable method of observation. In particular it is used largely in metallurgical and chemical research, revealing phenomena that would be invisible to the naked eye.

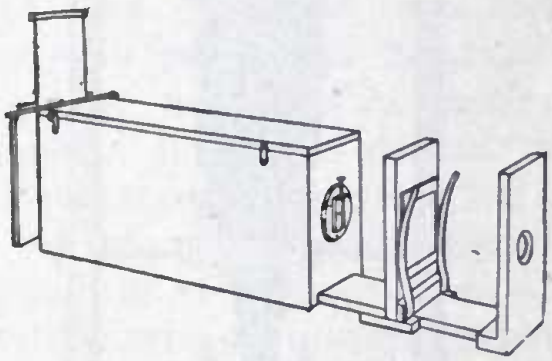

FIG. 41

TALLENT SPECTROSCOPIC CAMERA

Any form of spectroscope may be employed for spectrophotography by suitably attaching a camera in place of the eyepiece. The direct vision spectroscope is most simply applied, as in this case the axial line of the camera is simply a prolongation of the axis of the spectroscope, and the latter takes the place of the camera lens, though if a lens is used the lines are sharper. The length of the spectrum band is controlled solely by the extension of the camera when no lens is used.

With the ordinary form of table spectroscope where collimator tube and telescope swing round a central axis it is best to replace the telescope by a light camera. It is essential with all but the direct vision spectroscopes

to arrange for swinging the plane of the plate so as to bring the violet end of the image nearer the lens than the red, because of the difference in focus of the respective colours.

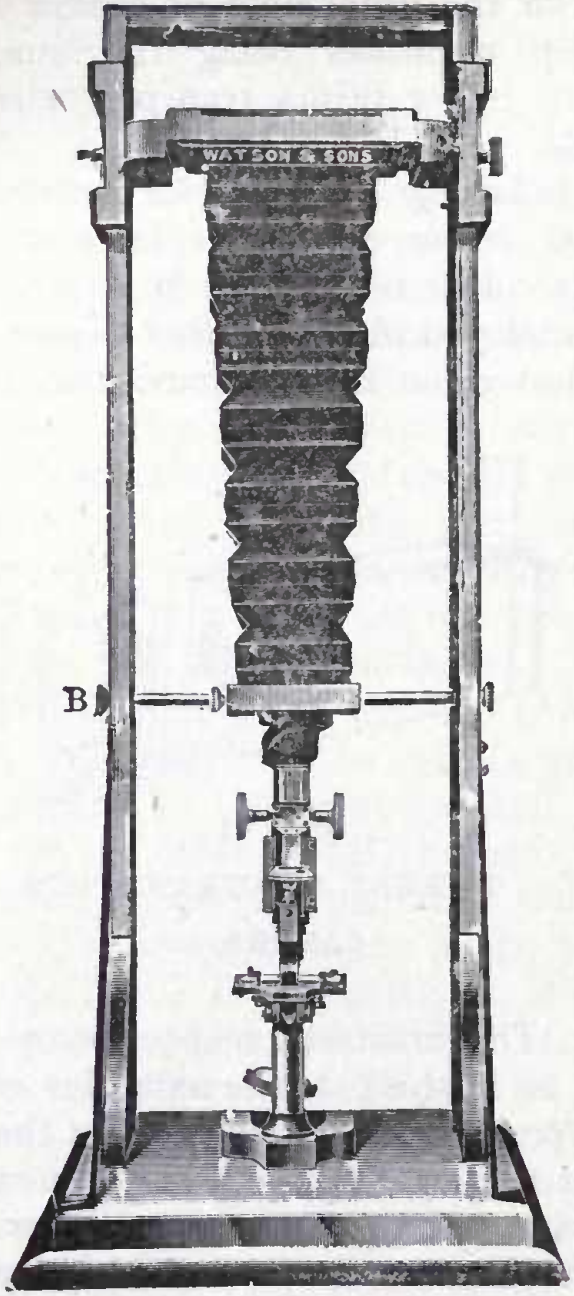

FIG. 42

PHOTO-MICROGRAPHIC APPARATUS

A drawback to the use of prismatic spectroscopes is the uneven dispersion, the red and yellow being cramped up and the blue and violet much more extended. It is accordingly found better to employ for most photographic work a spectrum produced by means of a diffraction grating. This gives a more even dispersion of the respective colours.

The principle of the direct vision spectroscope is combined with the advantages of the diffraction spectroscope in the Tallent Spectroscope camera (Fig. 41), in which a transparent replica of the grating is mounted on a prism so as to bring the angle of diffraction into line with the axis of the camera.

The most perfect form of spectrographic arrangement consists in the employment of a concave grating, the lines being ruled on a mirror-like surface of speculum metal. It is not then necessary to use a lens as the concave mirror forms the image. All the drawbacks due to absorption of the ultra violet by the glass of lenses and prism are thus obviated and a finer spectrum is obtained.

In all forms of spectrographic cameras it is usual to have an arrangement for shifting the dark slide by steps, so that a number of exposures can be made on one plate for comparison.

Photo-micrography has been developed to a high degree of perfection, and has proved an invaluable aid to scientific investigation, especially in medical work and biological research. It can be worked on quite a simple scale by the amateur possessing but a student's microscope, or on the most pretentious scale with highly elaborate apparatus of extreme precision.

In its most elementary form the photo-micrographic apparatus may consist of a camera and microscope attached to each other. The microscope is brought to a horizontal position, the camera lens removed and the eye end of the miscroscope inserted in the aperture previously occupied by the lens of the camera. Light must be excluded from the connection by means of a dark cloth thrown over it, or by any other suitable means. The slide is fixed in the stage of the microscope and illuminated in the usual way. The image is formed on the ground glass screen of the camera with any desired magnification that the length of the camera bellows will allow. Naturally the bellows must be drawn out more and more as the magnification is increased.

For high-power work more elaborate apparatus is

necessary (Fig. 42). The base connection must be very rigid ; a long rod connection to focus the microscope whilst watching the image on the ground glass is requisite as the microscope pinion may be out of reach ; a more powerful light and a substage condenser are requisite to secure better illumination ; a highly corrected objective and a projection eye-piece are necessary, and colour filters may be employed to advantage in some kinds of work. For opaque objects arrangements must be made for illuminating by means of a reflector. Most modern books on photo-micrography now describe the best forms of apparatus and the procedure for this work.

Radiography, or X-Ray photography, does not require any of the usual photographic apparatus. There being no way of bringing X-rays to a focus the images produced on the photographic emulsion are merely shadows of the objects. In medical work, for which the X ray method is chiefly used, the patient is usually placed on a special couch, under which is the X-ray tube for producing the illumination. The tube is placed in a box with an opening towards the patient, and the box runs on wheels or slides so that it can be brought to any desired position (Fig. 43). Special dry plates with extra thick and highly sensitive films are used, and these are contained in light-tight envelopes which are placed on the body of the patient in a position opposite the X-ray tube, the film side towards the rays. Intensifying screens are used for the purpose of shortening the exposure. These screens are coated with some substance giving a white or violet fluorescence. The coated side of the screen is in contact with the sensitive film of the dry plate, which is then exposed with its glass side facing the rays.

Another valuable application of photography has been

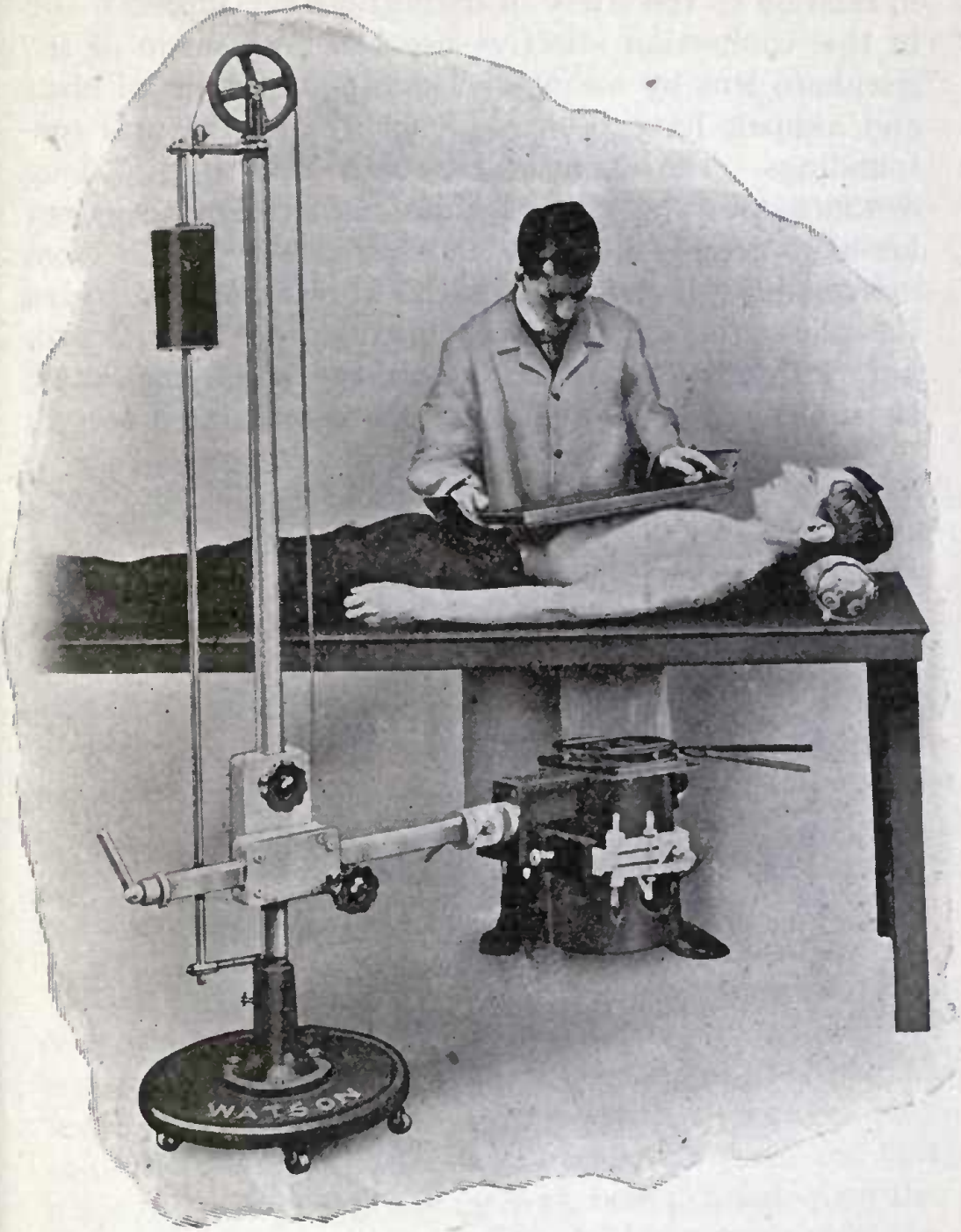

FIG. 43

PHOTOGRAPHING BY X-RAYS

in relation to the study of natural history subjects, and in this connection effective use has been made of the telephoto lens by means of which photographs of birds and animals have been obtained in their natural surroundings. The operator has been able, from a long distance away, to secure from observation the most life-like pictures of birds in their nests in the most inaccessible places. The telephoto lens has provided the photographer with the equivalent of a telescope, but with the additional advantage over the latter instrument of being able to secure a permanent record.

CHAPTER XIII

CINEMA-PHOTOGRAPHY

THE camera used for taking negatives for cinematograph projection is in its fundamental principle no different from the ordinary roll-film camera, and it is conceivable that if a succession of pictures with the same point of view were taken in quick succession with the ordinary film camera the result would be roughly equivalent to a cinematograph film. It is not, however, possible to make the necessary exposures and changes of film by hand quick enough to convey the appearance of motion, as it is necessary that the exposures should be made at the rate of 16 a second, and each individual photograph requires an exposure of from $\frac{1}{30}$ to $\frac{1}{100}$ second.

The cinema camera, accordingly, is provided with a special shutter mechanism, and an arrangement for unwinding and rewinding the film simultaneously with each exposure. The lens must be a rapid one, usually working at about F/6, and as it only has to cover a very small area of film the focus is short, generally varying from $1\frac{1}{2}$ to 4 in.

Focussing in the ordinary sense cannot be done. The distance the object will be in focus is estimated and the position on the film obtained by means of a finder. Some cameras are, however, fitted with a small opening at the back enabling the operator to focus on the film while it is stationary, the opening being closed when the focussing has been done. For greater convenience the opening is sometimes at the side, the image being diverted by means of a right-angle prism. Figs. 44, 45, show the Williamson cinematograph camera.

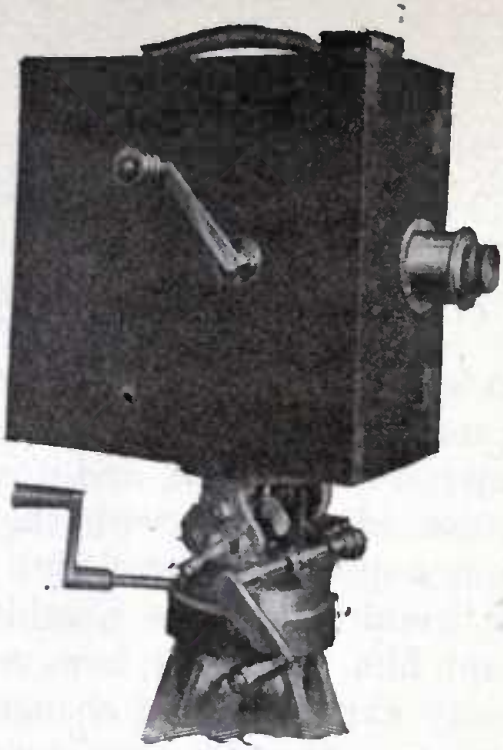

FIG. 44

WILLIAMSON CINEMA CAMERA

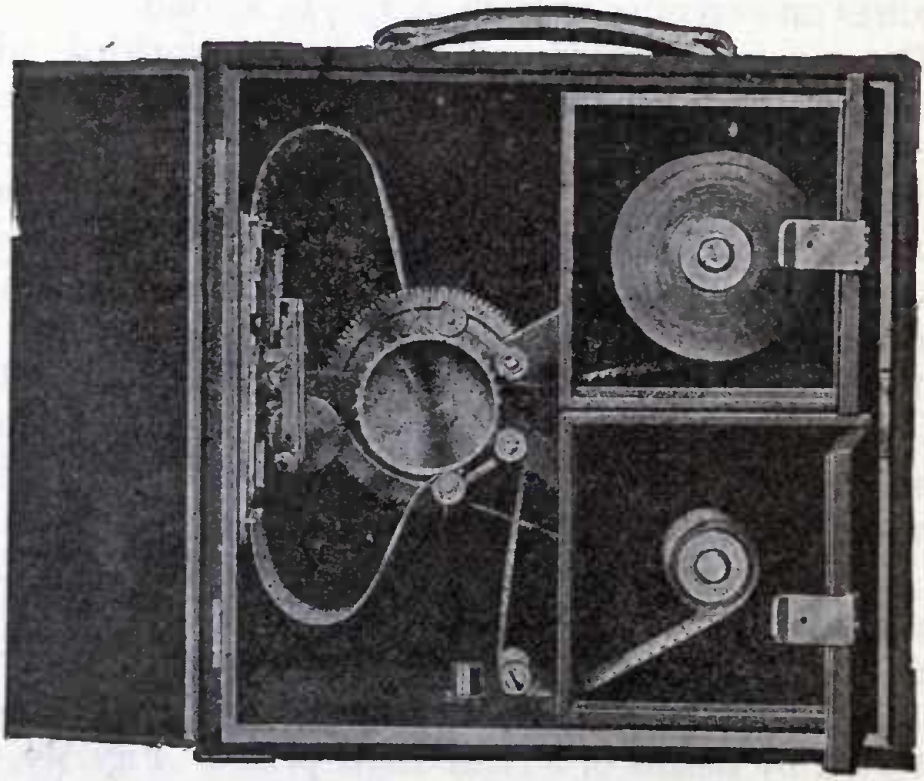

FIG. 45

MECHANISM OF WILLIAMSON CINEMA CAMERA

The exposed film is wound on a large frame or drum for developing, which operation is done in large tanks. After developing and fixing the film is rewound on to large drums revolving in hot air chambers.

When dry the negative film is run through the printing machine, in contact with a sensitive film. The arrangements of the printing machine are somewhat similar to those of the taking camera, but there is an unwinding and rewinding apparatus for both the negative film and the positive film and both go past the lens together. The illuminant shines through the lens and then through the negative films, the shutter being set to make the intermittent exposures. When the film has been passed through it is developed, fixed, washed and dried as the negative film. It is then ready to be exhibited.

Numerous efforts have been made to reproduce and project the natural colours of objects by the cinematograph, but so far only one method has proved successful, that known as Kinemacolour. It is based on the use of colour filters, but only two filters are used instead of three as called for by the theory of colour reproduction. The filters are red and green, and the blue filter is considered unnecessary as the green filter transmits a considerable amount of blue light. The pictures accordingly show blue sky and water besides black and white. The camera resembles an ordinary cinematographic camera, but is fitted with a rotating colour filter-holder in front of the lens. This holder is wheel-shaped, and has two open segments filled with the colour filters, which are of dyed gelatine, whilst the other two segments are open so that they shut off the light between the successive exposures. The machine is so geared that the exposures are made alternately through the red and green filter, at the rate of thirty-two images per second instead of sixteen as in the

ordinary cinema camera. The negative film shows no colour; there is simply a difference of tones in the two images. This negative film is printed from in the usual way, and the positive film likewise shows no colour. The projecting apparatus is provided with a rotating colour filter-holder similar to that on the taking camera. Fig. 46 shows the projecting arrangements. A is the arc light, B the lantern, C the condenser, D the film with green and red images alternating, L the projecting lens, G and R the green and red segments of the shutter, and S S the opaque segments. About a third of the red segment is covered with a segment of green, with the object of obtaining balance of the green, since red is more vivid to the eye than green. The overlapping segment of green has to be nicely proportioned in size, and this is shown to be attained when the revolving disc transmits to the screen a neutral white, due to the perfect mixture of the two colours. On the film being run through the result is that when a picture taken through the green filter is opposite the lens it will be projected as a green image, but as the red image instantly follows persistence of vision causes the eye to see the two images fused into one, with the result that the picture on the screen shows not only red and green, but complementary colours intermixed with many

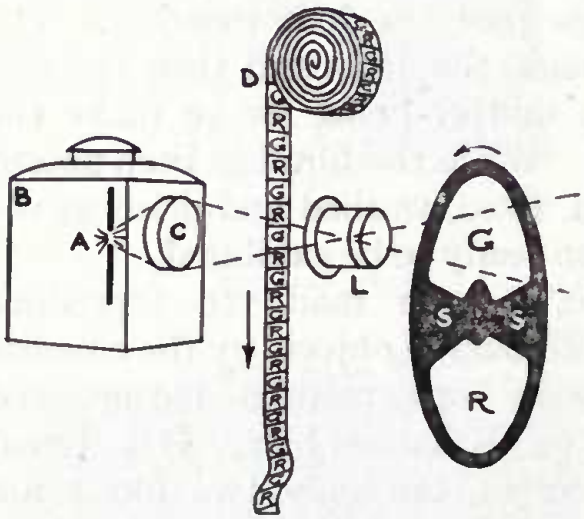

FIG. 46

KINEMATOGRAPH PROJECTOR

other hues resulting from the blending of varying proportions of red and green. The eye does not notice the absence of a blue image ; thus the complete natural colour effect is obtained. The results are not perfect, but the process is a most successful compromise.

The ideal colour cinematograph process has yet to be evolved, but many inventors are at work on it. Probably it will take the form of running three films simultaneously, so as to secure the red, green and blue image respectively ; then projecting these three images so that they blend on the screen. This has been accomplished very effectively for stationary images by F. E. Ives in his Photochromoscope, but so far it has not been possible to accomplish the same result with equal success with moving films. The optical and mechanical difficulties in the way are very great.

Attempts to apply the principle of the Autochrome and the Paget system of colour photography to the cinema film have met with no success, probably owing to the difficulty of preparing the colour screen on the film. The Warner-Powrie method of using a screen of parallel stripes of red, green and violet came near the attainment of practical application.

Undoubtedly the problem will eventually be solved, and pictures in colour will then take the place of the monochrome photographs now projected in the cinema theatres.

CHAPTER XIV

PHOTO-MECHANICAL PROCESSES

UNDER the above heading are distinguished a large number of processes which are based on photographic action, but which are distinguished from "pure" photography in the fact that they are used not for preparing actual photographs, such as are obtained on paper or other substances by the action of light alone, but as a means of preparing printing surfaces from which many impressions can be made mechanically without any further assistance from light action.

In many of these processes the photographic image is made capable of yielding impressions in greasy printing inks by typographic or lithographic methods, but there are some processes in which the use of a greasy ink is not necessary, and yet which are classed as photo-mechanical. We may instance Woodburytype as one such method.

One characteristic is common in all these photo mechanical processes, viz., that their starting point is generally the action of light on a bichromated colloid. The only important exception is the bitumen process, the oldest of photographic methods.

Niepce when experimenting with bitumen of Judea on metal plates, found that the image obtained by the action of light was resistive of acids. Consequently he deduced that if the image could be formed of lines, dots or patches of asphaltum it would be possible to etch the bare metal between in order to produce the relief necessary to enable the plate to be used as a printing surface.

In carrying out this idea Niepce coated pewter plates

with asphaltum dissolved in some suitable solvent which would evaporate and leave the surface dry; then exposed the plate under a print or other object which would act as a stencil protecting some parts of the plate, whilst allowing the light to act on the other parts. The effect of the light was to so harden the exposed parts that they were not dissolved when the plate was flowed with turpentine or some other solvent of bitumen. In this way a negative image was obtained on the metal plate if the exposure had been made through a print of black lines. This image being etched, the bare metal corresponding to the black lines of the print were deepened, until the plate corresponded to one of the engraved copper plates from which address cards are printed. The sunk lines were filled with ink, a piece of damp paper laid down on the surface and the plate run through a copperplate press. The result was a fac-simile of the original print.

If the image was wanted for printing on the lithographic or typographic press it was necessary to get a positive image on the stone or plate instead of the negative image which Niepce obtained by using the original print as a positive. The process of photography solved this difficulty, for when negatives were as a matter of course produced in the camera it was only necessary to print through the negative on to the plate and get a positive image.

A great deal was done with the bitumen process in the early days of photography, and some excellent work was accomplished both on the lithographic stone and on zinc and copper plates, but its great drawback was extreme slowness, and only in countries where strong sunshine prevailed was the process a success. In England exposures of several hours with bitumen have only resulted in failures.

A great step forward in photo-mechanical processes was made by the discovery of Mungo Ponton that a gelatine or similar colloid film treated with bichromate was hardened by the action of light, just as bitumen was hardened. It was only necessary to expose under a negative to get a hardened image, and on washing with water the other parts washed away. The image was not hard enough to withstand the action of acids as in the case of bitumen, but a compromise was discovered. It was found that if the surface after exposure was coated thinly with a greasy ink, the portions which were soluble would carry the ink away in the parts to remain white when the print was washed with water.

In applying this idea paper was coated with bichromated gelatine exposed under a negative, inked, developed by washing away the soluble gelatine with water, and thus was obtained a print of ink lines on paper. This was used as a transfer and applied to lithographic stone or zinc by running through a press ; the ink was thereby left on the stone or zinc and could be printed from in the usual lithographic manner. This is the transfer process of photo-lithography.

Later it was found that the paper transfer could be dispensed with, the stone or zinc being sensitized with bichromated gelatine, or albumen preferably, and printed on to direct through a negative. This method was not found very practicable in the case of stone, because of the weight and cumbrous character of the material, but direct printing on zinc is most extensively used at the present day for lithography, and the same method has been applied to aluminium.

Out of this process grew that of zinc etching. Gillot, a Parisian lithographer, found that if an ink print was made on to zinc either by transfer or direct, and strengthened by dusting with finely powdered resin

which was incorporated with the ink by applying heat, the plate could be etched into relief by means of nitric acid. A difficulty at first was that as the lines were etched into relief the acid began to attack the sides of the lines, causing an undercutting action. This was overcome by strengthening the ink by rolling up with more ink in the lithographic way, again dusting with resin, and heating to such an extent as to cause the ink and resin to run down the sides of the lines so as to protect them. By this process an enormous amount of what is termed " line " work is done at the present day in, making blocks for printing purposes.

The " line " process is only capable of reproducing clearly defined lines or areas of black or solid colour against white or other contrasting surface. It is not possible by this method to reproduce " tone," that is to say, differences of shade.

Taking the simplest case of a " black-and-white " wash-drawing, the artist obtains his effects of tone by means of washes of colour of more or less density. If we reckon black as full tone there will be a shade mid-way between that and the whiteness of the paper which may be termed " half-tone," and there will be varying shades of darkness and lightness on either side of this half-tone, on the one hand deepening towards black and on the other lightening towards white.

If a photographic negative were made from such a picture, and an attempt were made to print it direct on to a metal plate in the same way as a line negative we should get a print, but it would not be possible to develop it so as to bring out the tones of the picture. All but the blacks would wash away, and leave a picture consisting of nothing but shadow and " high lights," the latter represented by bare metal.

The early experimenters endeavoured to solve th

problem of reproducing the tones as well as the shadows and the theory underlying all processes with this object is that the tones must be broken up into grain points or dots, varying in fineness or coarseness according to the depth of tone required.

It is obvious that if a large number of grain points or dots are printed close together and are large in area, they will represent a dark shade, whilst those which are small and placed widely apart, so that they show white paper between will represent a light shade. This is the principle on which half-tone processes are based.

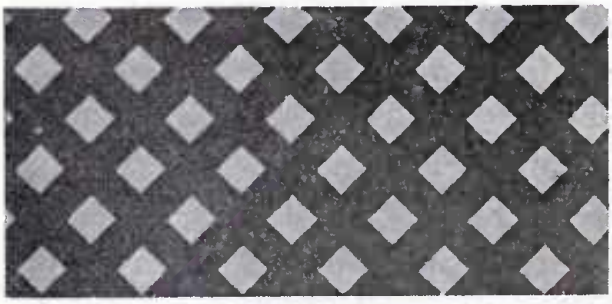

FIG. 47

HALF-TONE SCREEN ENLARGED

It was found that the easiest way of breaking up the tones into dots was by placing a "screen," which consists of a network of ruled lines on glass, in front of the sensitive plate (Fig. 47). The light penetrating the interstices of the screen forms opaque dots on the negative. But it may be urged by the reader unfamiliar with the process that, if the interstices of the screen are all the same size, the dots will be all of one size and therefore there can be no representation of tone.

It must be remembered, however, that the various parts of a picture which is being reproduced do not reflect the same amount of light, and as the area of the dots formed is proportional to the amount of light reflected from corresponding points on the picture the dots will be of varying size. There will be large dots formed opposite to white portions of the picture and small dots opposite dark portions, and there will

be intermediate sizes for less dark or less light parts. Thus we get the required variation of dot to reproduce the tones (Fig. 48).

Again it may be urged that such a dot negative might be expected to print crossed lines on to the plate, because the light would act in the spaces between the dots, but the fact is that the large dots grow so much in the negative that they join up to each other, forming a sort of chess-board pattern, so that the light acting through the clear space between produces a dot on the plate. This effect can be best understood by examining, with the aid of a magnifier, any of the half-tone prints in this book.

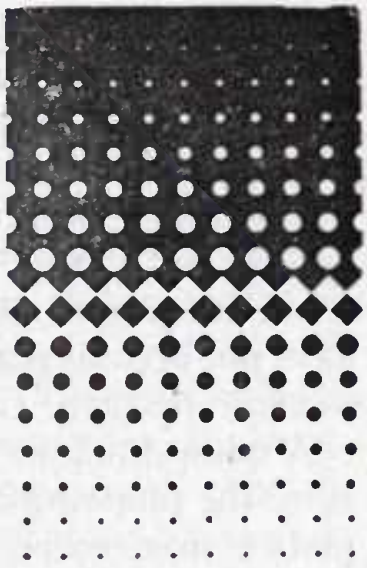

FIG 48.

GRADUATED DOT SYSTEM PRODUCED BY SCREEN

The half-tone negative produced in this way is to all intents and purposes the same as a line negative in that it consists of areas of black and white. It is in a sense a stencil, and all we have to do is to print it on to a metal plate coated with a bichromated composition to obtain an image which when developed consists of hardened dots with bare metal between.

The same process as used for line work may be employed for the printing and etching, but it was found that it did not yield clean results for finely screened work, the ink and resinous powder tending to fill up the spaces between the dots and thus give them a ragged dirty appearance. A better method was discovered, called the "enamel" process, and copper was found to be a superior metal to zinc for such work. The

copper plate is coated with fish glue mixed with bichromate of ammonia. After being dried the plate is printed under the half-tone negative, a powerful electric arc lamp being usually employed to furnish the light. After exposure the plate is developed with water, with the result that the unexposed fish glue is removed from between the dots leaving the bare metal. The plate is then dried and held over a gas stove until the heat converts the fish glue image into a hard enamel which will withstand the subsequent etching in a solution of perchloride of iron. The dots thus stand in relief so that they may be inked and printed from as a letterpress block.

The same method of reproducing half-tone can be applied to " grain " by inserting in the camera a screen formed of granulated particles, but the blocks so produced have not become popular, as the results are not so pleasing as those from the ruled screen.

A quite different way of obtaining tone reproductions is by the photogravure process. In this case the copper plate is first coated with a fine powder of asphaltum, the shower of dust particles being so regulated as to produce fine grain points. The plate is heated to fix the grains, then a carbon print from an ordinary (non-screened) negative is developed thereon by the methods described in Chapter IX. When dry the plate is put into a solution of perchloride of iron which penetrates the gelatine image in proportion to the thickness of the film. As this thickness varies with the different tones, being thinnest in the shadows and thickest in the high lights, the result is an etching which is deepest in the shadows and hardly, if at all, affected in the lights, the other tones being of varying depth. The hollowed out parts are then filled with ink, just as the copper-plate printer fills in the sunk engraving on an address card plate,

and the surface is cleanly wiped. When a sheet of damped paper is applied to the plate and the whole run under a roller press an impression reproducing the tones of the picture without any visible screening effect is obtained.

This process is capable of producing highly artistic prints, but the method of printing is slow and the work is correspondingly expensive. Of late years a compromise between this process and the half-tone block has been discovered. The carbon tissue before or after being printed under the picture positive is exposed under a ruled screen. The tissue is then developed on a clean copper surface, usually of cylindrical form for rapid printing, and the etching is done as already described in the plate photogravure process, except that the cylinder is rotated in the etching solution. The effect of the screen is the same as that of the asphaltum grain, it holds the ink in little cups or hollows, preventing it from being wiped away in the more delicate parts of the picture. The cylinder is put into a special printing machine with an ink roller in contact, and also with a thin steel scraper resting against it, so that after the inking roller has smeared the cylinder with ink the scraper cleans the surface. Paper is fed between the printing cylinder and a rubber-covered impression cylinder above it, the result being that prints are obtained at a high rate of speed. This process is called rotary photogravure. Fig. 49 illustrates one of the machines for printing by this process.

The same principle has been applied to flat plates, but the difficulties of mechanical wiping with a scraper are greater than in case of cylinders, and the printing is necessarily slower. For these reasons flat-plate printing is not much favoured and has not attained

anything like the popularity achieved by the rotary printing.

A totally different process from either of the foregoing methods for obtaining reproductions in tone is the collotype process. In this case a glass plate about ½ in. in thickness is coated with a mixture of gelatine and bichromate. When dry it is exposed under a negative then washed to remove the surplus bichromate. The excess of moisture is removed, and the plate is flowed

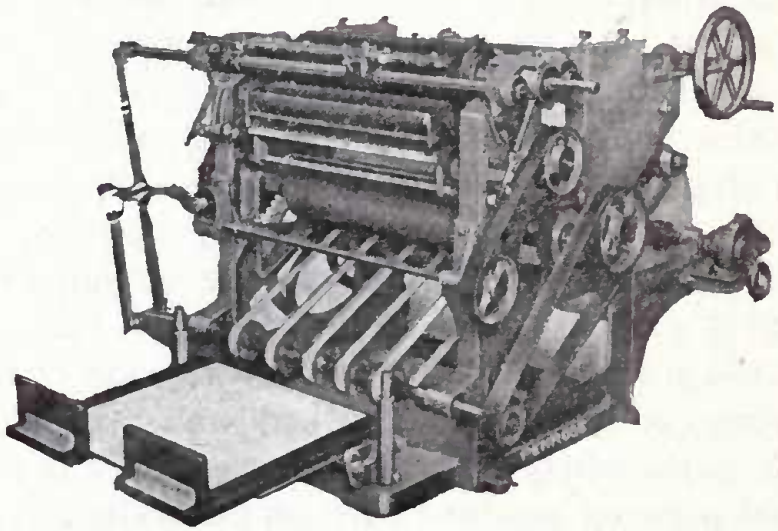

FIG. 49

ROTARY GRAVURE PRINTING MACHINE

with glycerine, which is allowed to soak in, after which the surplus on the surface is removed. The effect of the glycerine is to keep the gelatine in a moist state. The moisture is proportional in the various parts of the picture to the amount of exposure to light each part has received, so that when an ink roller is passed over the plate the ink is taken up in proportion to the light and shade of the picture. The dark parts which have received most exposure hold very little moisture and therefore take up most ink. The principle is that of the repulsion of greasy

ink by moisture, and the corresponding affinity for ink of the parts where there is least moisture. A sheet of paper is laid down on the plate, and the whole run through the press, when a print is obtained. The result is a nearer approach to a real photograph than anything obtainable by other photo-mechanical processes. There is an absence of visible grain, but if the print is examined under a microscope it will be seen that the image is formed of reticulations. The gelatine image is in fact reticulated, so that it gives the effect of granulation. The grain is most open in the lights whilst being closer and denser in the shadows. This has a discriminating effect in taking up ink.

Photo-lithography can be utilized for reproducing half-tone by adopting the principle of collotype. The bichromated gelatine mixed with certain other chemicals is spread on paper and printed under an ordinary negative. The gelatine reticulates in the same way as on a collotype plate and the print can be inked up so as to form a transfer which can be applied to stone.

The method more generally applied to lithography is to coat a zinc plate with bichromated albumen and print direct on to it a half-tone negative. After exposure the plate is coated all over with a thin layer of special ink, and then laid to soak in water. With a little gentle rubbing with a tuft of cotton wool the unexposed parts are cleaned away and an ink image is left on the plate. This can be strengthened by application of an ink roller and printed from in the usual lithographic manner. The best method of printing for such plates is the off-set process, which consists in first printing on to a rubber covered cylinder which in turn transfers its print to a sheet of paper.

A photo-mechanical process which formerly had much vogue, but is little used now, is the Woodbury

process or Woodburytype, as it was called. A strong paper very thickly coated with pigmented gelatine, as in the carbon process, was printed under an ordinary negative. After exposure the unaltered gelatine was washed away so that the image stood up in relief. When dry a mould was taken from this relief in a lead plate by hydraulic pressure. This mould was laid level on a press and a very fluid ink (actually gelatine and pigment) was poured over it. Paper was laid on and pressure applied with the result that the surplus ink was squeezed out where there were high portions in relief, and left where there were low portions, these latter corresponding to the shadows. On removal of the paper a beautifully rich toned print was obtained. The pigmented ink had in reality formed a cast from the lead plate, and the intensity of the tones was proportional to the depths of the ink.

A modification of this process was called Stannotype. Instead of making a mould in lead the gelatine was covered with thin tinfoil which was pressed into contact with the gelatine, the latter having being coated with india-rubber solution to make the tinfoil adhere. The surface of the tinfoil then showed all the original relief and formed a durable coating, so that the plate could then be printed from direct.

There are many ramifications of these photo-mechanical processes, but the foregoing are those which have come into commercial use. The other methods are merely modifications of these processes.

Three colour printing methods are essentially based on the methods we have just described for single colour printing. The chief variations from the regular practice is in the making of negatives. The principles of the three-colour process have already been described in Chapter XI. Let it be supposed that instead of making

three negatives through colour filters for the purpose of producing stained films we use them for making blocks for letterpress printing, and we have the same principles involved. The difference is that the negatives must have a "grain" or dot formation in addition to the colour rendering of the tones. This result may be brought about by making positives from such negatives as are produced for the triple film method, and recopying the positives so obtained whilst interposing a ruled screen to break up the tones into dots. This was the original method adopted and was known as the indirect process. It has been superseded by the "direct" process in which the picture or object to be reproduced in colours is photographed by three separate exposures, with not only the ruled screen but also the respective colour filters interposed between the lens and sensitive plate. The latter has to be colour sensitive equally or as nearly so as it can be made to all colours. This is termed a panchromatic plate. The negatives thus produced are hardly distinguishable in general appearance from ordinary half-tone negatives, the only difference discernible on a close examination being that the tones vary in the respective negatives according to the colours they represent. The negatives are printed on to copper and etched in the same way as half-tone blocks. In printing the block which was taken through the blue filter is printed first in yellow ink, that through the green filter in red ink, and that through the red filter in blue ink. If the blocks have been made correctly so that they register exactly and represent the colours properly the result on paper will be a pleasing colour print, and thousands can be run off in succession from the same set of blocks.

The same principles can be applied to photogravure, collotype, and photo-lithography by making suitable

printing plates instead of blocks, but it is more difficult to achieve good results, and as a rule any really excellent colour work done by these processes is the result of a combination of skilful handwork with the product of the photo-mechanical processes.

It should be mentioned that the pictorial daily newspapers, and the numerous illustrations in weekly and monthly periodicals are the results of the great progress made in these photo-mechanical processes of late years. It has led to the development of a new branch of photography, and the press photographer is now as ubiquitous as the newspaper reporter. The negatives he produces are very rapidly developed and printed on bromide paper, whilst the " process " department, which is now a part of the organization of every important daily newspaper, make the half-tone blocks with almost equal rapidity. In cases of special urgency, blocks are often produced within half an hour of the photograph being received.

The Rotary Photogravure process has now been largely applied to the printing of weekly newspapers.

CHAPTER XV

INDUSTRIAL APPLICATIONS OF PHOTOGRAPHY

APART from such industrial applications as the making of prints for engineers, architects, etc., the photographing of buildings during or after construction, recording manufacturing operations, photographing machinery and other objects for illustrative purposes, there are some other applications to industrial requirements which are becoming increasingly useful.

In many large manufacturing businesses photography is now employed to a considerable extent. The old blue print method has been largely superseded by a " black line " print, which is produced on a photographic basis. A blue print is first produced in the usual way by exposing the sensitive paper under the tracing. This gives a negative result, and without development the print is laid face down on a pad consisting of gelatine mixed with glycerine and ferric chloride. The chemical matter in the lines of the blue print hardens the gelatine so that it will take up ink in these parts when a roller is passed over the pad, whilst the parts which should remain white refuse to take the ink. A sheet of paper is pressed into contact with the pad and, on being lifted, takes up the ink yielding a print in black lines.

Another application of photography to industrial purposes consists in the use of an apparatus variously called the Photostat, Cameragraph, Planograph, or Rectigraph. The plan or drawing to be copied is laid on a horizontal board, and the image is first viewed in a right-angled reflecting prism, thence passing through the lens on to a roll of bromide paper. After the exposure is made, the piece of paper is cut off and passed

into a developing chamber where it is developed automatically, or partly so. There are scales on the apparatus for setting the focus for any desired size without the necessity of focussing, and the whole of the arrange-

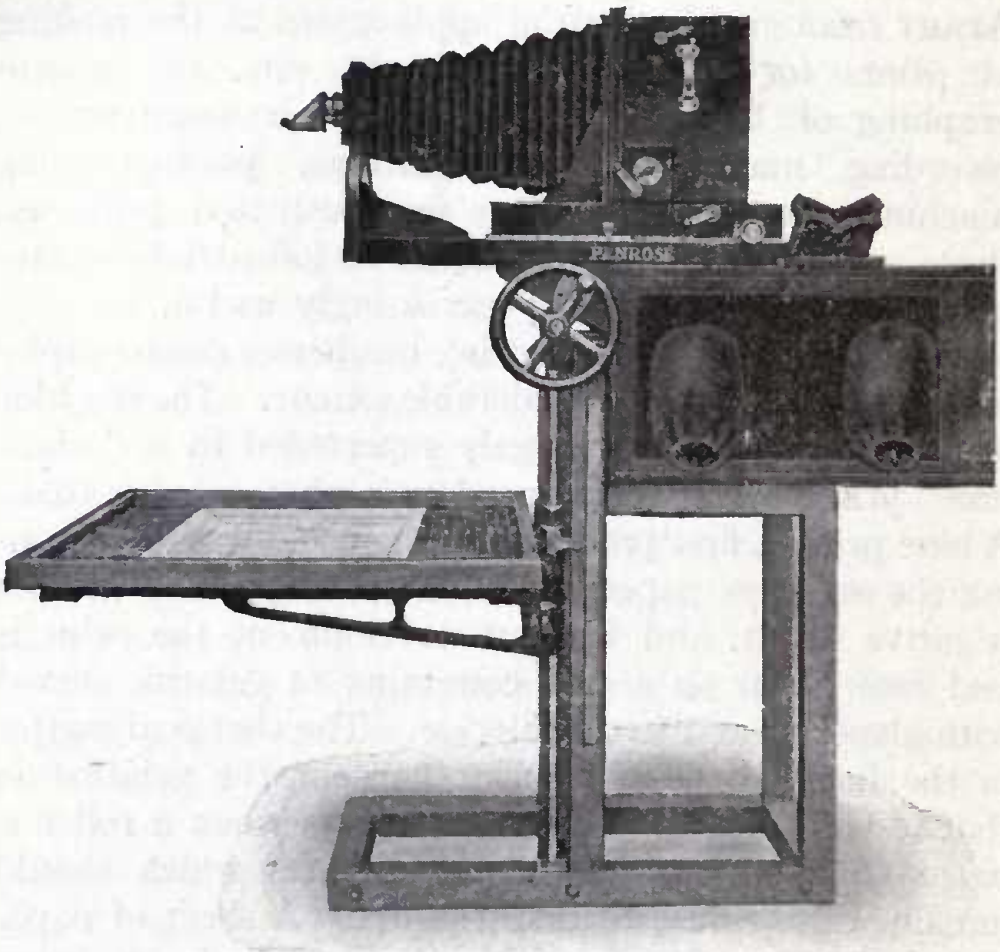

FIG. 50

PI ANOGRAPHY COPYING APPARATUS

ments are so simplified that even in unskilled hands a large number of prints can be quickly turned out. The apparatus is also used in libraries, museums and government offices for copying prints, documents, etc. Fig. 50 shows one form of this apparatus.

Photography has also been applied to the production

of engraved plates such as scales, dials, and instruction labels on instruments and machines; also for the production of graticules and scales on glass in optical instruments. The photographic process saves a great amount of hand engraving where many duplicates of the article are required.

There have been numerous efforts to apply photographic methods to the decoration of ceramic ware, but although very beautiful results have been obtained, it cannot be said that the methods have reached any degree of commercial success. This is probably due to the fact that the processes regularly employed are worked very quickly and cheaply by comparatively unskilled labour, whilst the photographic processes could not be so readily done.

The method of ceramic photography that has been most successfully employed is that known as the " Dusting-on " process. The sensitive film consists of gum, fish glue, or albumen mixed with such substances as honey or glucose, and glycerine, together with a bichromate salt. A glass plate is coated with the mixture, and when dry is exposed under a transparency. The image is slightly visible if the exposure has been correct. The development consists in brushing over the plate a ceramic powder, *i.e.*, a colour that is vitrifiable when fired in a furnace. The powder adheres in proportion to the light and shade of the picture, the reason for this adherence being that the plate is tacky through absorbing moisture from the atmosphere, this condition being brought about by the honey or glucose and glycerine added to the coating mixture. The exposure to light makes the various parts of the picture more or less tacky. In the shadows the powder mostly adheres, and consequently the darkest shade is produced. In the high lights little or no powder

will adhere so that the result will be white. As soon as development is complete the film is covered with a coating of plain collodion and the plate is next allowed to soak in water to remove the unaltered bichromate. Next it is placed in a bath of fused borax and water, after which the film is stripped from the glass by a simple method, and allowed to float in a basin of the fused borax solution. A plaque or other piece of ceramic ware is introduced under the film and the two are lifted out together, any wrinkles formed in the film being smoothed out with a camel hair brush. The plaque is dried, and then placed in a muffle gas furnace, the heat of which destroys the photographic film and fuses the powder. Finally the plaque is glazed by a further firing and is then complete.

Another method is that called the "Substitution" process. A glass plate is coated with collodion and sensitized in a silver bath in the same way as in making a wet collodion negative. It is exposed in a transparency camera so as to produce a positive and is developed as usual. After fixing with potassium cyanide and washing very thoroughly the film is floated from its glass support, and the image is toned in a solution of iridium chloride. Then it is transferred to the enamel plaque on which it is to be fired. The firing is done in a muffle furnace, the heat destroying the collodion film and fusing the iridium and gold of the image into the enamel. After being glazed the enamel picture is complete. It is then quite permanent and the result, if the operations have been carried through properly, is very beautiful. The reason for the word "substitution" being used to describe this process is that the original silver of the image is substituted by the iridium and gold.

Photography has also been employed for the

decoration of tiles and for stained glass, but not to any large extent. Attempts have been made to create businesses for working these processes but with little or no success. The results obtained were excellent, but apparently the processes were too costly and slow to be commercially profitable in working.

The decoration of wood panels has also been done successfully by photographic means, but has not found a permanent commercial application.

Photographic printing on silk, satin, and other fabrics, though giving charming results has never come to anything in a business way.

An Austrian inventor, Jan Sczcepanik, endeavoured to apply photographic processes to the production of cards for the Jacquard loom, and he succeeded in obtaining excellent results. Experimental works were set up in Austria and in England, but the venture proved a commercial failure. Better success has attended efforts to apply the photogravure process to the printing of calico and wall papers, the copper cylinders being produced by photo-etching, but the method has not yet come into general use.

Another direction in which photography has been applied to industrial work is in the production of reliefs for electrotyping. A thick gelatine film treated with bichromate will swell up into relief when developed after exposure under a negative. A plaster cast can be taken from this relief, and from this cast a wax mould can be taken. Copper is deposited on this mould and medals or other relief designs obtained. Printing plates have also been made in this way, the process being called " Photo-electrotype."

Photo-sculpture has been a fascinating field for experiment by several inventors. To increase the relief effect the photographs have been taken from

different points of view, the subjects being rotated on a turntable or in some other way shifted to secure different positions according to a uniform scheme. These photographs have been used as a guide to the sculptor.

Photography has also been pressed into service for music printing. In one method the notes and signs on a large scale were cut out from paper or thin metal and were fixed in their proper positions on a large board ruled with the musical staves. When complete the whole was photographed on a reduced scale, and the print from resulting negative formed the sheet of music, or the negative could be used for making a block or a transfer for lithographic printing. Another method was to have the notes printed on separate pieces of paper and stuck on to a glass ruled with the lines of the staves. When complete the plate was photographed and the negative used as in the process last described.

Photo-process work has been applied to Stencil cutting, much more elaborate designs than could readily be cut by hand being produced. A negative line print is put down on the stencil metal and the line etched through ; the back and the parts to be left intact being protected by acid-resisting varnish.

Lastly we may mention the application of photography to the decoration of gold and silver ware. A carbon print, in one method, was developed and transferred to the surface, and then lacquered over, but a more permanent method was to etch the image in the same way as a photogravure plate, using the carbon transfer as a resist. Yet another way was to make a half-tone negative and print it on the metal surface by the fish glue enamel method, burning-in the image, in the same way as done for etching. The image thus produced is very hard and will stand a good deal of wear. A

variation was that of making a half-tone positive, printing it on to the metal in enamel and etching. The sunk dots thus obtained, were filled in with black and gave the effect of a *niello* engraving.

Although, as will be seen from the foregoing, photography has not met with much success commercially in superseding handicraft work it has proved extremely useful as an adjunct in many industrial methods, and will be found very largely employed in many businesses for producing enlarged or reduced prints for a great many purposes as aids to the artist or craftsman.

CHAPTER XVI

PHOTOGRAPHY IN WARFARE

We close our survey of the applications of photography by a brief indication of its amazing developments brought about by the recent great European War.

Photography has been used for military purposes from the time it became a practical process. Even before the advent of the dry plate it was used to a limited extent in military operations by enployment of portable dark rooms for the development of the wet collodion plates on the spot. It has also been largely employed for the photo-lithographic and photo-zincographic production of maps in the survey departments. At the Ordnance Survey Office in Southampton photographic methods have been extensively used for something like forty years with the most successful results.

Photographic caravans completely equipped with every appliance for rapid work have been a feature in military organization.

From time to time apparatus has been devised for photographic surveying to replace the tedious methods of work with the theodolite, compass, plane table, and other apparatus used in trigonometrical surveying. Though these new methods have not yet come into general use they have revealed great possibilities, and have pointed the way to short cuts in military observation that have been found invaluable in the present war.

It was soon realized after the outbreak of war that photography from aeroplanes gave an immense advantage in military observation, and the first efforts made

with such apparatus as were obtainable showed the value of this new aid to warfare.

Gradually the apparatus was improved or new appliances constructed to suit the needs of the work, and a large number of photographic observers and their ground-helpers were trained. An enormous amount of valuable reconnaissance work has been done and the commanders of the armies in the field have highly praised the efficient aid rendered them by the photographic section of the service.

When it is remembered that before the war very little had been done other than in an experimental way in aero-photography the magnitude of the progress made can be understood. Photography from balloons had been accomplished, and efforts made to utilize these photographs for survey work by arranging for datum lines or scales to be reproduced on the photograph, but little or no practical use was made of such work.

Kite photography had also been developed to some extent before the war, a special form of camera being attached to the kite, with an automatic means for opening and closing the shutter. Some excellent photographs were taken in this way, but the difficulty of utilizing this method was no doubt the impossibilty of exactly directing the camera towards any particular point of view.

The advent of the aeroplane naturally pointed to fresh possibilities in aerial photography, but the instability of the early machines, and the fact that the pilot had enough to think about in handling his controls and watching his instruments did not encourage the idea of attempting to take photographs. In the early days of the war, however, there were instances of pilots having taken excellent photographs whilst keeping control of their machines. These efforts were casual

and experimental, and it was not until larger and better machines were sent into the air, carrying an observer as well as the pilot that the possibilities of photography began to be realized. At first ordinary cameras were used, but it was soon found that the changing of the plates and other manipulations were too slow and inefficient for such work.

The Germans and the French were the quickest to realize the necessity of constructing special cameras with automatic shutter-setting devices, changing boxes, and sighting attachments. With such cameras it was possible for an observer to bring back two or three dozen excellent negatives from one flight. Our frontispiece shows one form of camera used by the British Air Force and how it was operated.

Cameras captured from fallen German aeroplanes in the early stages of the war did not reveal any great originality. They had been adapted from types of hand cameras existing before the war.

The French showed great ingenuity in devising new types of cameras. They especially improved the plate-changing and sighting devices.

Naturally ideas were interchanged by the allies, and British camera makers were set to work to produce suitable types, which have been made in many thousands.

The lack of suitable lenses was early felt to be a weakness, but British and French optical firms have been stimulated to produce new types of lenses working at a large aperture. British firms were particularly successful in turning out lenses of very fine quality, and eminently suited for the work.

The size of plates used has been mostly small, for obvious reasons, the British standard being 5 × 4 in. means being employed for rapidly enlarging the pictures when necessary. The French have used larger sizes,

for instance, 24 × 18 cm. (9½ × 7 in.). Panchromatic plates were almost entirely used, both for their correct rendering of coloured objects and for their rapidity.

It was found that when taking photographs from a great altitude it was desirable to use long focus lenses, and this led to lenses being chosen with a focus much longer than was demanded by the size of the plate. The French carried this to the extreme by using lenses of nearly 2 metres focus on plates of 24 × 18 cm. The object was to secure a telephoto result, by bringing the object apparently nearer and thus securing larger detail in a smaller field. The Naval section of the British air service also adopted this idea, using plates of 8½ × 6½ in. or 10 × 8 in.

It might be supposed that a better result could be obtained by using telephoto lenses or focus-lengthening attachments to existing lenses, but as these do not give a large aperture and necessitate longer exposure, they were found impracticable.

In all cases the cameras are set at a fixed focus for infinity, as obviously focussing would be impossible and for high altitudes unnecessary.

As a rule the cameras are pointed vertically downwards through an aperture in the floor of the aeroplane body, but cameras have also been arranged to be directed over the side of the machine.

Shutters were mostly of the focal plane type, working directly in front of the plate.

Various devices have been tried for registering the view point, compass direction, altitude, and angle of inclination to the horizon, but for the most part these have not been found very practicable.

The usual method is for the observer to fly with a level keel at a determined altitude and take photographs in quick succession. Prints are made from the resulting

negatives, and joined up by locating objects which are repeated on succeeding photographs. In this way a complete bird's eye view of the ground is obtained along the line on which the pilot has been flying. By comparison with ordinary maps positions are located and names, heights, distances, etc., filled in by hand lettering. Eventually this patched-up photograph is reproduced and prints furnished to the commanders of the armies.

The Germans essayed to improve on this method, as shown by a camera which fell into the hands of our troops. This camera was arranged to make a series of exposures on a continuous film after the style of a cinema camera, by simply turning a handle or by connecting it to a motor. The exposures were made at determined intervals, each picture representing a certain distance on the ground. The resulting pictures were joined up as already described and reproduced as a single map.

The British air force also had automatic cameras for making exposures in quick succession, one form being operated by a small air propeller.

At the time of writing the regular type of cinema camera has not been used to any considerable extent from aeroplanes, there being evidently some technical difficulties in the way, but experiments are in hand, and results obtained promise great possibilities. Obviously it would be a great gain to register any movements within the field of view, and the camera would reveal what could not be seen with the naked eye. The films being projected on a large scale show up detail which would be unnoticed on a small print.

It may be thought singular that roll film photography has not been used to a greater extent in aerial photography, thereby avoiding the use of more or less clumsy

changing boxes and dark slides for glass plates, but these latter have been preferred as being more reliable and practical.

An ingenious camera in the form of a gun was used to teach shooting. The user of it aimed at a small target inside the apparatus, and the effect of the shot was recorded on the negative.

The Navy do not appear to have utilized photography on board ship in the systematic way adopted by the military forces, but that a large amount of photography is being done in the Navy is evident from the numerous photographs of life on board ship and of naval battle scenes.

Probably we may eventually see submarine photography developed. There is evidence that this can be done under suitable conditions as shown by the remarkable series of cinema and other photographs taken under the sea by Williamson Bros., and shown publicly in London.

There seems to be no field the photographer is unable to conquer on the earth, under the earth, on the sea and under the sea, or in the sky, and even to the remotest planets and stars. The most minute objects are revealed by the photo-microscope, and the intricate movements of life and nature with the aid of the cinema camera, and the X-ray apparatus. The reproduction of natural colours is accomplished, though long accounted an impossibilty. Sound waves, water currents, and almost all the phenomena of nature have been revealed by photography, and undoubtedly we shall see even more marvellous things yet by its powerful aid.

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