The Masterpieces of the Exhibition

THE

MASTERPIECES

OF THE

CENTENNIAL INTERNATIONAL EXHIBITION

ILLUSTRATED

VOLUME III

HISTORY, MECHANICS, SCIENCE

BY

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PHILADELPHIA

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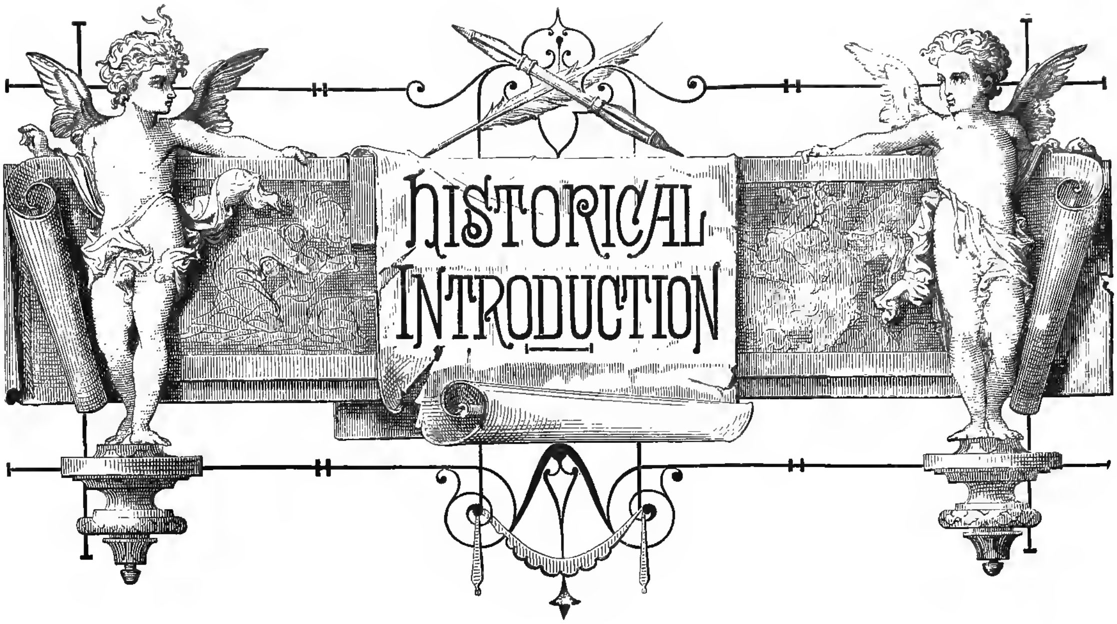


INTERNATIONAL EXHIBITIONS.

EXHIBITIONS undoubtedly date back to a very remote period, even the Olympic games of the Greeks might be classed as such, and the ancient periodical fairs for the display and sale of natural and industrial products, some of them continuing to the present day, although not properly speaking, true expositions or intended for such, yet gave great encouragement to the arts and manufactures of their time.

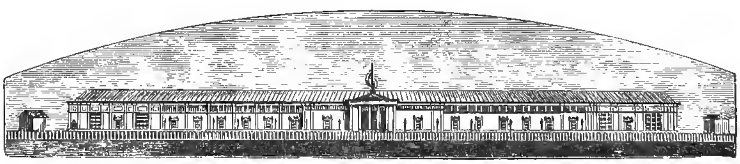
After Europe began to recover from the blight of the Dark Ages, the arts of civilization and luxury, centering and developing in Italy, rapidly found their way into France, a country already prepared for them by its ancient Roman education; and from being the recipient, she gradually became the producer, early taking a pre-eminent stand among the nations of the earth in almost every known branch of manufacture, especially those connected with art. This she has retained to the present day. It is but natural, therefore, that she should have been foremost, at least in the modern world, to originate the idea of Industrial Exhibitions.

The first of which we have any record was that of 1798, born of the Revolution, a reaction as it were from the turbulent spirit of the times, back to the pursuits of peace and industry. The Marquis d'Avèze, shortly after his appointment in 1797 as Commissioner of the Royal Manufactories of the Gobelins, of Sevres, and of the Savonnerie, found the workmen reduced nearly to starvation by the neglect of the previous two years, while the storehouses, in the mean time, had been filled with their choicest productions. The original idea occurred to him to have a display and sale of this large stock of tapestries, china and carpets, and obtaining the consent of the government, he made arrangements for an exhibition at the then uninhabited Chateau of St. Cloud. On the day, however, appointed for the opening, he was compelled by a decree of the Directory, banishing the nobility, to quit France, and the project was a failure. The following year, however, returning to France, he organized another exhibition on a larger scale, collecting a great variety of beautiful objects of art and arranging them in the house and gardens of the Maison d'Orsay for exhibition and sale. The success was so great that the government adopted the idea, and the first official Exposition was established and held on the Champ de Mars, a Temple of Industry being erected, surrounded by sixty porticoes, and filled with the most magnificent collection of objects that France could produce. Here was first inaugurated the system of awards by juries, composed of gentlemen distinguished for their taste in the various departments of art, and prizes were awarded for excellence in design and workmanship.

The government was so satisfied with the good effects resulting from this exhibition, that it resolved to hold them annually; but notwithstanding the circular of the Minister of the Interior to this effect, the disturbed state of the country prevented a repetition until 1801. The First Consul taking the greatest interest in the affair, visited the factories and workshops of the principal towns in France, to convince the manufacturers of the great importance to themselves and their country of favoring the undertaking. A temporary building was erected in the quadrangle of the Louvre, and notwithstanding great difficulties attending the establishment of the exhibition, there were two hundred competitors for prizes; ten gold, twenty silver, and thirty bronze medals being awarded,—one of the last to Jacquard for his now famous loom. Among these prizes, were some for excellence in woollen and cotton fabrics, and improvements in the quality of wool as a raw material.

The third exhibition was in 1802, where there were six hundred prize competitors. These expositions became so popular as to result in the formation of a *Société d'Encouragement*, thus creating a powerful aid to the industrial efforts of the French manufacturers. At the fourth exhibition, in 1806, the printed cottons of Mulhausen and Logelbach, and silk-thread and cotton-lace were first displayed, and prizes were adjudged for the manufacture of iron by means of coke, and of steel by a new process.

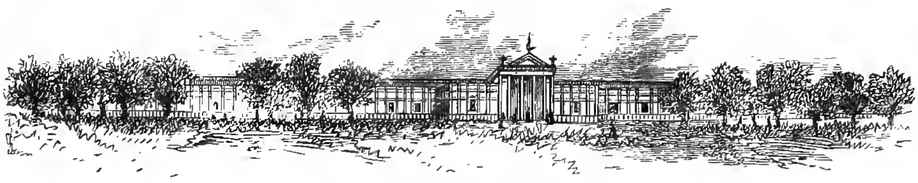
Foreign wars prevented further exhibitions until 1819, after which time they became more frequent, being held in 1823, 1827, etc.; the tenth being in 1844, the last, under the reign of Louis Philippe, when three thousand nine hundred and sixty manufacturers exhibited their productions. It was the most splendid and varied display that had ever been held in France. The building, designed by the architect Moreau and erected in the Carré Marigny



Exhibition Building, Paris, 1844.

of the Champs Elysées, was an immense timber shed, constructed and entirely completed in seventy days, at a cost of about thirty cents per square foot of surface covered. We present an elevation showing the royal entrance. It was at this exhibition that the first Nasmyth steam-hammer was shown on the continent, and the display of heavy moving machinery was much greater than had ever taken place before.

In 1849, notwithstanding the political revolution through which France had just passed, she organized another exhibition on a still grander scale than any preceding. The services of the architect Moreau were again called into requisition, and another building, of which we give an engraving, erected in the Champs Elysées, more pretentious in its character than



Exhibition Building, Paris, 1849.

any previous one, covering an area of 220,000 square feet, exclusive of an agricultural annexe, and costing about the same price per square foot as the building of 1844. At this time the number of exhibitors had increased from one thousand four hundred, in 1806, to nearly five thousand, there being no less than three thousand seven hundred and thirty-eight prizes awarded, and the building remained open for sixty days.

Other nations, noticing the beneficial results of the French exhibitions, became active in the matter; the King of Bavaria giving an exhibition at Munich, in 1845, and previous to this time occasional ones had been held in Austria, Spain, Portugal, Russia, Denmark, Sweden, etc.; those of Belgium being numerous and important. In the British Dominions, exhibitions had been held in Dublin as early as 1827, and later at Manchester, Leeds, etc.; but they partook more of the nature of bazaars, or fairs for the sale of the productions of the surrounding country; even that of Manchester, 1849, was of this character.

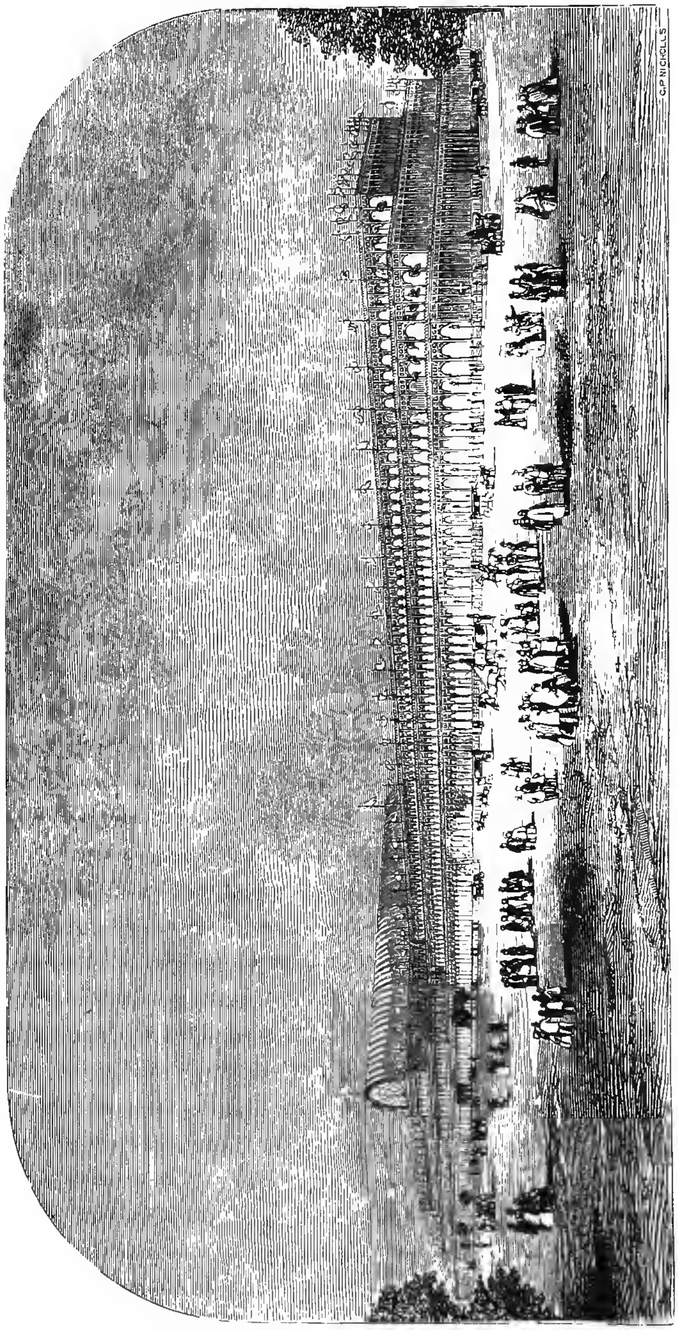
Each of these previous exhibitions had been strictly national, confined to the products of the special country by which it was held. The idea seems to have been suggested, however, in France, in 1849, of giving an International feature to that exhibition; M. Buffet, the Minister of Agriculture and Commerce, having addressed a circular letter on the subject to various manufacturers, with a view of ascertaining their opinions; but the resulting replies were so unfavorable that the project was abandoned, and France lost the opportunity, which was reserved to England, of the credit of the first really International Industrial Exhibition, in that of London, 1851.

It may truly be said that the great success of this effort was owing to the indefatigable perseverance and indomitable energy of His Royal Highness Prince Albert, who took the greatest interest in the proceedings which gave it birth, from the very commencement, bringing to bear all the influence which attached to his position, his remarkable sagacity in matters of business, and his courageous defiance of all risks of failure. At one of the first meetings held on the subject, on the 29th of June, 1849, at Buckingham Palace, he communicated to those present his views in relation to a proposed exhibition of competition, in 1851, suggesting that the articles exhibited should consist of four great divisions, namely, raw materials, machinery and mechanical inventions, manufactures, and sculpture and the plastic arts; and at a second meeting, on July 14th of the same year, he gave still further suggestions of a plan of operations which he recommended, comprising the formation of a Royal Commission, the definition of the nature of the exhibition and of the best mode of conducting its proceedings, the determination of a method of deciding prizes and the means of raising a prize fund and providing for necessary expenses, etc.; and he also pointed out the site afterwards adopted, stating its advantages, and recommending early application to the government for permission to appropriate it.

After various preliminary proceedings, the Royal Commission was issued, and at the first meeting of the Commissioners, on January 11th, 1850, it was decided to rely entirely upon voluntary contributions for means to carry out the plans proposed.

The appeal made to this effect was answered in a most encouraging manner; a guarantee fund of $1,150,000 was subscribed, one gentleman opening the list with $250,000, and contributions began to come in from all directions.

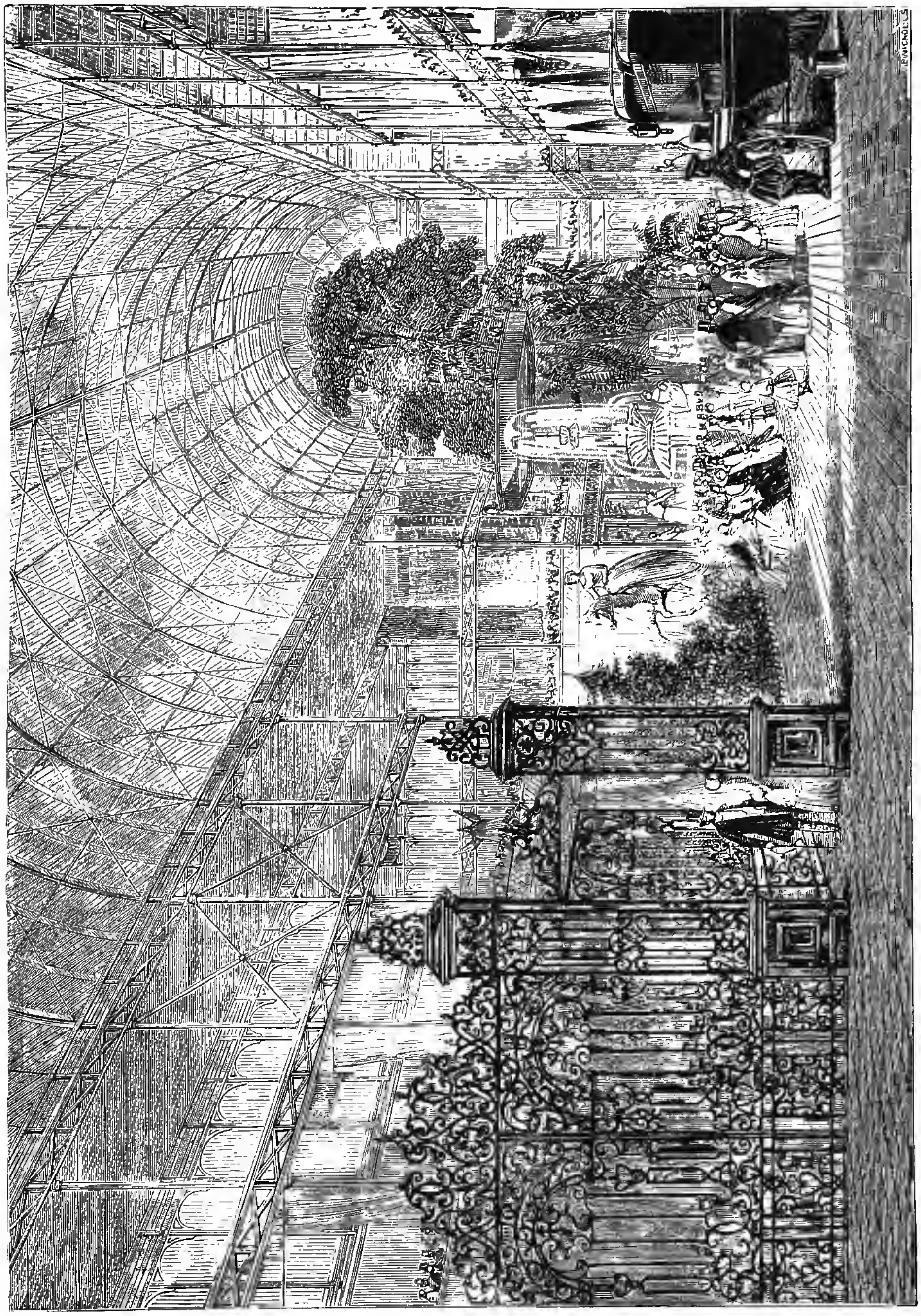
Upon the security thus provided the Bank of England undertook to furnish the necessary advances. Invitations were issued to architects of all nations to submit designs for a building to cover 700,000 square feet, and although the competitors amounted to two hundred and thirty-three in number, not one design was found entirely suitable for adoption. In this dilemma, the Building Committee prepared a design of their own, and, notwithstanding it was strongly condemned by public opinion as inappropriate and unsuitable in many respects, the committee warmly defended it and advertised for tenders to erect it, requesting at the same time, that competitors would make any suggestions they saw fit, that could in their opinion effect a reduction in the cost.



International Exhibition London, 1851.

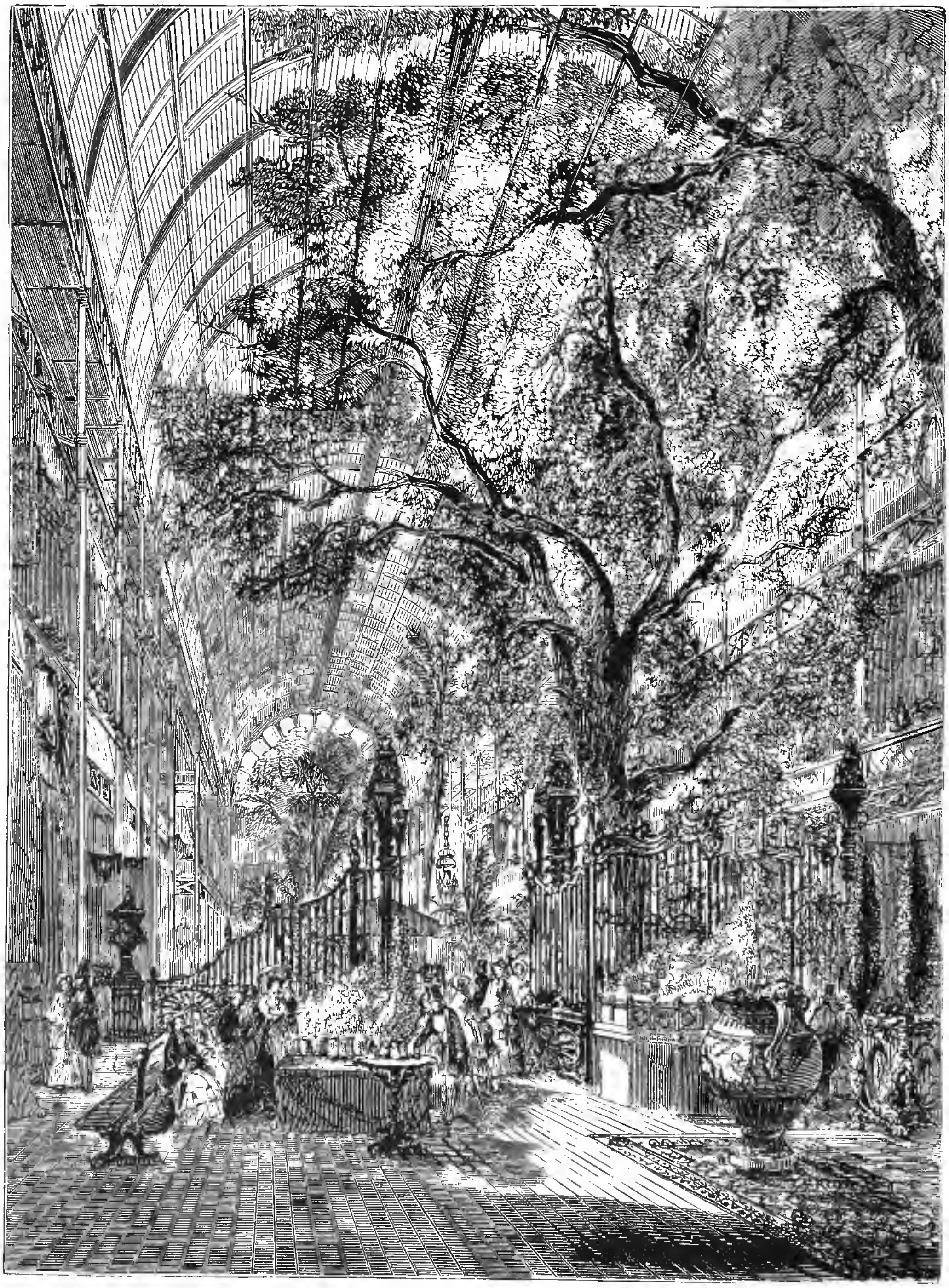
Messrs. Fox and Henderson availing themselves of this clause, presented a tender for a building of an entirely different character, on a plan proposed by Sir Joseph, then Mr. Paxton, who was at that time engaged in the erection of a large plant-house for the Duke of Devonshire, at Chatsworth. The design fully met the approbation of the Committee and their tender was accepted, on the 16th of May, 1850. Possession of the ground was obtained on the 30th of July, and work commenced forthwith,—the actual erection beginning about the first week in September.

Mr. Fox made the working drawings himself, devoting his great experience and skill personally to the work for eighteen hours a day, during seven weeks, and the preparation of the iron work and other material for the construction of the building was taken charge of by Mr. Henderson. As the building progressed, extensive experiments were made to test its strength for the purposes intended, and it was found fully equal to the severest requirements. The contract was not finally consummated until the end of October; but with a courage and enterprise characteristic of this firm, the work was pushed forward for many



Interior of the Transept, from the South Side, Exhibition of 1851.

weeks on faith alone, in order to insure the completion of the building at the time fixed for the opening,—the first of May, 1851. It was opened at the time appointed, by the Queen in person, with great ceremony, although considerable work still remained to be done. A report of the proceedings of the Royal Commissioners was read by Prince Albert as President, which being replied to by the Queen, the blessing of the Almighty was invoked upon the



The Transept of the Exhibition of 1851, from the North Side.

undertaking by the Archbishop of Canterbury, and the ceremonies terminated with the performance of the Hallelujah Chorus by the united choirs of the Chapel Royal, St. Paul's, Westminster Abbey, and St. George's Chapel, Windsor. The inauguration was one of the most imposing sights that had ever been witnessed in Great Britain. Our engraving gives a view of the building on the south side, extending east and west, and showing the main entrance at the great transept.

In appearance it called to mind one of the old, vast cathedrals, designed, however, in a new style of architecture; not massive, dark, and sombre, but light, graceful, airy, and almost fairy-like in its proportions,—built as if in a night by the touch of a wand,—a true "Crystal Palace," and a noble example of the use of our modern material—iron—for building purposes.

It was obvious that nothing more suitable could have been designed, and that the modern adaptation of one of the oldest architectural ideas—a great rectangular cruciform structure with nave and transepts—was just what was desired, possessing many more of the requirements of a building intended for industrial exhibitions than would appear at first glance. The old cathedral was a place for great ceremonials, for processions, and for exhibitions, in one sense of the word; its walls were covered with pictures and sculpture, and its windows filled with richly stained glass. Extending over a vast area, at the same time it had a grand central point of attraction, visible from all parts, and from which all parts were visible. These advantages were just what was required in an exhibition building, and the fact has been acknowledged over and over again in succeeding exhibitions. It will be seen, further on, that in our exhibition building the same ideas have been carried out, and that the building of 1851 has really been the type for all the most successful buildings erected since.

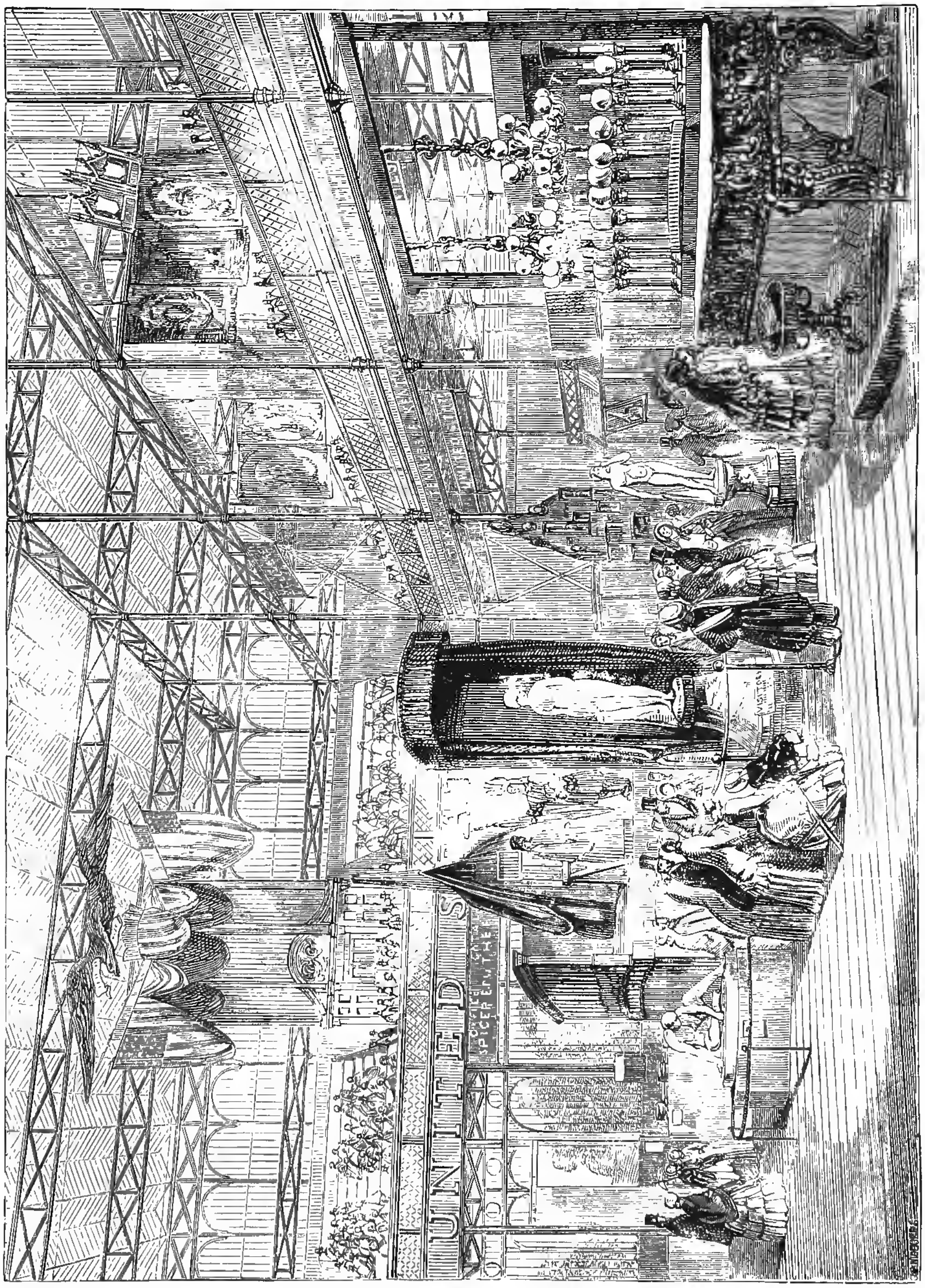
Fergusson characterized this building as belonging to a new style of architecture, which might be called the "Ferro-Vitreous Style," and states that "no incident in the history of architecture was so felicitous as Sir Joseph Paxton's suggestion." "At a time when men were puzzling themselves over domes to rival the Pantheon, or halls to surpass those of the Baths of Caracalla, it was wonderful that a man could be found to suggest a thing that had no other merit than being the best, and, indeed, the only thing then known which would answer the purpose."

The light appearance of this structure was so strongly marked that many persons, uneducated as to the effect which should be produced on the eye by an iron and glass construction on such a large scale, expressed grave doubts as to its stability. To satisfy these doubts in the public mind, extensive experiments were carried out during the progress of the work, and also after its completion, in the presence of the Queen, Prince Albert, and a number of scientific men, by means of large numbers of workmen, crowding them on the platforms, and moving them back and forth, and also by means of companies of troops, arranging them in close order and marching them on the floors. Frames holding cannon-balls were also constructed and drawn over the floor, and the results of all these experiments were such as to entirely satisfy every one that the building was properly planned and constructed for its purposes.

Passing into the building at the west end, we enter a grand nave 72 feet wide, 1848 feet long, and 64 feet to the roof, crossed by a noble transept of the same width, but crowned by a semi-circular vault, increasing its height to 104 feet at the centre. On each side of the nave and transept a series of aisles spread out the building to a total width of 456 feet, the entire area covered being 772,784 square feet, and, with the addition of the galleries, making a total exhibition space of 989,884 square feet. The quantities of materials in the structure were as follows:—

Cast iron, 3,500 tons;	Glass, 896,000 superficial feet, or 400 tons;
Wrought iron, 550 tons;	Wood, 600,000 cubic feet;

and the total cost was about $850,000; the building remaining the property of the contractors after the exhibition was over. The late Mr. Owen Jones, so well known for his taste in art ornamentation, was entrusted with the decoration of this palace, and the result fully justified the trust reposed in him, and met with very general approval.



United States Department, Exhibition of 1851.

It is said that, in designing the structure, the magnificent transept, with its semi-circular roof, was suggested in consequence of a desire to retain several lofty trees which were on the grounds. Be that as it may, the trees were retained, and we are glad to be able to give an engraving showing the beautiful effect thereby produced. These enclosed trees made a marked feature in the exhibition.

The United States department was quite well represented,—bearing in mind the comparatively small advances which this country had made, at that time, in the higher departments of art manufacture,—and we furnish a view of this department as it appeared. Powers exhibited his celebrated "Greek Slave," shown in the foreground of the picture, of which we believe there are several originals in existence,—one at the Corcoran Gallery in Washington. He also exhibited his "Fisher Boy," a work in every way worthy of the artist, and seen to the right of the "Greek Slave." The piano, on the right, was exhibited by Messrs. Nunn & Clark, of New York. Messrs. Chickering, of Boston, also exhibited a very fine instrument, and even at that time they had obtained a high reputation for power and brilliancy of tone, among European professors. Cornelius & Co., of Philadelphia, exhibited two elegant examples of gas chandeliers, which were very much admired. Some handsome carriages were shown; our celebrated Watson, of Philadelphia, being among the exhibitors. The exhibition of agricultural implements and raw materials was very creditable.

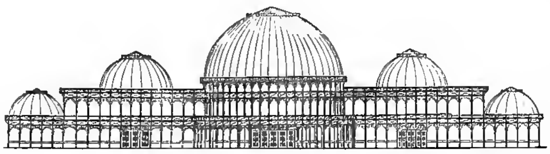
We also present a view of the interior of the transept from the south side, which will aid in giving the reader some idea of the structure and its exhibits. In the centre is seen the curious glass fountain, contributed by the Messrs. Osler, of Birmingham, which attracted so much attention by the novelty of its design, its lightness, and its beauty. Passing on through the building, the visitor came into contact with objects from India, Africa, Asia, the West Indies, and all quarters of the globe; articles of sculpture, textile fabrics, modern and mediæval brass and iron work, animal and mineral products, machinery, works of utility and those of ornament—everything that could furnish delight to man or add to his comfort: a vast collection, exemplifying the great progress which civilization had wrought in the world by the skill of man adapting the materials of nature to his own use.

The exhibition of 1851 was in every way a great success. Upwards ot $200,000 had been received from the sale of season tickets alone before the opening. During the six months that it remained open, from May to October inclusive, the average daily number of visitors was 43,536; the total number for the whole time was 6,170,000, and the amount of receipts, $2,625, 535; there being a balance of $750,000 in the hands of the Commissioners after all expenses were paid. The exhibitors, coming from all parts of the world, amounted to more than 17,000.

The unique style and acknowledged beauty of this magnificent edifice—the first of its kind—and the delightful recollections connected with its use, combined to preserve it from destruction; and visitors now see the same building, more permanently constructed in a modified and much improved form, at Sydenham, as one of the great pleasure resorts of London. Of those who have been abroad, who does not remember Sydenham?—the beautiful grounds laid out with shrubbery, walks, lakes, and fountains, for the special purpose of making the whole as attractive as possible; the splendid band in constant attendance, the delightful concerts, amusements of all kinds in the most interesting variety, and the vast crowds, wandering about and so thoroughly enjoying themselves. Special excursions are made up, numbering sometimes thousands of people, for a happy day at the Crystal Palace,—a rest from the bustle and turmoil of the city, adding renewed vigor to the tired body to struggle in the battle of life. It is not alone, however, as a pleasure resort, but also as a place of education for the masses, that Sydenham Crystal Palace is worthy of note. Portions of the building are fitted up to represent the styles of architecture of different periods of the world's history, such as the Pompeian Court, the Italian Court, the Renaissance Court, the English Mediæval Court, &c. Another portion contains copies of the works of great sculptors of ancient and modern times, and of paintings of great artists, and down by the lake in the gardens, one finds models, life-size, of the pre-historic animals of the ancient world.

The success attending this exhibition stimulated other countries in efforts to have something of the same kind. Exhibitions, more or less local in character, were projected and held in the large manufacturing towns throughout the British Empire,—at Cork, Dublin, Manchester, &c.

That at Dublin, in 1853, under the auspices of the Royal Dublin Society, which had previously had triennial exhibitions, was the result of a proposition made to the Society by Mr. William Dargan, a well-known contractor, providing a certain fund for the exhibition under certain conditions; and, although international in its features, was not practically as entirely so as the exhibition of 1851. The building consisted of five large, parallel, arched and dome-roofed halls. The great central hall was longer, as lofty, and one-fourth wider than the transept of the Crystal Palace of 1851, being 425 feet in length by 100 feet in breadth and 105 feet in height, with vaulted roof and semi-circular domed ends. We give an elevation of this building, which shows very clearly its general design.



Dublin Exhibition Building, 1853.

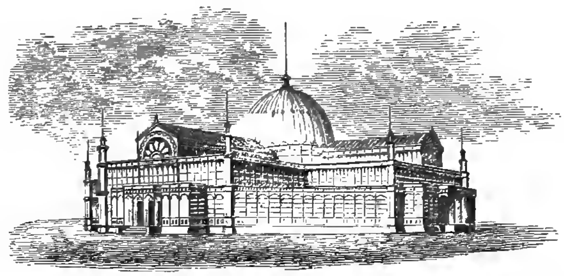
The erection commenced August 18th, 1852, and the exhibition was opened by the Irish Viceroy, May 12th 1853, the building occupying in construction about two hundred working days.

The interior effect was spacious and beautiful, and the decoration, notwithstanding the small sum appropriated for it, quite effective,—the prevailing tints being light blues, delicate buffs, and deep ultramarine, with white and red used very sparingly. The columns of the central hall were dark blue, and the skeleton frame of the building was marked out and emphasized by dark and heavy tones of color. The total area covered was 265,000 superficial feet, costing, per square foot, about five-sixths of that of the building of 1851, but the exhibition itself was not a financial success. The collection of art productions was large and particularly fine,—the works coming principally from Great Britain, Germany, Belgium, and France; and the method of lighting the picture gallery was considered very effective, and the best that had been as yet devised.

The most interesting of all the exhibits was the collection of Irish Antiquities, which was very large and arranged with admirable skill, forming something at once valuable and unique. At the close of the exhibition the building was torn down and sold. The materials, however, did not realize more than one-fourth the amount of their valuation; the unwieldy forms of the curved parts being so badly adapted for future use, and the timbers being so injured by nails and the summer heat, and so shattered in taking apart, that very few portions were ever again erected. The result demonstrated two facts: first the expensiveness of temporary buildings for such purposes, and secondly the great increase produced in the cost by the introduction of curvilinear work.

This same year an International Exhibition was also held in the City of New York under the organization of a few influential citizens, as a joint stock company, clothed with sufficient powers by legislation to carry out the objects proposed. This exhibition had in view the comparison of the productions of America with those of other countries, with the object of the promotion of her advancement, it being acknowledged that she had more to gain by such comparison than any other of the great nations of the world. It was liberally assisted by contributions of exhibits from European manufacturers and artists, but misfortune seems to have attended it from the beginning.

It labored under the great disadvantage of professing to be a national undertaking, without receiving support in any way from the government; of exposing itself to the imputation of being a private speculation under the name of a patriotic movement, and was viewed with jealous feelings by many of the great cities of the Union. Great injustice may have been done to the exhibition and its promoters, but still the effect of these adverse influences was perceptible. Although recognized in a semi-official way by the President, and by some of the foreign powers, it cannot be said to have been by any means a success, many exhibitors suffering serious loss. These consequences seem to be inherent at the outset of any great international exhibition that may be held here, from the very nature of our political institutions. Our present exhibition has had its difficulties in this respect. How nobly it has triumphed over all, its record will show. The country is so large, and the interests of the different portions so various, that it requires an anniversary like the Centennial to unite all together in a common celebration.



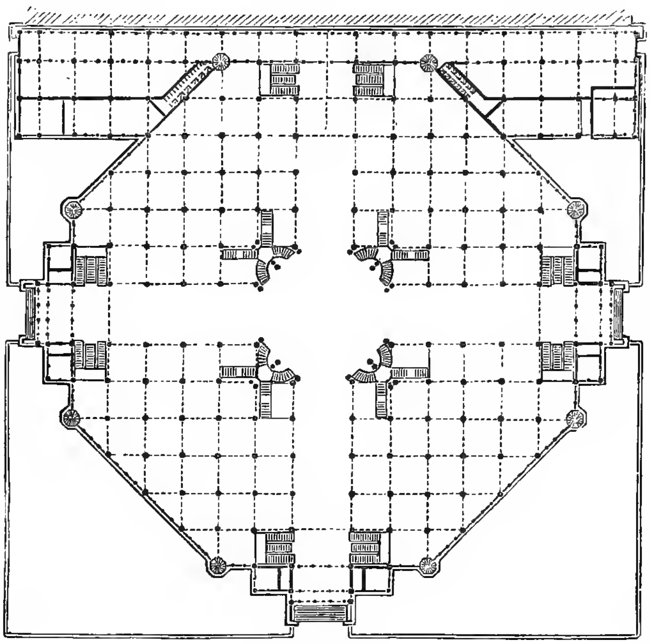
Crystal Palace, New York, 1853.

The opening, although advertised to be early in June, did not take place until the middle of July, in the midst of our hot season; President Pierce formally taking part in the exercises, in the presence of six commissioners of Great Britain, those of many other foreign governments, and all the heads of the various State departments.

The building was erected from designs furnished in competition by Messrs. Carstensen and Gildmeister; the consulting and executive engineers and architects appointed to carry out the plans being Mr. C. E. Detmold, Mr. Horatio Allen, and Mr. Edmund Henry. Although much smaller than the exhibition building of 1851, and possessing considerable originality in architectural effect and constructive detail, it was based upon the same general principles of construction in glass and iron, then so novel, and considered so appropriate for the purpose. Located upon an unfavorable piece of ground, 445 by 455 feet in extent, an octagonal form of building was adopted, changing at the height of twenty-four feet to a Greek Cross with low roofs in the four corners, and crowned by a dome at the centre. The length of each arm of the cross was three hundred and sixty-five feet, five inches, and the width, one hundred and forty-nine feet, five inches. On one side of the building was placed a rectangular, one story annexé, for machinery in motion. The plans which we give, of the ground-floor and galleries, will sufficiently explain the mode of construction. The columns indicated on these plans were placed twenty-seven feet apart each way; there being two principal avenues or naves, forty-one feet, five inches wide, with side aisles and galleries fifty-four feet wide. The dome was one hundred feet in diameter, with a height from the ground-floor to the springing of nearly seventy feet, and to the crown of the arch of one hundred and twenty-three feet, being at that time, the largest dome erected in this country.

The roofs of the building, including the dome, were covered with white pine sheathing boards and tinned, and light was communicated to the interior by the glass construction of the main walls, and by the clerestories of the main avenues and dome. The dome above the clerestory contained thirty-two ornamental windows of stained glass, decorated with the arms of the Union and of the several States, forming quite a conspicuous feature of the interior effect. The exterior walls were constructed of cast-iron framing and panel work, filled in with glazed sash,—the glass used being one-eighth inch thick, enameled, and of American manufacture.

Octagonal turrets were placed at the angles of the building, eight feet in diameter, and seventy-six feet high, containing circular stairways for the private use of the officers and employées of the exhibition. The lower floor was connected with the galleries by twelve stairways, one each side of the four main entrances and four under the dome,—the latter being in reality double stairways with a common half landing.

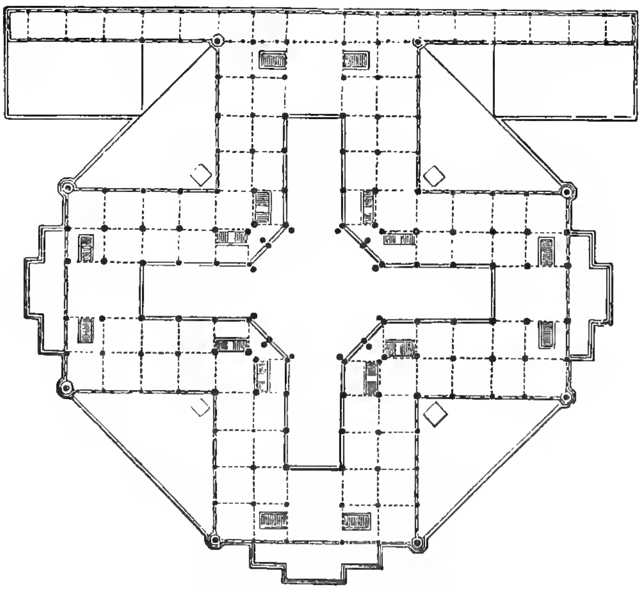


Ground Plan, New York Exhibition, 1853.

The decoration of the building was considered particularly fine, it having been placed in the hands of Mr. Henry Greenough of Cambridge, near Boston, Massachusetts, excepting only the interior of the dome, which was designed by Signor Monte Lilla. Mr. Greenough started out with the very correct assumption, that the only true method was to ornament the constructive details, following and bringing out the lines therein indicated, without attempting to conceal them by useless and unmeaning decoration.

With the exception of the ceiling of one of the lower corner roofs, and the interior of the dome, which were executed in tempera on canvas, the whole of the exterior and interior work was in white lead in oil, brought to the various tints desired by the admixture of various colors.

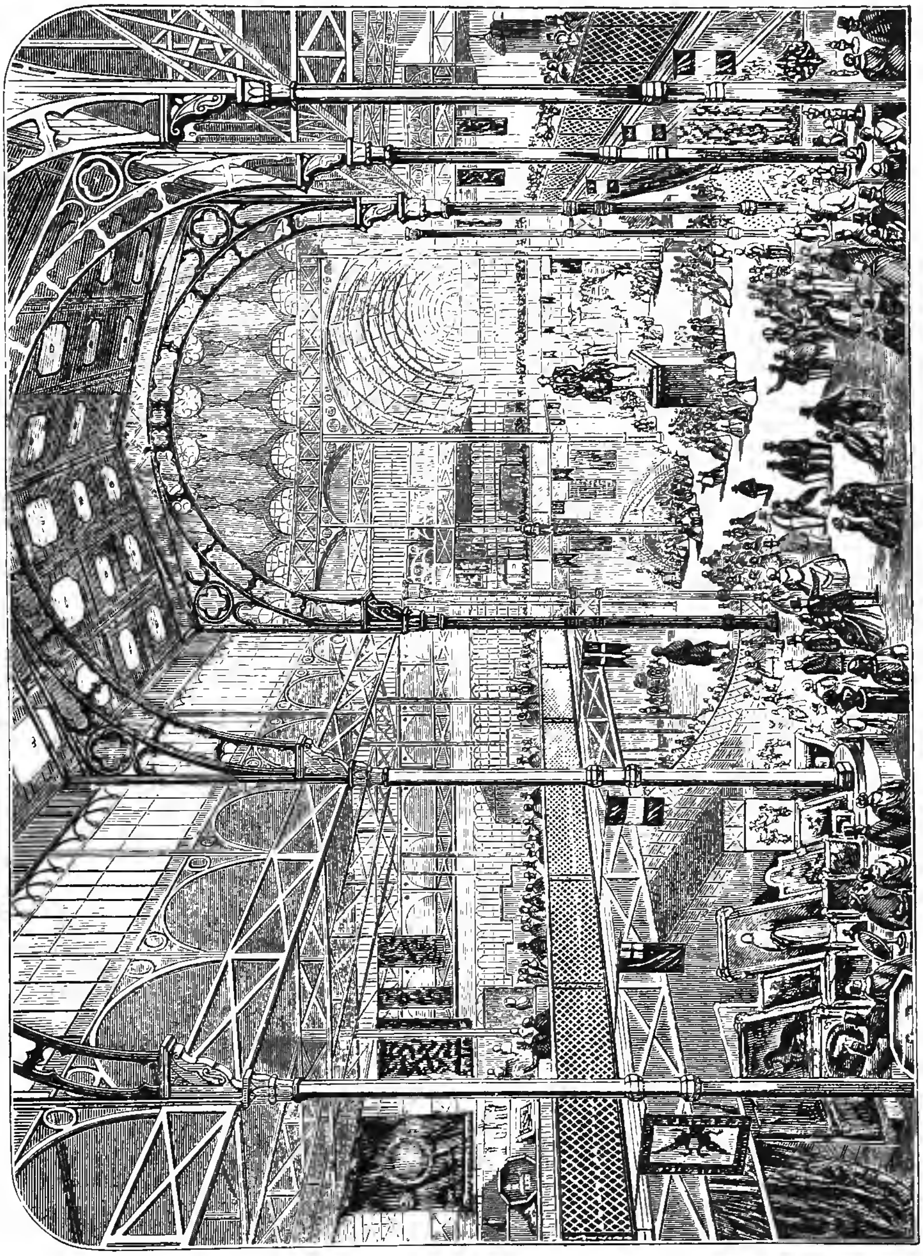
Mr. Greenough has given the following rules, to which he states that he mainly adhered in working up the design, and as they were productive of such excellent results, and are so generally applicable, we take the liberty of quoting them:—



Gallery Plan, New York Exhibition, 1853.

"I. Decoration should in all cases be subordinate to construction. It may be employed to heighten or give additional value to architectural beauties, but should never counterfeit them. Being in the nature of an accompaniment, it should keep in modest accordance with the air, and not drown it with impertinent embellishment. Coloring, to be employed with good effect on a building, should resemble the drapery of the antique sculptures, which, displaying between its folds the forms beneath, serves rather to enhance than to conceal their beauty.

"II. All features of main construction should have one prevailing tint, enriched occasionally by the harmonious contrasts of that color. All secondary, or auxiliary construction, may be decorated by the employment of a richer variety of the principal color. This mode of treatment is suggested by the distinction which nature has made between the coloring of the trunk, branches, twigs, and leaves of trees.



Interior View, International Exhibition, New York, 1853.

"III. The prevailing color of the ceilings should be sky-blue, thus borrowing from nature the covering which she has placed over our heads. Monotony may be prevented by the introduction of orange (the natural complement of blue), garnet and vermilion, in such quantities only as may be necessary to recall these colors employed elsewhere

"IV. Rich and brilliant tints should occur in small quantities, and be employed to attract the eye to the articulations and noble portions of the members, rather than to the members themselves. As in the human figure, variety of color and form is most displayed in the extremities and joints, to which the broader style of the limbs and trunk serve as a foil, so in buildings, the bases and capitals of columns, brackets of arches, and the frame-work of panels, would seem legitimate objects for the reception of rich coloring. Occurring at fixed numerical distances, they are measured out in equal proportions as to space, and afford also a due quantity of brilliant and stimulating tints,—sufficient to enliven the large proportion of mild color, so essential to a general effect of quiet and repose.

"V. All natural beauty of color existing in any material, should, if possible, be brought into play, by using that color itself, instead of covering it with paint of another hue.

"VI. The leading feature of beauty in the Crystal Palace, being that of proportion and geometrical harmony, rather than elaboration of detail, all ornament introduced should be of the same character, mere geometrical outlines and forms, to the exclusion of classical decoration, the characteristic of which is an imitation of the organization of foliage.

"VII. White should be used in large quantities in all cases of simple compositions, not only to give value, by contrast, to the few colors employed, but to reflect light and cheerfulness to the work."

The appearance of the building on its exterior was a light-colored bronze or olive tint, with the purely ornamental features enriched by gilding. The ceilings and dome of the interior had the ground-work of a sky-blue, producing loftiness and airiness, the constructive framing being painted of a rich buff or cream color, harmonizing with the blue and throwing a cheerful tint of sunshine over the whole. These prevailing colors were relieved by the judicious use of the positive colors, red, blue, and yellow, in their several tints of vermilion, garnet, and orange, and in certain parts by gold.

The area covered by the first floor was 157,195 square feet, and by the galleries, 92,496 square feet, making a total floor space of 249,692 square feet, or about 5¾ acres, and the quantities of material used in the structure amounted to 300 tons of wrought iron, 1500 tons of cast, 55,000 square feet of glass, and 750,000 feet, board-measure, of timber.

Marochetti's Statue of General Washington.

We give an exterior and also an interior view of the building, which has now passed away from sight forever, having been entirely destroyed by fire in 1858.

We also present an engraving of the Equestrian Statue of Washington by Baron Marochetti, the largest work shown at this exhibition, and located in a prominent position immediately under the dome. The artist was an Italian sculptor of note, born in Turin, in 1805, long resident in France, and who died in 1867, in London, where he had removed on the outbreak of the French Revolution, in 1848. From the criticisms made on this statue at the time, we should judge that its merit lay only in its size, being two and a half times that of life, and that it was lacking in all the fine attributes of a first-class work of art.

In the Mechanical Department, the exhibits of the United States were, as might have been expected, exceedingly creditable. The high price paid for labor in this country has necessitated the invention of machinery to supersede it, to a much greater extent than in foreign countries, and the result of this is always apparent,—our machines, as a general thing, being more numerous, of better quality, and more varied in their application than those from abroad. The sewing machine was comparatively a new invention at this time, there being in the exhibition of 1851 only three,—one from France, for sewing sacks, one from America, and one from England. At this exhibition of 1853, there were not less than ten varieties by American inventors alone; some using a double and some a single thread, and some adapted to special purposes, as for sewing cloth, leather, etc.

The United States Coast Survey Department made an exhibit of its various instruments, and showed the results of its labors by means of maps, charts, etc., evincing the great progress and honorable position which this country had attained, even more than twenty years ago, in this work.

Gas was supplied to the building primarily for policing purposes only; but it was afterwards arranged to open the building on certain evenings to visitors, and the effect of the interior, when fully illuminated, especially the dome, was exceedingly grand.

France, encouraged by the great success of the London exhibition of 1851,—regretting, perhaps, the opportunity which she lost in 1849, of setting the example of the international feature in exhibitions, and conscious that the exclusive or merely national system which she had previously adopted, would, if continued, be detrimental to the best interests of herself, and contrary to the national pride of her people,—determined to hold an International Exhibition in 1855.

While she had little to fear in the way of competition in those specialties for which she had so long been famous, she also knew that, by bringing before her people those productions of human skill more especially adapted to the *necessities* of mankind, and which heretofore had received so little attention in France, she would benefit her country immensely. The result would be that the French would either improve their own methods of production or make such arrangements by more extensive commercial relations as would insure future supply from those countries best adapted to furnish it.

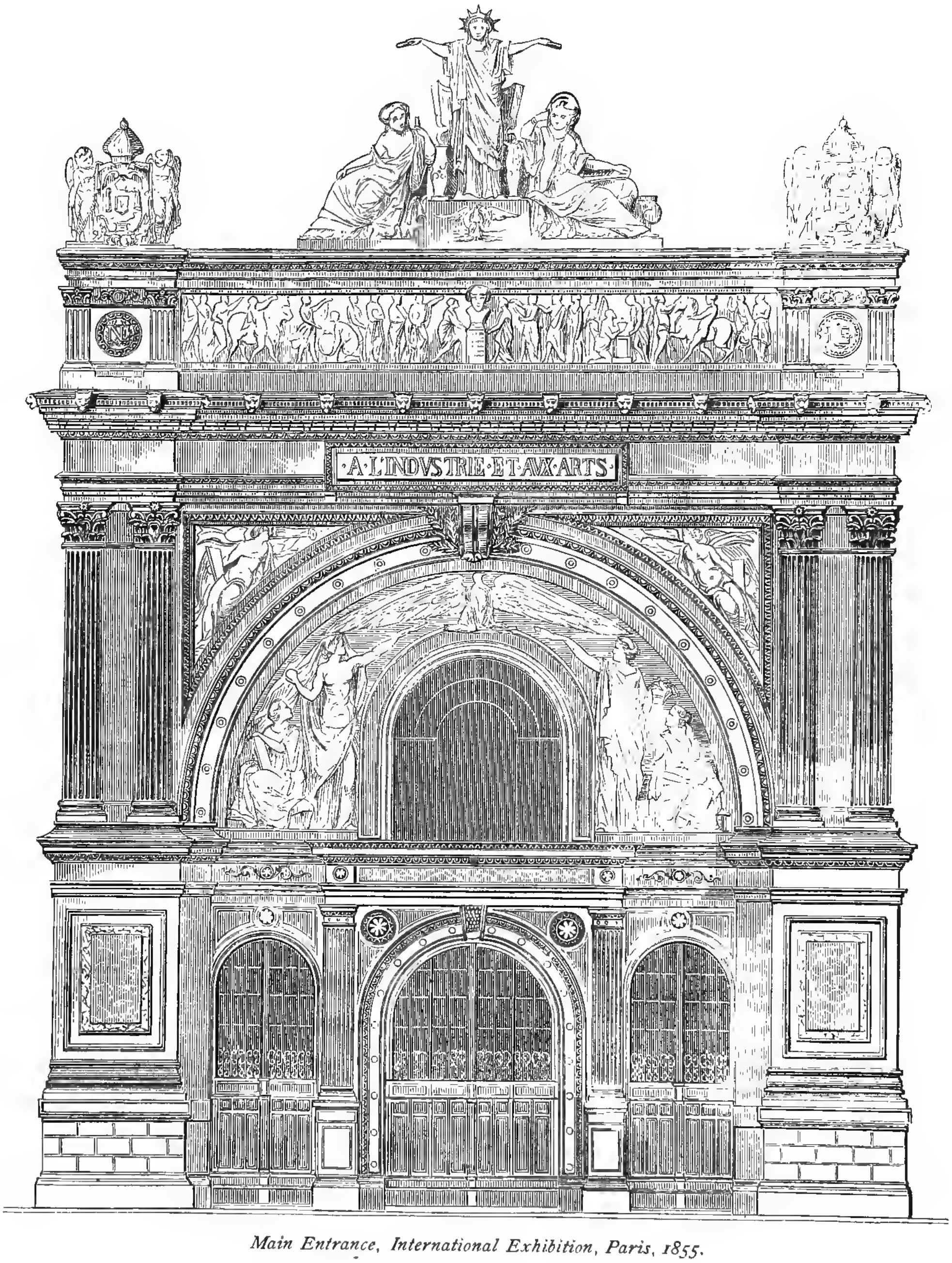
The Emperor had determined, as early as March, 1852, upon the erection of a large permanent building in the great square of the Champs Elysées, for the purposes of national expositions, and also to be available for great public cerémonies and civil or military fêtes. This building, with temporary additions, it was decided to use for the Universal Exposition of 1855.

The site adopted was authorized by the prefect of the Seine to be given over to the State in July, 1852, and a public company was organized in August of the same year, with M. Ardoin at its head, as "concessionaires" for the erection of the building—the concession to last for thirty-five years, and the receipts from expositions to produce the return for the required outlay of capital.

The buildings for this exposition afford to us an excellent example of the manner in which the French undertook the construction of a permanent building in connection with a great international exposition, and might serve, in some respects, as a precedent for our Memorial Hall.

The first design was prepared by MM. Viel and Desjardins, but it was found to involve great expense in the construction, and an amount of work so immense that it could not possibly be completed by the time fixed upon for the opening. At last, in December 1852, a contract was entered into, by MM. York et Cie. with M. Ardoin et Cie., for the construction of a building—all the work except the decorative painting and sculpture to be completed by a fixed day for a fixed sum,—the contractors to be at liberty to make any alterations in the design they desired, under the conditions that no change was to be made either in "the dimensions, the solidity, or the artistic aspect of the building, considered as a national monument."

The contractors appointed M. Barrault, Chief Engineer to the Palace, and M. Cendrier, Architect to the Lyons Railway, to prepare the modified design, assisted by MM. Bridel and Villain. M. Viel, one of the authors of the original design, was given charge of the masonry.



Main Entrance, International Exhibition, Paris, 1855.

The adopted design was very similar, in general appearance, to the original of MM. Viel and Desjardins.

Although work was commenced immediately, it advanced but slowly—very little being accomplished before February, 1854, and the opening of the Exposition, which was to have been on the 1st of May, 1855, did not take place until the 15th of the same month.

The principal edifice, now known as the "Palais de l'Industrie," and still in use for national exhibition purposes, was a rectangular building, eight hundred and twenty feet long by three hundred and sixty feet wide, exclusive of the central and end projections, containing entrances and stairways, and covered eight acres of ground. It was built of stone, and quite ornamental in appearance,—the main exhibition hall being spanned by a central arched roof of one hundred and fifty-seven feet, with two side arches of seventy-eight and a half feet each, parallel to the centre one; and two of the same span running transversely at the ends, and beyond its gables. At the corners these latter connected by hips and ridges, leaving a clear space underneath. The covering of a large portion of these roofs (about one-third) was roughened glass, which, together with great defects in ventilation, appears to have been a serious mistake in the hot summer climate of Paris—great inconvenience being experienced in consequence, and it being necessary to resort to the expedient of muslin screens. We present an engraving of the front entrance on the Champs Elysées, which will give the reader an idea of the style of architecture adopted.

The structure, as a whole, was framed of iron, designed to stand by itself, without side-walls or anything except the base upon which it rested. The exterior walls were placed around this, being of ashlar masonry, designed in a simple, bold style, encasing and concealing the framed structure within, but having openings for the admission of light.

Our engraving does not give a complete idea of the building, as it comprises only the central entrance of about two hundred and fifty feet, whereas the total length, formed by extensions on each side of this, amounted to over nine hundred feet. The great central roof, although possessing some defects, was, at that period, the noblest specimen of arched roof that had yet been erected, excelling in magnitude, dignity, and true principles of construction. Although Great Britain had then some bold specimens of work, they would not admit of comparison with this.

Fergusson, in giving a criticism on this building, states that the greatest defect in the exhibition building of 1851 was its want of solidity, "and that appearance of permanence and durability indispensable to make it really architectural in the strict meaning of the word." He was of opinion that "the only mode of really overcoming this defect was, probably, by the introduction of a third material. Stone was not quite suitable for this purpose—being too solid and uniform," and "the designers of the Palais d'Industrie seem to have thought so also, as, instead of trying to amalgamate the two elements at their command, they were content to hide their crystal palace in an envelope of masonry, which would have served equally well for a picture gallery, a concert room, or even for a palace." "Nowhere was the internal arrangement of the building expressed or even suggested on the outside, and the consequence was that, however beautiful either of the parts might be separately, the design was a failure as a whole."

The other buildings attached to this exhibition were temporary in character, and were as follows:—a circular building, known as the panorama, in the rear of the permanent building, three hundred and thirty feet in diameter, and covering about two acres; an annexé for machinery, 4,000 feet long by 85 feet wide, covering $7\frac{8}{10}$ acres; and a palace for fine arts, located at a considerable distance from the permanent building and covering 4 acres. The total space covered, including the gallery floors, which we have not considered in giving the several areas, amounted to 29 acres, and the exterior ground devoted to exposition purposes to 6 acres additional, the entire space being greater than used in any previous exhibition. The Panorama, which was a pet of the Prince Napoleon and one of the most attractive spots of the exhibition, containing the exhibits of the products of the French Imperial manufactories, the "Buffet" being also established here, and was a circle of 165 feet diameter; and around this a circular gallery was constructed of timber, in three spans, roofed with sheet zinc and glazed with skylights, increasing the building to the total diameter of 300 feet previously given, and adding some 97,000 square feet to the exhibition in the short space of thirty days from the time that it was first decided upon. A covered passage connected it on the north with the Palais de l'Industrie, and on the south it communicated with the extensive machinery annexé by a covered lattice bridge of three spans, thrown over the Chaussée du Cours la Reine, covered with glass and approached at each end by grand flights of steps. The machinery annexé was built of timber and iron in combination, with masonry foundation,—the end portions of the building being solid blocks of timber, brick and plaster, and presenting quite an imposing appearance. The length of this building was entirely too great, compared with its span, to obtain any good interior effect.

Far greater prominence was given at this exhibition to the Fine Art Department than had ever been previously done. A special building for this purpose was isolated from all the others—as much for greater safety to its valuable contents from fire as by the necessity of the site—and it contained, in addition to a great hall for paintings of 462 by 198 feet, a distinct hall for sculpture of 215 by 72 feet, together with a refreshment department and the necessary store-rooms and offices. It was a timber structure covered with zinc and glass, and lighted from the roof, with an interior ceiling of glass which tempered the light, protected the works of art from leakage, and gave much better opportunities for ventilation than in previous arrangements. The hanging or wall surfaces were very much increased by numerous screens rising from the floor.

The number of exhibitors was nearly 21,000,—France contributing about one-half, and occupying 13½ acres, while Great Britain had 4¼; Germany, 1¾; Austria, 1¼; Belgium, 1; Switzerland, one-half acre; and the United States, one-third acre; the balance of the countries exhibiting decreasing to quite small spaces, and the Republic of Dominica having only two metres. The total cost of the buildings was about $3,373,300.

The Exhibition was closed by the Emperor in person, on the 15th of November, with considerable pomp and ceremonial, and with the distribution of the honors and awards, which were as follows:—for the Industrial Department, 112 grand medals of honor, 252 medals of honor, 2,300 medals of the first class, 3,900 of the second class, and 4,000 honorable mentions; and for the Fine Art Department, 40 decorations of the Legion of Honor, 16 medals of honor voted by the Jury, 67 medals of the first class, 87 of the second class, 77 of the third class, and 222 honorable mentions. The main central nave of the building was fitted up and arranged for the ceremony by removing all exhibits and placing a throne on one side, with a grand central platform, the remaining space being covered with seats rising one above the other, and forming—with the galleries—a vast amphitheatre from which the assembled multitude gazed down upon the gorgeous and exciting spectacle. With such a wonderful advance as shown by this exhibition from the small beginning of 1798, France might well be proud. Here, as before, were found the exquisite tapestries of the Gobelins and of Beauvais, improved and brought to the utmost perfection that art and science combined could make them,—the delicate tints so completely wrought and graded, each into its proper place, with so much mechanical dexterity and artistic skill, that it was difficult to decide whether the original or the copy was most to be admired,—the great softness and perfection of tone and color deciding in favor of the latter in almost every case. Also, here again, were exhibited the porcelain productions of the famous manufactory of Sèvres, excelling all competitors, and fairly astonishing the visitor with the capabilities of the material. The *chef-d'œuvre* was a vase commemorative of the great exhibition of 1851. It was Roman in form, ornamented with antique scrolls in white and gold in low relief, upon an Indian red ground. A collar or fillet supported the body upon a short shaft, which was broken by four masks representing Asia, Africa, Europe, and America; and the body itself was decorated with detached groups of figures proceeding from the back to the front, where Peace was represented as enthroned, with Plenty on one side and Justice on the other. The groups to the left were formed of figures symbolic of England and her colonies, Russia, the United States of America, and China; while those to the right represented France, Belgium, Austria, Prussia, Spain, Portugal, and Turkey. At the back, and dividing the groups, was a figure ingeniously posed in the attitude of sending them on their mission. Olive-leaves in bronze, with gilt fruit, decorated the upper curve of the body and neck, and the words "*Abondance*," "*Concorde*," "*Equité*," were inscribed above the whole.

Savonnière, also, was again represented by her carpets; but, although the work on them was extraordinary and, in one sense, perfection, yet the designs were wanting in adaptation to the true purposes for which carpets are intended,—having too much color, too large forms, and too much relief, or, in other words, not showing an improvement in taste which one would have been led to expect from the advance in other departments.

In the Agricultural Department, under the specialty of Reaping Machines, the United States was in the front rank,—exhibiting a number of very efficient machines. In the trials which were made, that of M'Cormick excelled all others from all countries,—performing the most work in the shortest time, and doing it in the most thorough manner, "evincing much greater perfection in its operations than any of the others whose powers were brought to the test."

In the Machinery Department, the Ribbon Saw—now so extensively used for scroll-sawing—was among the novelties.

The Paris Exhibition of 1855 differed from all previous ones in the "extent of its productions, the variety of its objects, and the facilities afforded for the disposal of the exhibited articles at a fair market-price,—conditions of great value to the exhibitors, in the immense selection submitted to view." It was really "an immense bazaar, from which might be selected every description of manufacture and almost every kind of produce."

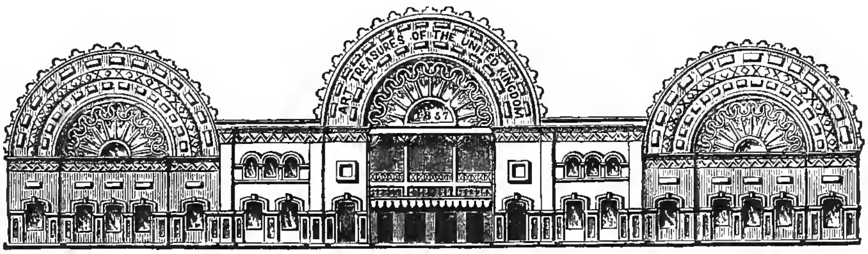
"Nothing surprised the observer more forcibly than the beauty and the extent of the articles offered for inspection, and the great skill by which such vast and varied forms of manufacture were produced."

These exhibitions all produced their good results, and in a very marked degree. Fairbairn very truly says of the exhibitions of 1851 and 1855, that "they have shown to the world in every department of industry and of practical science, wherein consists the prosperity of nations, and the happiness of mankind. They have shown how all materials, whether derived from the forest, the field, or the mine, may be turned to purposes of utility; how the labor of man may be multiplied a thousand-fold; how the fruits of the earth may be cultivated and gathered in for man's necessities; and how works of art may be elaborated to increase the happiness and enjoyment of his existence." "All these things were exhibited on a scale commensurate with the greatness of an undertaking so vast in extent, so varied in form, and so characteristic of all the duties and wants of human existence, as to elicit the admiration and praise of astonished multitudes from every country of the civilized world."

In the year 1857, Manchester, England, held an exhibition of Fine Art and Fine Art Manufacture, more particularly confined to the Art Treasures of the United Kingdom,—plans being advertised for in May, 1856, with the conditions that the building must be fire-proof, must cover about 135,000 square feet, or a little over three acres, at a total cost of not more than $125,000, and must be capable of erection within six months.

The design and proposal of Messrs. C. D. Young & Co., of Edinburgh, constructors of corrugated iron buildings, was accepted for the sum of $122,500, the building to be completed by January 1st, 1857, under penalties for delays beyond the 15th of that month. An architect (Mr. Salomons) was appointed to confer with the contractors and modify the design in some respects, so as to improve the architectural effect, if possible, without material increase of cost, and the improved plan, of which we furnish a front elevation, was erected.

The building, in general plan, was a parallelogram, 700 by 200 feet, covered by five roofs running in the direction of the length of the building, the centre and two outer roofs being semicircular. The former was 56 feet span, and the two latter each 45 feet. The intermediate roofs were of the ordinary triangular construction, and each 24 feet span. A transept crossed



Industrial and Fine Art Exhibition, Manchester, 1857.

the building at a distance of 460 feet from the main-entrance end, consisting of a semicircular span of 56 feet, and two side spans of 24 feet each, exactly the same as the centre portion of the main roof, and forming a total width of 104 feet. The structure was supported by cast-iron columns, and the centre arch had a height of 65 feet, the two side arches 48 feet, and the intermediate spans 24 feet. The outside covering was corrugated iron, the sheets being fitted into wave-line recesses in the cast-iron columns without bolts or rivets, and the inner walls were of wood.

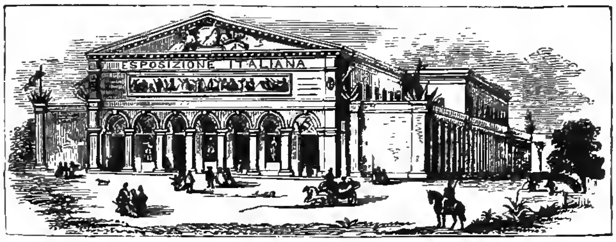
The walls and roofs were lined internally with boards, upon which was stretched muslin, and on the latter ornamental paper decoration was placed, the work being under the direction of Mr. Crace, of London. The side-walls of the great halls were a deep maroon, the paneled surface of the roof a warm grayish tint, the whole being relieved by lines and tracery of red and white, and the columns and metal work, bronze with rivet heads, etc., picked out in gold.

The sides of the ribs of the roof were decorated in vermilion on a soft cream-colored ground. The walls of the picture-galleries were of a sage green, with the roof a warm gray, and the border a cream color. The work was considered a remarkable success, combining great repose and beauty.

The facade of the building, up to the springing of the arches, was built of red and white brick, and the ends of the semicircular roofs above were filled in with ornamental work in wood, iron, and glass. Skylights, having an opening of about one-third the span, extended the whole length of each roof, and afforded a most excellent light, especially for the Fine Art Department, but the glass required screening with muslin during the summer months. It seems to be a great desideratum in all large picture-galleries to have the lighting so arranged that, by means of some sort of movable screen or velabrum, it may easily be increased or diminished as necessity requires. The quantity of light at our service varies so much at different periods of the year, and, indeed, at different times of the day, that it is almost impossible to do the lighting to perfection without some such arrangement,—a matter which, as in this case, is too often neglected. The interior effect of the central arched roof—which was constructed entirely open, without any ties or braces to interfere with the line of vision—was exceedingly light and elegant. The total floor space for exhibition purposes was increased by means of galleries, until it amounted to 171,000 square feet.

The Art Treasures included the works of the old masters—commencing with the oldest specimens that could be obtained—and were intended to show the gradual progress in Art from the earliest epoch, on through the periods of Titian, Correggio, and Rubens, up to the modern schools of Art, especially those of England.

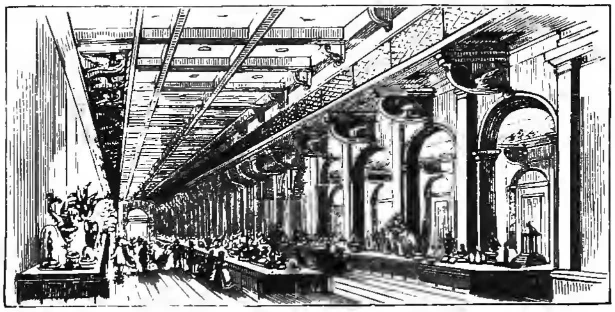
Italy—with its principalities freed from the trammels and tyranny of a foreign yoke, and united into one grand nation—resolved upon holding an exhibition at Florence in 1861, for the purpose, perhaps, of inaugurating its new birth, and taking its place among the kingdoms of Europe. Previous exhibitions had been held in various parts of Italy—some at a remote period—but they partook more of the nature of agricultural exhibitions. There had also been one at Naples some years before, but this exhibition, now held, was far superior to any that preceded it, and forming, as it did, an exceedingly attractive display of Italian industrial, fine art, and agricultural products, it seems singular that it did not attract the attention from abroad that its importance deserved.



Exhibition, Florence, 1861.

The classification adopted was based upon that of London and Paris, but more simplified. It was divided into four great departments,—Industrial, Fine Arts, Agricultural, and Horticultural. The main building consisted of a rectangular front portion, built of masonry, as a permanent construction, with a great octagonal building in the rear, covering an interior garden. Into this main building the industrial and a portion of the fine art departments were placed, a detached building containing the balance of the latter. The agricultural department was accommodated in large temporary buildings, and the horticultural display took place in hot-houses and in the gardens surrounding the exhibition.

We present both exterior and interior views of the permanent portion of the main building. The display of the peculiar agricultural products of northern and central Italy was particularly rich, and the fine art collection could not have been otherwise than excellent.



Interior of Exhibition, Florence, 1861.

It is to be hoped that Italy—once the centre of the arts and luxuries of the civilized world, and now again rapidly taking her position—will, before long, give another exhibition, showing her progress since she has become united under one head, and—this time—in Rome, where the ancient and modern may be brought face to face, and the faded magnificence of the eternal city seen in contrast with the development and progress of industrial art of the present time.

The advantages which England had experienced from the Exhibition of 1851, had been very great. Before that time, very little had been accomplished in the department of art industry. In fine arts, such men as Reynolds, Gainsborough, Hogarth, Hayman, and Wilson, had achieved great reputation. Gibbons, Wedgewood and others had also been celebrated in their several specialties. These men were, however, all artists, working for themselves, not manufacturers, and their arts died with them. They promulgated no fixed principles and nothing was left to their successors. Art was not imbued into the masses. England was content with styles of art industry that would have shamed a South Sea Islander, and not only was she making no progress, but there was, at one time, an actual deterioration in public taste. She had discovered that, with the mechanical skill and the great producing capabilities which she possessed, she could rapidly accumulate wealth without taking time to attend to points of artistic design, and, in truth it may be said, that the term "industrial art" was really unknown in England before 1832.

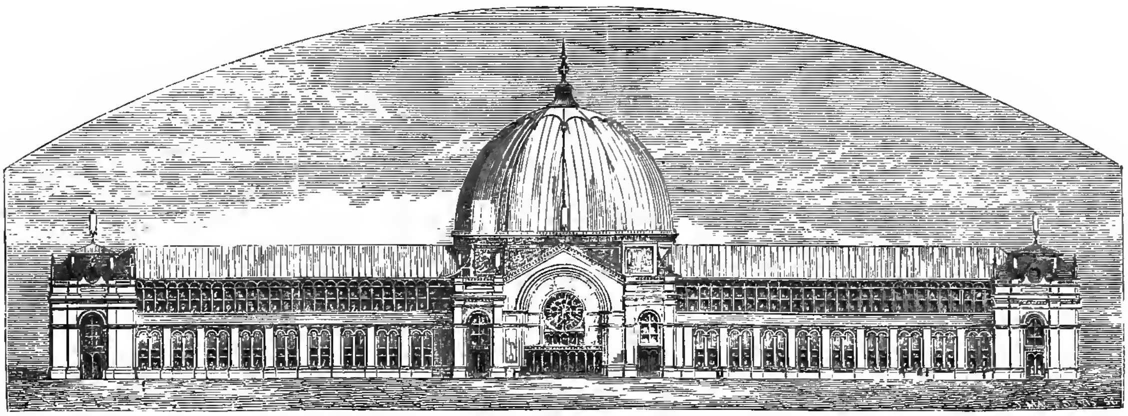
Then she awoke to the fact that the artistic ability of France and the Continent was successfully competing with her mechanical superiority in the markets of the world, and she was obliged, in self-defence, to take measures to retain her supremacy. Art schools were accordingly established, and some efforts made to bring the productions of the country up towards the high standard to which the Continental manufacturers had already arrived. But the great difficulty with these schools was the want of practicability in their management. Those employed as teachers were artists, having sufficient influence to give them position, not practical men, and, if an appointment was to be made, it was always a question of blood, not brains. A student was taught not to think and study out a design for himself, but to copy from the designs of others; to reproduce from the French—which was considered the highest standard of taste—and not to originate. The result was an apathy and want of spirit, and, of course, a failure.

On the Continent, practical men were placed to teach practical subjects. Watchmakers were the professors in schools of design for watches. Men of the stamp of Quintin Metsys, who could execute as well as design, were the teachers; and, when in the Exhibition of 1851, England came face to face with the work of such men, the result showed her defects. She became aware that the course she had pursued was not the correct one, and she was even in a worse position, in some respects, than if she had never made any attempts—being obliged not only to commence at the beginning, but also to eradicate the false teaching which her artizans had already received. What was intended as a great display became, in fact, a great teacher, and the improvement in consequence was very marked. The schools of art were reconstructed and improved; a collection of art objects made by purchase from the exhibits of the great exhibition, forming the nucleus of the present Kensington Museum, and a strong progressive movement followed, producing great effects.

Among the direct results were reduced tariffs, increased postal facilities, and a vast increase of industrial prosperity, adding greatly to the commerce of the country. It was but natural, therefore, that England, conscious of the great advantages accruing from this Exhibition of 1851, and seeing also the good results of the French Exposition of 1855, and of her own local exhibitions, should desire, in time, a second great international exhibition; and this desire culminated in the London Exhibition of the Art Works of All Nations of 1862.

On the 14th of March, 1860, a Charter of Incorporation was issued by the Queen to Royal Commissioners for this exhibition, defining their duties and investing them with full powers,—the Prince Consort being made President of this Commission. It was decided, in anticipation, to test the popularity of the undertaking by public subscriptions, and a Guarantee Fund of $1,250,000 was formed with a rapidity beyond all expectation, allowing of the formal execution of the Guarantee Deed to the full amount by the 15th of March, the day after the incorporation of the Commission. This Guarantee Fund was afterwards signed by 1157 persons, in all, to the amount of $2,255,000, and upon this security, the Bank of England advanced $1,250,000 for the expenses of erecting the buildings and making the requisite preparations for the Exhibition.

At South Kensington, within a short distance of the site of the Exhibition of 1851, and at the south end of the new gardens of the Royal Horticultural Society, was a piece of ground belonging to the commissioners of the previous exhibition, and purchased with their surplus funds. This was selected as the location for the buildings of the present exhibition, and arrangements were made for its use. This location was quite favorable in some respects, and unfavorable in others. The new gardens of the Horticultural Society were finely situated, laid out with considerable dignity of style and in excellent taste, and formed a noble and attractive addition to the exhibition. It was imperative, however, in order to provide sufficient space, that the whole of the selected ground should be covered with buildings, and the result was that they were thrown out to the very verge of the street in front,—the street not being of very great width, and already built upon to a considerable extent on the other side,—so that no matter what the elevation of a building necessarily so long, it could never be seen to advantage, and no opinion could be formed of its proportions, whether good or bad. The approaches were also restricted, few, difficult and dangerous for the great multitudes which such an exhibition would draw together. In fact, the arguments opposed to the selection of this site seemed to preponderate very much over those in favor of it. Having determined upon the site, the Commissioners decided not to allow open competition for designs, and during a consideration of the propriety of permitting a limited competition, a plan was presented to their notice, designed for the site in question by Captain Fowke, of the Royal Engineers, an officer of great skill and experience, who had been in the British Department of the Paris Exhibition, and who had prepared this plan so as to meet many practical defects, found, in his opinion, to exist in the buildings of the exhibitions of 1851 and 1855. This plan met with so much favor that it was immediately adopted, and Captain Fowke appointed sole and responsible architect for the Exhibition buildings; the Commission thus passing over the whole engineering and architectural professions of the country, including those who had



Front Elevation, International Exhibition, London, 1862.

been so honorably connected with the previous exhibition, and creating much jealous feeling and disappointment. The plans were somewhat modified, in order to keep the cost within certain figures fixed upon by the Commissioners: bids were received, and the work was let on the 23d of February, 1861. We present an exterior view of the building from the Albert Road, which will give the reader a very fair idea of its appearance. The design was severely criticised at the time; the frontage on the Cromwell road,* showing to the right on our picture, especially being condemned as featureless and ugly; and the Art Journal characterized the building as "the wretched *shed* that was the Fowke version of the Paxton Crystal Palace." But it must be remembered that the site was determined upon, and that the question of cost was fixed, precluding any expense beyond a certain amount. There seems also to have been

* Vide page xliii.

an intention of making a certain portion of the buildings so permanent that it could be finished up after the close of the exhibition as a national gallery of Fine Art. Any architect, under these conditions, would have worked to great disadvantage. And in reference to the front on the Cromwell road, it may be said that there would have been very little use in finishing it up expensively and artistically, as no one could see the building on this side, except in small portions at a time.

Designating the south face of the building on the Cromwell road as the main front, we may describe the building as follows:—

This main front occupied an extreme length of 1150 feet 9 inches, and a depth of 50 feet, and was constructed in brick, with a grand central entrance consisting of three arched openings. The wings on either side were built in two stories, the upper being used for picture-galleries; and the face walls were pierced with arched window openings, filled in on the lower story with glass, and on the upper with blank panels, so as to allow an uninterrupted wall-space in the interior for pictures. At the ends of these wings, as will be seen by the perspective view, were double corner towers. Passing into the central entrance, grand stairways led to the upper floor, where in the centre was a sculpture gallery, 150 feet in length, with entrances leading to the picture-galleries on either side.

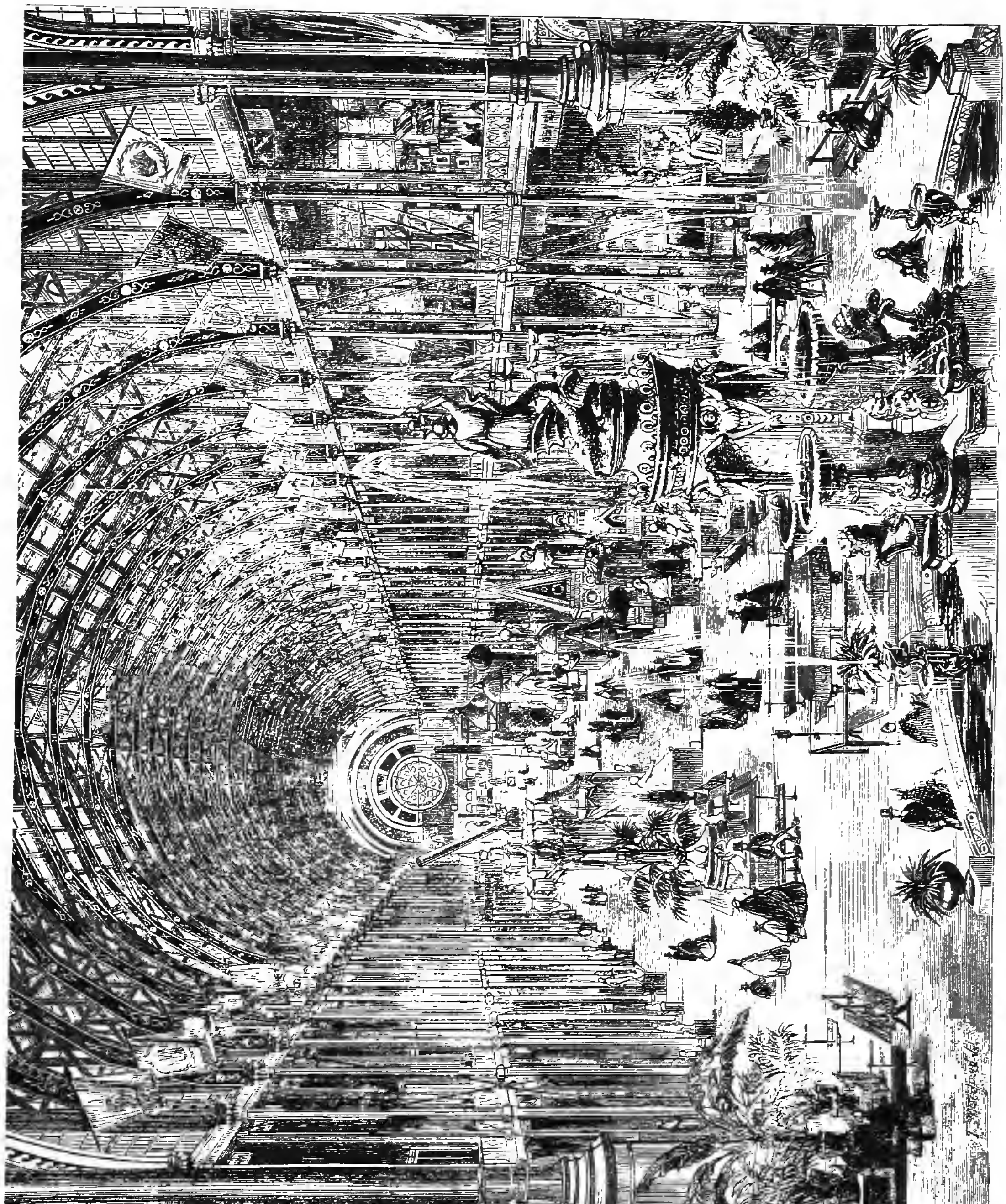
These galleries possessed noble proportions and were effective and useful for their purposes. On the east and west sides, on Prince Albert and Exhibition roads, brick fronts extended north from the corner towers, each having a face of about 700 feet and a large central arched entrance, and really presenting a better appearance than any other portion of the building. The wings on the sides of the central arch were only 25 feet wide, and were built in two floors, the upper forming auxiliary picture-galleries, and the lower being used for offices, retiring rooms, etc.

The picture-galleries, all together, produced about 4600 feet lineal, or two acres superficial, of hanging space. A grand nave extended through between the central entrances on the east and west sides, 800 feet in length, 85 feet in width, and 100 feet in height from the floor to the ridge of the roof. At either end of this were large octagonal spaces 135 feet in diameter across the faces of the octagon, crowned by great duodecagonal glass domes 150 feet in diameter. We give a view of the interior of the great nave, looking west.

Two transepts crossed the nave at the domes, extending north and south, having the same width, height and manner of construction as the nave, and nearly 600 feet in length, right through. The nave and transepts had arched timber roofs, supported by double columns of iron. The domes rose to a height of 200 feet, with gilded finials 55 feet higher, and were constructed of wrought-iron framing, covered with glass. They presented a very light appearance, and were quite transparent when viewed from a near point of sight, showing the skeleton of the framing through the glass. The best view of them was that from some point a mile or two distant. Between the nave and the south front, and also on the north side of the nave up to the gardens of the Horticultural Society, the whole area was roofed over with glass and traversed with galleries.

Annexes, 200 feet in width, extended north for a distance of about 900 feet, on each side of the gardens, being prolongations, as it were, of the east and west fronts. That on the west front was devoted to machinery, and the one on the east to agriculture,—the latter having an open court in the centre. These annexes were of timber framing, very lightly constructed, the outside walls being of plaster on lathing, and the roof consisting of a series of four consecutive arches of 50 feet span each, boarded and covered with tarred and sanded felt. Each arch had a continuous glazed skylight for its whole length. A range of refreshment rooms was placed at the north end of the Horticultural Gardens, constructed over the arcades of the entrance, and connecting the ends of the two annexes. The view from here over the gardens was the most beautiful that the whole ground afforded.

The decoration of the building was placed in the hands of Mr. J. G. Crace, a gentleman of considerable reputation in his special art; the same who had decorated the Manchester



Interior View of the International Exhibition, London, 1862.

Exhibition Building, and who also had been specially selected by Sir Charles Barry to carry out the decorations of the Houses of Parliament. The work was completed in three months and gave, with one or two exceptional points, very general satisfaction. A light gray was adopted in the main portion of the building for the interior roof surface, and the timber framing marked out in colors more or less decided, each piece forming the polygonal rib, being painted in red or blue alternately, so arranged that in consecutive ribs, like sides of the polygon, were of different colors, and red showed against blue, or *vice versa*. It was intended, in taking a view of the roof, that these colors should mix and balance each other and produce a soft effect. The result was not as expected, and it would have been better to have painted the ribs of one uniform color. The sashes, and much of the wood-work on the sides below the roof, were of vellum color; the cast-iron work of columns and girders light bronze green; and the capitals of columns picked out red, blue and gold. The portions of the building below the arches were made quiet in color, so as not to interfere with the brilliancy and richness of the exhibits, while the vividness of coloring in the roof was intended to carry up, in some degree, the gaiety of the scene below.

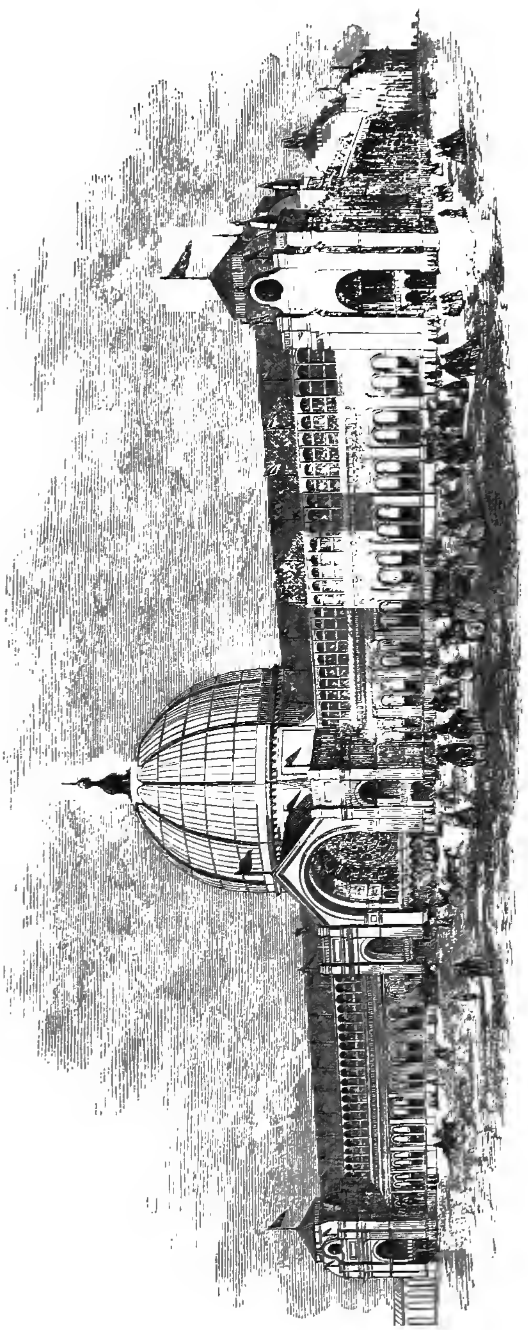
The walls of the vestibule, stairways, etc., intended for sculpture, were colored in tints of maroon and quiet reds, with some green. Those of the picture-galleries were nearly all a subdued sage green, relieved along the cornices and string-mouldings by stenciled ornaments in a sort of cream or vellum color. Under the domes, the large supporting iron columns—nearly 100 feet in height—were a dark maroon, with the capitals gilt; and the panels between the arches and frieze were in shades of red, relieved by colored lines, the names of the four quarters of the globe being inserted in four of the compartments, with the initials of Victoria and Albert below. On the eight spandrils of the four main arches, medallions were placed, emblematic of manufactures, commerce and the various arts and sciences. The moulding of cornice and facia was of vellum color, relieved by gilding; the trusses gold-color, with the facia between them red, and the broad facia below, blue, and inscribed with scriptural sentences in gold letters. In the domes proper, the main ribs were painted bright red, with spaced black and white at the edges, and a fine gold line in the centre, spreading at intervals into lozenges and circles containing gilt stars on a blue ground. At the ring-plate above, the red was carried round, the points of intersection being painted black and white, and above that the eight main ribs were painted deep blue, relieved with red, gold and black, until they met in the centre pendant, which was gilt, bordered with red. The covering above was light blue with gilt rays diverging from the centre.

The domes of this building were by far the most costly part of its construction, and were thought by many to be quite a useless and unnecessary expense. The roof covering adopted was found much better than the glass covering of previous exhibitions, resulting in a much more equable and pleasant temperature in the interior.

The total area roofed in was 988,000 square feet—larger than that of any previous exhibition; but the total area of space, covered and uncovered, and available for exhibition purposes, was not as great as that of Paris, 1855; the proportions standing 1,023,000 in the present case, to 1,500,000 in the other. The total cost was not less than $2,150,000, equal to about $2.18 per square foot. Including the expenses of the exhibition, during the time it was open, the total amounted to $2,298,155, and the entire amount received by the Royal Commissioners amounted to precisely the same sum, making no loss or no gain,—the exhibition just self-sustaining and no more.

By great exertions, the exhibition was opened upon the day appointed,—the 1st of May, 1862. One great loss was felt in the death of Prince Albert, to whom so much was due for the favor and encouragement he had given to international exhibitions, and to whom they really owed their origin.

The contrast between the administration of the Exhibition of 1851, under his charge, and that of 1862, after he had been called away, was very marked; and of the great throngs who crowded into and around the building on that day of opening, not one but felt his absence. The Queen, of course, was not there, and although the ceremonies were very stately and imposing, a gloom was cast over the whole which nothing could entirely dispel. Apart from his royalty, Prince Albert was a very popular man,—endearing himself to the people by the active part he took in all industrial and art matters,—and hence the loss to the nation was felt all the more keenly.



International Exhibition Building, London, 1862:—Showing Cromwell Road.

The Queen was represented by the Duke of Cambridge, who received and replied to the address of the Commissioners, and to whom was handed the master-key, which opened all the different locks on the various doors of the exhibition building. After this, the grand orchestra, consisting of 400 instruments and 2000 voices, opened with a grand overture by Meyerbeer, followed by a chorale, composed by Sterndale Bennett, to the words of an ode written for the occasion by Tennyson, and then by Auber's "Grand March." After a prayer by the Bishop of London, Handel's choral hymns—the "Hallelujah" and "Amen," from the *Messiah*—followed, and the National Anthem was again sung in conclusion. The Duke of Cambridge then rose and proclaimed the exhibition open; a prolonged *fanfare* from the trumpets of the Life-Guards saluted the announcement, and the ceremony ended.

The display from the United States at this exhibition was very small—owing to the troubles at home—but what was exhibited, was very creditable, and—as in the Paris Exhibition—agricultural machines took a conspicuous position. McCormick's Reaper, with its self-raking attachment, was exhibited, and published as one of forty thousand made and sold from one establishment; and Russell's Screw-power Reaping Machine also attracted considerable attention. A very novel and ingenious invention—and one that received much notice—was the "Improved Cow-Milker," of Messrs. Kershaw & Colvin, of Philadelphia. Two machines for Boot and Shoe Stitching, invented by Mr. L. R. Blake, were remarkable for their simplicity of construction and efficiency and rapidity of production. Sewing-machines—which were novelties in 1851—had improved and increased in variety to a very great extent, and a large number of United States manufacture were exhibited.

Hoe & Company, of New York, exhibited their famous Printing Machines, by a model provided with ten impression-cylinders, as then used by the London *Times* and *Telegraph;* and the Composing and Distributing Machines of Mitchell were wonderful specimens of American ingenuity.

In the Machinery Department, Mr. Ramsbottom, of England, exhibited his admirable invention for supplying locomotive tenders with water while at full speed, now adopted in this country, and used with so much success for express trains on the Pennsylvania Railroad. It consists of a dip-pipe, or scoop, attached to the bottom of the tender, its upper end running into the upper part of the water-tank, and the lower end curved forward and dipping into water contained in a shallow, open trough lying longitudinally between the rails. The Giffard Injector—now in such universal use—was also among the new inventions at this exhibition.

A very efficient apparatus was a Folding, Pressing and Stitching Machine, from Switzerland, registering and folding sheets of paper with far greater precision than the most experienced hand-labor could do, at the rate of 1400 to 1500 sheets per hour, and at the same time pressing and stitching them.

Among the notable exhibits was Babbage's Calculating Machine, which could work quadrations and calculate logarithms up to seven places of figures, and, with the improvements of Schentz, of Stockholm, print its results. The Calculating Machine of M. Thomas —the Babbage of France—was also shown, dividing 16 figures by 8 figures in half a minute, or giving the square root of 13 figures in one minute, although not larger than a musical snuff-box.

The exhibits in reference to Electric Telegraphs, and electrical apparatus, showed a great advance in this department of science.

The steel exhibits were remarkably fine; Bessemer Steel, now so extensively employed for railway bars, then just coming into use; and the greatest progress was shown from the time of the previous exhibition.

The display of Chemicals was the finest that had ever been made,—far exceeding that of 1851. The Pharmaceutical Society, of London, exhibited a splendid collection of drugs.

The coal-tar dyes, then newly discovered, were among the most important of the exhibits. Aniline, but a few years previously so rare as to be known among chemists almost only by name, had now become an article of commerce, and a circular block about 20 inches high and 9 inches in diameter, was shown, which was the whole product of no less than 2000 tons of coal, and was sufficient to dye 300 miles of silk fabric. Those beautiful blue and purple dyes which are obtained from lichens were also exhibited.

The number, variety and beauty of the articles in Pottery was very great, although in the English department the designs of the ornamentation still showed a predominance of French ideas. The Majolica and Tile exhibits of Messrs. Maw & Co., and Messrs. Minton, were exceedingly fine. The majolica fountain of the latter—under the eastern dome—the largest exhibit of its class, and executed from designs of the sculptor Thomas, although a work of great expense, elegant, symmetrical and bold, and, so far as workmanship went, of great merit, was not considered a success, and fully exemplified the non-adaptability of the material to the purpose for which it was used, giving a lesson of warning what to avoid rather than what to copy. The Sèvres Porcelain exhibit maintained its standard of excellence, the leading feature of this display being the sea-green ware, or *céladon changeant*, which first appeared in the Paris Exhibition of 1855; a gray, dull sea-green as a body-color, more like what one might expect to find in old oriental ware—more easily recognized than described—on which is penciled with a similar but white paste, designs of leaves and flowers, standing out in slight relief, as white upon a céladon ground. The céladon changeant is a variety which possesses the singular capability of reflecting local color.

England made a superb exhibit of Glassware, being first in quality of material and artistic development, and far outstripping Austria and France, which, in 1851, held the supremacy.

In Furniture, the advance made by England since 1851 was very marked, the designs departing from the French, or rococo renaissance, which had been the order of the day, and partaking of the Italian school, being much purer in tone, simplicity and taste, and showing greater progress than by any other nation.

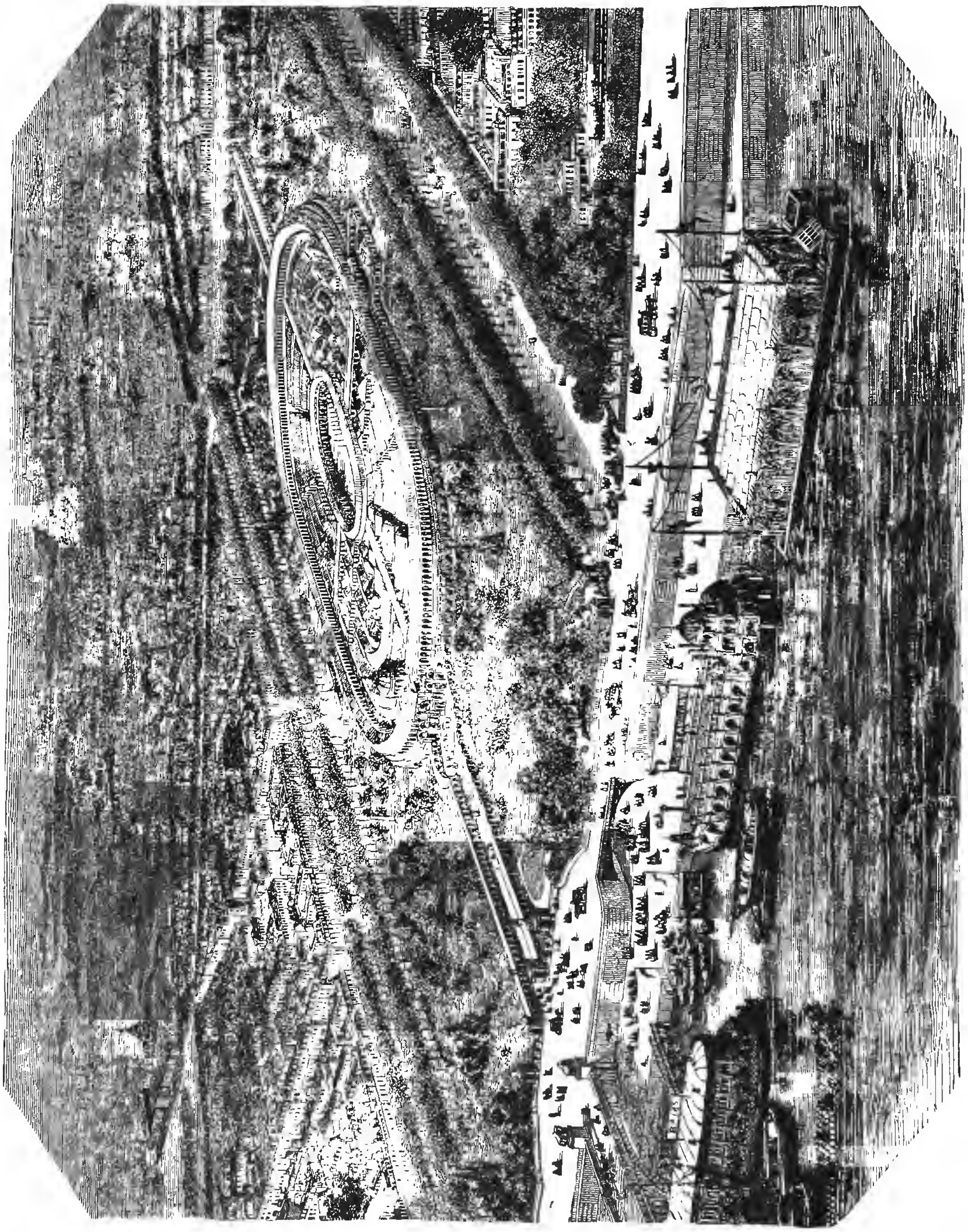
In Metal Work, the progress had also been rapid, the British outstripping all competitors, and developing an inherent strength, artistically, as well as mechanically. M. Ducel, of Paris, exhibited some remarkable figure castings in iron. Works in the precious metals showed great advance, and in this department the French were far ahead of the English.

Among the Sculpture exhibits, we may mention Fuller's bronze statue of "The Castaway," representing a shipwrecked man—faint, bruised and exhausted—floating on a piece of wreck, raising himself up and holding his hand aloft as he makes a last desperate effort to attract assistance. It was a work of great merit, gaining for its author a high reputation.

The "Reading Girl," by Pietro Magin, of Milan,—which the writer had the pleasure of seeing at Milan, several years ago,—was another one of the gems of the exhibition. A girl of no decidedly idealized type, loosely draped, as if partly prepared to retire for the night, is seated on a common rush-bottomed chair, sideways, and reading a book, supported on its back. The position is so entirely free from affectation, and the attitude and expression so natural, that it appeals to the heart at once, and no one could fail to notice and appreciate it. Gibson exhibited a colored "Venus," a work of elaborate and exquisite execution, and exceeding beauty and refinement,—the coloring, by many, however, was considered a failure. It was not merely a tone given to the marble, but polychromatic, and too weak,—not approaching nature sufficiently to give human expression, and yet sufficiently tinted to take away the divine purity of the simple marble. Miss Hosmer exhibited her "Puck," and "Zenobia Captive;" and Powers, his "California."

The exhibition closed on November 1st, a day of fog and drizzling rain. There was a very large number of persons present, among them Prince Napoleon, the Duke of Cambridge, and many others of distinguished rank, but no special ceremonial took place, in the usual acceptance of the term. As an exhibition, its success was not equal to that of 1851, either in fitness of edifice, novelty of articles exhibited, or in financial results.

Whatever may be said of the Emperor Napoleon III., all will admit that he systematically labored to advance the interests and promote the happiness of the people under him, continually engaging in projects for the development of the great natural resources of his empire; originating and giving an impulse to national industries, before unknown, and taking every opportunity of pleasing the inherent tastes of his people, and gratifying their pride by improving and adorning Paris, until it grew to be called the most beautiful city of the modern world—the very Heaven of the pleasure-seeker. In strict accordance with his expressed views, and with the characteristic features of his reign, he decided upon holding a great International Exhibition in Paris, in 1867, and on the 22d of June, 1863, an imperial decree was issued to this effect; the "Universal Exposition," as it was called, being intended to comprise typical examples of works of art, and of the industrial products of all countries, and to include every branch of human labor or skill. The invitation was extended to artists, manufacturers and workers of all nations, to take part in the Exposition, and it was expressly stated that the decree had been issued so early in order to afford all desiring to enter the Exposition ample time for mature consideration and reflection, and for arranging and carrying out the necessary preparations. This was followed by a second



International Exhibition and Grounds, Paris, 1867.

decree in February, 1865, confirming the previous one, explaining in full such details as had become at that time necessary, and defining the leading features of the proposed exhibition. An Imperial Commission was appointed, a Guarantee Fund provided, Commissions and

Committees formed—at home and abroad—and a comprehensive system of co-operation organized and brought into service. The Presidency of the Commission was confided to Prince Napoleon, the Emperor by this selection bearing high testimony to the importance which he attached to the success of the Exposition. Formal invitations were issued to Foreign Governments; and in reference to these, it was required as an absolute condition for the admission of any exhibitors from any country, that the government of such country should first accept the invitation extended to it, and assume the responsibility of forming the exhibition of its section.

In arranging the plan of the exhibition, two fundamental points were determined upon by the Commissioners: first, that a two-fold classification should be adopted, allowing the contributions from each country to be kept separately in one mass, while, at the same time, all the productions of a class from the various countries should be grouped together; and secondly, that the building should be so constructed, and of such ample dimensions that the whole display could be made upon the main floor, without the use of the galleries.

The site selected for the exhibition was the "Champs de Mars"—the same spot upon which was located the first French Exposition of 1798—a rectangle of 119 acres, to which was attached, also, the Island of Billancourt, affording an additional area of 52 acres, or 171 in all. The main building was located upon the former, and the latter was used for the Agricultural Department. An elliptical form of building was adopted, or, in reality, a rectangle with rounded ends; the length of the straight portion between the curved ends being 360 feet, the total length 1,608 feet, and the width, 1,247 feet. The total area within the outer limits of the building was $37\frac{8}{10}$ acres, and an open garden of $1\frac{1}{2}$ acres occupied the centre, reducing the amount under roof to $36\frac{8}{10}$ acres. The building was composed of a series of vast concentric oval compartments, each one story in height, the inner one encircling the centre garden as an open colonnade. The whole list of objects exhibited was divided into ten groups; of these, seven were provided for in the main building, a compartment being appropriated to each special group. There were, therefore, seven principal compartments; and the arrangement of area under roof was as follows, proceeding from the centre outwards:—

Promenade around centre garden	17	feet wide.
Gallery de l'Histoire du Travail	28	"
1. Gallery of Fine Arts	49	"
2. Corridor for the Liberal Arts	20	"
Passage-way	16	"
3. Corridor for Furniture	76	"
Passage-way	16	"
4. Corridor for Textile Fabrics	76	"
Passage-way	16	"
5. Corridor for Raw Materials	76	"
6. Gallery for Machines	115	"
Gallery for Restaurants	33	"

The spaces devoted to the different countries were arranged in a wedge-like form, radially from the centre of the building to the outer edge, and the visitor, by proceeding around one of the concentric oval departments, passed through the different countries exhibiting, one after the other, always keeping in the same group of subjects; but if he walked from the centre of the building outwards, radially, he traversed the different groups of the same country. The arrangement of double classification required was, therefore, by this plan, completely accomplished, and afforded great convenience and facility for study and comparison.

The area encircling the Industrial Palace—amounting to 81 acres—was divided into the Park and the Reserve Garden, and in the former, numerous structures, constructed by the different nationalities, grew up, in all varieties of style,—from the hut of the Esquimaux to the palace of a Sultan—the workmen or attendants at each being almost universally peculiar to the special country, and imparting additional interest to them. The Champs de Mars, in a short space of time, changed like magic from a dry and arid plain—useful only as a place for manœuvres of troops—to a charming Park, containing a city in the midst of groves and green lawns; a place such as the author of the "Thousand-and-one Nights" alone could have imagined—groups of buildings so violent in their contrasts as to produce harmony only by reason of their oddity, and leading the visitor to imagine that he had been transported to dream-land. Turkish and Egyptian palaces; mosques and temples of the Pharaohs; Roman, Norwegian and Danish dwellings by the side of Tyrolese chalets; here, a specimen of the Catacombs of Rome—there, a group of English cottages; workmen and farmers' dwellings, light-houses, theatres, a succession of hundreds of constructions, as unlike each other as possible; restaurants and cafés everywhere, for all classes of people; noises of all kinds filling the air; concerts, orchestras, the ringing of bells and the blowing off of steam-boilers; such was the Park of the Champs de Mars during the Exposition Universelle.

The Reserve Garden contained the botanical, horticultural and piscicultural collections. Nothing so charmed or rested the eye as the green lawns spread out so extensively before the visitor; nothing so picturesque as the chance glimpses of ground beyond, that intercepted the horizon; as the shrubbery, the grottoes, the cascades, the conservatories, some so grand, and others so *petite* and pretty. No one who saw the Exposition could forget all the beauties of this spot; the aquariums, the diorama, the pavilion de l'Impératrice, or, above all, the aristocratic restaurant of the Jardin réservé.

An iron coliseum grew up in the midst of all this, far exceeding in magnitude the ancient Coliseum of Rome itself, gathering beneath its roof nearly 50,000 exhibitors from all parts of the world.

Flowers, statuary and fountains adorned the open garden in the centre, and a central pavilion contained an exhibition of the weights, measures and moneys of all countries. The outer compartment of the building was the highest and broadest of all, having a width of 115 feet, and a height to top of roof of 81 feet. The roof was of corrugated iron, supported by iron columns; and along the centre of the whole length of the compartment was an elevated platform, carried upon iron pillars, and forming a promenade, at once safe and convenient, from which to view the machinery below.

The vast supply of water necessary for the use of the exhibition, for the display of the fountains, etc., was obtained from the Seine, and raised by means of powerful steam-pumps to a reservoir on high ground on the opposite bank of the river.

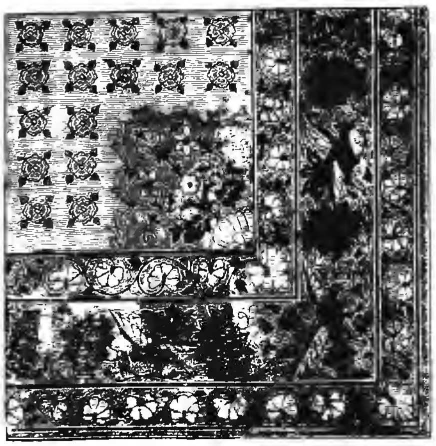
The Government surrendered the site to the Commissioners on the 28th of September, 1865; the first iron pillar was raised April 3d, 1866; and, although the building was not entirely completed by the time fixed—the 1st of April, 1867—the opening ceremonies, nevertheless, took place, as per appointment, with considerable pageantry.

The Emperor and Empress arrived at two o clock in the afternoon, accompanied by the Ministers of State, the Prefect of the Seine and the Imperial Commission. Entering the Palace by the *Porte d'honneur*, facing the Bridge of Jéna, they traversed the grand Gallery of Machinery, commencing at the French Department and terminating at the English. They then passed through all the galleries, and having received the artists and authors of distinction in the Salon des Beaux-Arts, they visited the Imperial Pavilion, and resting a while, then entered their carriage and departed, amidst vociferous acclamations from the assembled multitude, and the Exhibition was open to the world.

The day was perfect, and everything combined to make the opening a success; the bright sun, the deep Italian blue of the sky, the varied and rich costumes of the multitudes, the gorgeous decorations, the oriflammes waving in the breeze, and the music from the orchestras floating through the air—all united to produce that elated, happy, contented feeling which one experiences at times—a true enjoyment—the struggles and toils of this world forgotten almost entirely in one real day of pleasure.

In two weeks' time everything was in order, and the exhibition had developed from its unfinished state into perfection,—an object of beauty and instruction to all who passed within its boundaries.

In passing through the exhibition, the first portion that attracted attention—after leaving the central garden—was the Gallery *de l'Histoire du travail.* This department was intended to exhibit the various phases through which each country had passed before arriving at the present era of civilization, and was a grand idea as a preface to the Exposition. It was exceedingly interesting, although not as complete as it might have been, and not carrying the connecting links quite up to the present date. The French Department was the most perfect, being divided up into a series of halls, or apartments, to represent the different periods. The first hall represented the Stone Age, and here one found the collections from the lake-dwellings of Switzerland, the bone-caverns and the peat-bogs. Next came the relics of the Bronze



Period—objects of ornament and utility, bracelets, agricultural implements, etc., extending down to the Gallo-Roman. Following, were the relics of the Celtic and Gallic races; the works of the Middle Ages, seals, caskets, croziers and illuminated missals; and after that came the Renaissance Period, embracing curious locks, spherical watches and a handsome exhibit of the enamels of Limoges, from the collection of Baron Rothschild. In the sixth hall were productions of the seventeenth and eighteenth centuries. In the contributions from other countries were some very curious articles—the cradle of Charles XII, of Sweden, fine collections of ancient arms and armor, etc.

The Department of Fine Arts—which occupied the next gallery—was one of great interest both to artists and amateurs, the different nations having almost universally furnished the best productions of their most eminent artists in both painting and sculpture. Some countries were very much crowded in the space assigned to them, and erected special buildings—outside the main building—for their exhibits. The statuary, from all countries, was very much scattered through different parts of the building, and over all parts of the Champ de Mars.

In Paintings, the French were well represented by Gérome, Meissonier, Corot, Cabanel, Hamon, Yvon, in his "Taking of the Malakoff," Rosa Bonheur, Fromentin and others. Among the *genre* subjects, Plassan, Fichel, Toulmouche and Welter were represented by some exquisite pictures. The Belgian exhibit—a very fine collection—was outside, and consisted of contributions by Leys, Stevens, Willems, Verlat, Clay and others. The government of Holland—also outside—exhibited 170 pictures, the artist Israels standing foremost in rank among the contributors, and distinguished by his delicacy of sentiment and simplicity of expression. The Belgian and Holland schools showed strong inclination towards the French, neglecting the styles of their ancestors, with the exception of Leys, who was the pre-Raphaelite prophet of the Netherlands. Switzerland and Bavaria also had their own buildings in the Park, and showed large exhibits.

It was a little singular that the exhibit from Italy—the cradle of art—consisting of fifty-one oil paintings, should have been scarcely above mediocrity. The collection from the United States was a very creditable one, the foundry scene of Weir being the best work of its kind in the Exposition. Bierstadt, Church, Kensett, Broughton, Huntingdon, Hart, Healy and others were well represented.

The influence of the French school was very apparent in all the Continental collections. The English and American pictures were quite different, showing much more character and individuality, the difference in system of study throwing the artist entirely on his own resources, and thereby bringing out his peculiar style, which, under the Continental method of teaching, might never develop.

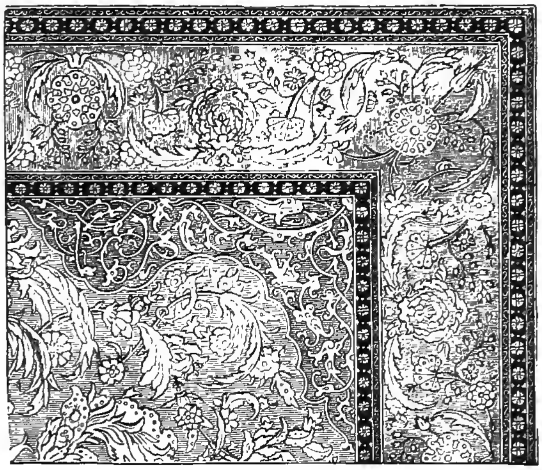
The Mosaic Work, contributed by Russia from the atelier of Michael Chmielevski, of St. Petersburg, was the finest, by far, in the exhibition.

The exhibition of Sculpture showed the influence of the realistic school over the classical, the best artists availing themselves of the good points of both schools without binding themselves to either. The gem of the classical school was of American origin, "The Sleeping Fawn," by Miss Hosmer. One of the most striking statues of the realistic school was "The Last Days of Napoleon I," contributed by an Italian, who received a gold prize for his work.

Passing on to the corridor for the Liberal Arts, one came into contact with books and printing, paper and stationery, lithography, photography, musical instruments of all kinds, medical and surgical apparatus, appliances for teaching science, mathematical instruments, maps and geographical and cosmographical apparatus.

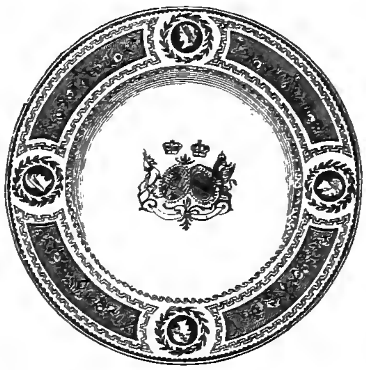
Among the Photographic exhibits was a fine series of views of the Yosemite Valley, by E.

Watkins, of San Francisco; also, Rutherford's photographs of the moon and the solar spectrum, attracting great interest from the savans, and receiving a silver medal.



Among the Musical Instruments, Steinway & Sons, of New York, and Chickering & Sons, of Boston, were considered as having the best pianos in the Exposition, and although the Jury of Awards had only four gold medals to award to this class, they each received a gold medal, and the fact of two going to America, under the circumstances, was a great honor. Mason & Hamlin's cabinet organs were objects of great interest on account of their superior workmanship and singularly pure tone, and received a silver medal.

The exhibition of Surgical Instruments made by the Surgeon-General of the United States was very complete and interesting, consisting of ambulances, medicine wagons,



field-hospitals, artificial limbs, and every species of apparatus which had been invented or improved by the exigences of our late war. A very ingenious orrery was exhibited from the United States, showing the planetary system in a very exact manner, not only giving the rotation of the earth round the sun, but at the same time that of the moon around the earth.

In passing through the gallery devoted to Furniture, one could not fail to notice the great degree of perfection to which the industries here represented had arrived.

The French glass works of Baccarat and the Compagnie des Cristalleries de St. Louis, and those of England and Venice; the Italian *faience*, the art bronzes of Paris, the productions of Sèvres, of Beauvais, and the Gobelins, the pottery, goldsmith-ware, cutlery, perfumery and other celebrated articles of Paris, and numerous other specialties of acknowledged merit, were here all displayed in profusion. The exhibit of English white crystal Glass was far finer than at any previous exhibition, showing a remarkable advance since the Exhibition of 1862, and distinguished for its purity and brilliancy of color. The French displayed an immense variety of colored, gilded and painted glass; but the white glass, when compared with the English, had a clouded and gray appearance, owing to a far less quantity of lead being used in its composition. Baccarat exhibited some effects in decoration, produced by giving to crystal glass a deep-colored surface, and then etching on this a design to different depths, producing different shades of color down to the clear, white glass itself. The effect was excellent, and the process evinced great capabilities. The most remarkable exhibit of Austrian glass was that of Lobmeyr, of

Vienna, the designs being in perfect taste, and the material first-class. The Bohemian glass was superb; the decorations in gold, especially those in raised gold, without an equal in either execution or artistic effect; and gilding and coloring were applied in such a way as not to be at variance with either the material or the purpose for which the article was intended to be used. Dr. Salviati, of Venice, showed some wonderful specimens of modern glass manufacture, inaugurating a revival of the glories of the old Venetian glass, and imitating the peculiarities of that production, such as gold metallic particles floating in the material, thread work, dainty touches of color, etc., in such perfection as to attract the attention of all lovers of art work.

Pottery stands among the earliest of art manufactures, and in none has there been less change; the finest designs of the present day being of the same forms as in use two thousand years ago. Taking a material possessing primarily less value than almost any other used in the arts, the manufacturer, by the exercise of labor, skill and taste, produces forms ministering greatly to the necessities of man, and often of untold value, ranging from objects of every-day use to the porcelain of Sèvres. We engrave on page xlix a vase produced from the Imperial manufactory of Sèvres, a beautiful work of art and an excellent specimen of the gems which are created in that school of pottery so creditable to the government which has established it.

In the display of Textile Fabrics, carpets and tapestries occupied a prominent place. Carpets from Persia were more like shawls in their exceeding beauty of texture and the style and color of their designs; and in the French Department those of Savonnerie and the Gobelins still held their own against all competitors. The Imperial manufactories of the Gobelins and of Beauvais had on exhibition exquisite specimens of tapestry, and those of the different manufacturers of Aubusson were of the highest merit. Among the varied collection of table-covers were those of Philip Haas & Sons, of Vienna, the most eminent and extensive manufacturers of Tapestries, Carpets and Curtains in Austria, and we engrave on pages xlix and li some specimens of their work, which were of great elegance, and so much admired that one exhibit was almost hidden from view by the vast number of cards attached, on which were written orders for similar pieces of work.

Mr. Harry Emanuel, of London, exhibited in *répousée* silver, Tazze of Night and Morning, designed by the eminent artist Pairpoint, of which the engravings we give on page lii convey an excellent idea.

An exquisite dessert service in turquoise and gold was exhibited by Messrs. Goode of London, and manufactured for the Duchess of Hamilton—also Princess of Baden—and we show engravings on page li of parts of this service, on one of which will be seen represented the arms of the Duchess.

What has been designated by many as the best work of its kind in the exhibition was the famous Milton Shield of Messrs. Elkington, London, from a design by Morel Ladeuil, one of the grandest works of its class that had ever been produced, admirable in conception, and perfect in execution. We understand that this shield will form part of Messrs. Elkington's exhibit this year, and give an engraving of it on the following page.

In Bronzes, France—especially Paris—had at this time achieved the highest reputation, which was fully sustained in this exhibition, the French Bronze Court surpassing anything of the kind ever before seen, either in extent or variety. The admirable collection of M. Barbedienne stood unrivaled, being fine art work in every sense of the term, the use of various tints of bronze, and gilding and silvering where required, displaying great decorative and artistic taste. M. G. Servant, of Paris, also exhibited excellent specimens of bronze work, and the Boudoir Mirror we engrave on page lv, was one of his productions.

The display of Furniture proper was very extensive, and remarkable for great variety of

style, excellence of workmanship and rich diversity of material, coming from all quarters of the globe, and representing all peculiarities of taste. The English showed simplicity of treatment and improvement in design. The French was very lavish in ornamentation, the use of caryatides and uncouth human figures, and although perhaps pleasing the popular eye, was unquestionably degenerate in taste. The German was solid and heavy, and the Belgian bold and effective, but too naturalistic and unartistic in the ornamental work.

An ebony Cabinet, of great beauty, and a production of the very highest order of art manufacture, was exhibited by Herr Türpe, of Dresden, and is engraved on the next page. The bas-reliefs were of pear-wood, and the sculptured figures were the handiwork of a true artist.

Some charming works in Carved Wood were shown by Mr. G. A. Rogers, whose father, W. G. Rogers, had achieved a great reputation in this specialty. The design and carving of the specimen we show on page lvii were both by Mr. Rogers and exhibit the same pure feeling for which his father was so celebrated. Switzerland has attained great reputation for wood carving and none of her contributors have a wider renown than MM. Wirth Bros., of Brienz, whose manufactures are true art productions, no two of them being ever exactly alike, and always the work of artists. On page lvii will be found several specimens of their work.

Mr. Charles J. Phillip, of Birmingham, one of the leading British manufacturers of ornamental gas-fixtures, exhibited fine specimens of his work, one of which we engrave on page lviii.

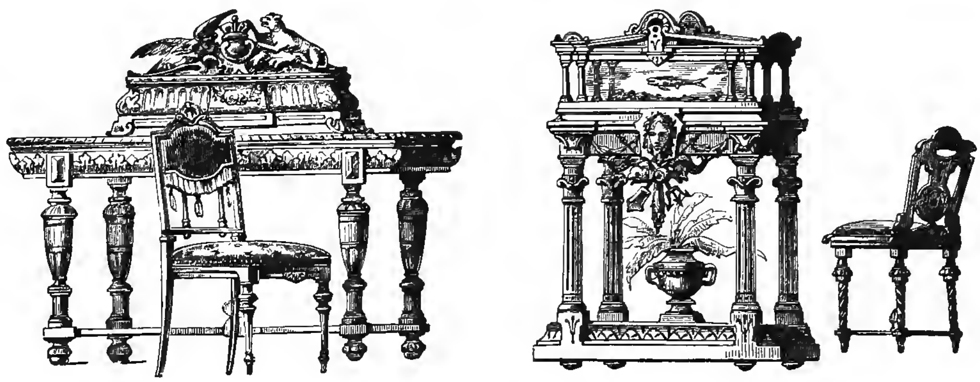
Passing on to the next gallery, we enter the Department of Textile Fabrics, comprising articles for clothing; goods in cotton, wool, silk, flax, hemp, etc.; materials and tissues collected together, from the most marvellous silks of Lyons to the cheapest cottonades; from the cashmere of the Indies — worked in gold—down to the merino scarf; from the robe of Alençon lace, or the point d'Angleterre, to the tulle which may be purchased for a few cents per yard. Here jewelry flashes in the

light, gleaming diamonds, emeralds, pearls and coral; there are displayed French artificial flowers so perfect as to excite even the jealousy of nature. In one portion of this department were life-size figures dressed to display the peculiar costumes of the various nations, those of Sweden and Norway being distinguished for their perfect execution.

The display of Lace and Embroidery was very profuse and beautiful. From the time of Marie dé Medici to the present day, nothing has been found to take the place of this costly fabric, lace; and nothing else can give to a lady's toilette the same finish and elegance. Its manufacture has attained great perfection in France, Belgium and England, and it is also made to a small extent in other parts of Europe, but not of so fine a quality. In Italy, the manufacture once so extensive, has degenerated, and the point lace of Venice and Genoa, so celebrated in the sixteenth and seventeenth centuries, has disappeared.

In France the principal varieties manufactured are the Point d'Alençon, the black lace of Normandy and the laces of Auvergne, of which Le Puy is the centre, and those of Lorraine at Mirecourt, with the light fabrics of Lille and Arras. The Normandy lace is made in the most perfection at Bayeux. MM. Lefébure, the eminent lace manufacturers of this place, exhibited some beautiful specimens of their work, of which we engrave part of a curtain on page lix, in the style of the the old Venetian point, of scroll pattern, with birds and flowers introduced.

In Belgium, which may be termed the "classic land of lace," the manufactories are

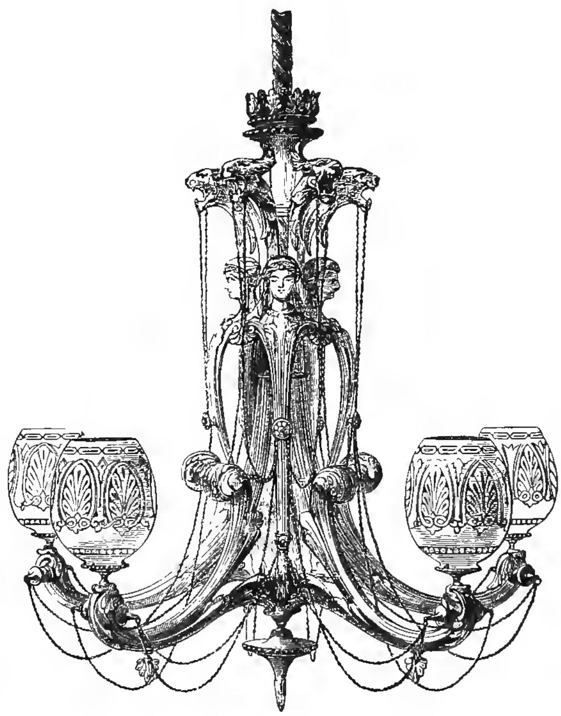


at Brussels, Mechlin, Valenciennes and Grammont. The especial lace of England is Honiton. Embroidery comes from Nancy, Switzerland and Saxony, and an important branch of industry in Switzerland is the fabric of net and muslin curtains, embroidered in crochet.

The display of Cashmere Shawls, both of Indian and French manufacture, was magnificent, showing great elegance of pattern and beauty of execution.

In Goldsmiths' Work and Jewelry, Froment-Meurice—whose father was styled the Cellini of France—exhibited beautiful specimens of work, and we engrave on page lx three examples of his ordinary every-day productions, which are always characterized by beauty, richness and great artistic taste. Some excellent and solidly-manufactured work was shown by Messrs. Tiffany, of New York.

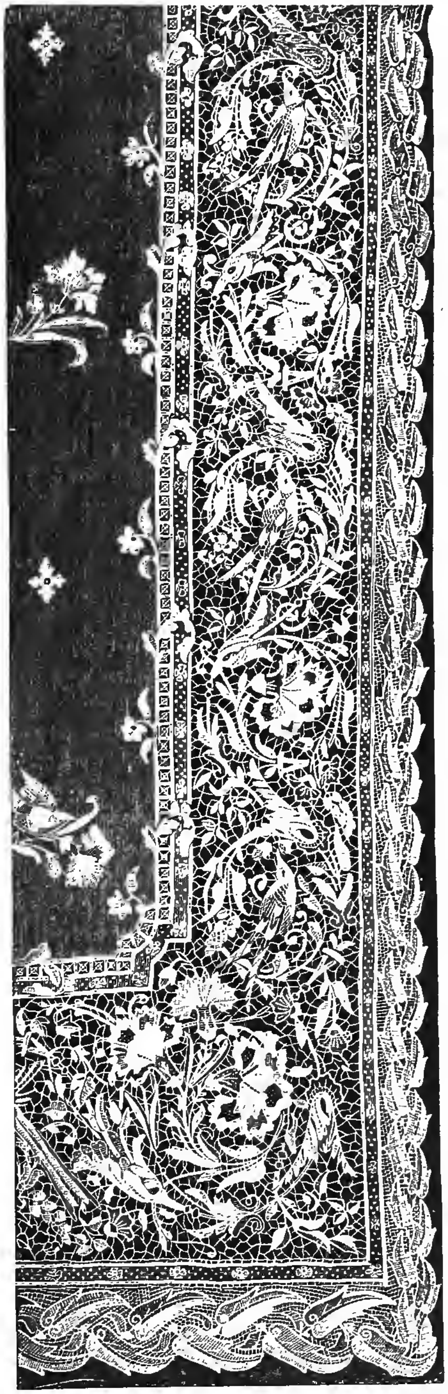
The next corridor, adjoining, was that for Raw and Manufactured Materials, obtained directly from nature; products of the soil and mine; of the forests, and industries pertaining to the same; of the chase and fisheries; uncultivated products; agricultural products not used as food; chemical and pharmaceutical products—specimens of chemical processes for bleaching, dyeing, printing and dressing of textile fabrics; leather and skins. Here one found collections and specimens of minerals and metals of all kinds, from all countries; coal



and fuel of all sorts; rock-salt, sulphur, sponges, metal manufactures, stearine, soap, paints, wool, cotton, silk in the raw state, furs, tobacco, seeds, various varieties of wood, etc.

The Prussian salt-mines of Strassfurt were represented by a quantity of the salt cut into large blocks and built up into the form of a half-dome. Spain exhibited blocks of cinnabar from the famous mine of Almaden; and Russia displayed large vases and candelabras made from malachite, jasper and rhodonite; great varieties of rough and polished precious stones, models of meteorites, etc. Alibert exhibited remarkable specimens of graphite from his mines in Siberia, now in such extensive use for the celebrated Siberian pencils; and a mass of malachite weighing over two tons was shown from the mine of Prince Demidoff.

There was a large and creditable mineral exhibit from the United States; coal, iron, lead, copper from Lake Superior, quicksilver, silver and gold from Idaho and California, and emery from Massachusetts. The exhibit of wrought-iron, in all forms of manufacture, was very great; enormous plates, bars and girders; cast-steel from the Krupp Works of Essen, Prussia; ornamental castings, etc. The ornamental cast-iron productions of Durenne, of Paris, were particularly noticeable for beauty of design and excellence of work. We reproduce on page lxi a specimen of railing exhibited by him. None had greater renown in iron castings at that time than Barbezat & Co., of Paris, and many fine designs were exhibited by them, of which we engrave one, a street-lamp, on page lxii. Some specimens from the establishment of Count Dimeidel, in Prussian Silesia—the famous foundry of Lauchaumer—were art castings of a high order of merit, exquisite in design, and remarkably sharp and brilliant in finish. One of them, a stove, which excited universal admiration, we engrave on page lxiii.



The exhibit of Furs was very extensive and in great variety, ranging from the rarest kinds of sable down to the ordinary, cheap, glossy rabbit skins. France and Russia had fine assortments; and Messrs. Gunther, of New York, displayed some excellent specimens of North American furs.

The next gallery was that for Machines or Apparatus and Processes used in the Common Arts. This was the highest and largest gallery of the Exposition, and on entering it for the first time, the *coup d'œil* was certainly striking. Gigantic masses of manufactured metal articles, arranged in the form of trophies, rose up on all sides, and a multitude of machines in motion, gave forth a thousand noises of all kinds, bewildering the mind and perplexing the ear. The elevated platform—passing around in the centre of the gallery—was a favorite promenade, and gave an excellent general view of the exhibits.

It would be impossible, in our limited space, to enter into any detail concerning the immense number of machines which had been brought together under one roof from all quarters of the world, and testifying to the inexhaustible inventive genius of man in its endeavors to supply the increasing wants of the age. We will, however, mention a few of the most important. Among the machines for drilling of rocks, the Diamond-pointed Drill occupied a prominent position, and now forms the basis of the most important machines of this kind in use. Traction engines were conspicuous in the English Department, and reapers and mowers in the American, the latter carrying off the prize in two trials made at the Emperor's farms at Vincennes and Touilleuse. Under the head of Machine Tools, the principal exhibitors were France, England, Prussia and America, the novelty of form and excellence of workmanship of America being admitted to be equal to that of any other nation. The planing-machines, exhibited by Messrs. William Sellers & Co., of Philadelphia, were unsurpassed by any in the Exposition, and were remarkable for many novelties. Their screw-cutting machine was also of an entirely new character and an excellent tool. The display of Messrs. Bement & Dougherty in machine tools was first-class and showed many points of excellence. The lathes of Harris and the American Tool Company possessed several very interesting peculiarities.

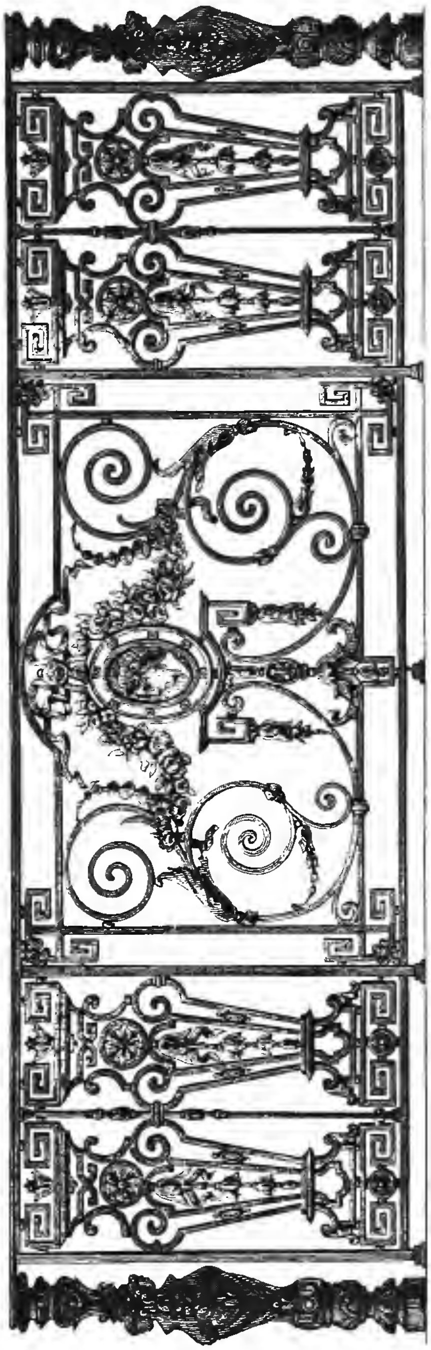
The principal improvements which this Exhibition showed to have taken place in machine tools during the preceding twelve years may be mentioned as follows:—greater simplicity, perfection and solidity of construction, and more frequent adoption of automatic motions; better adaptation of form to the materials employed; increasing tendency to completion of products by mechanical means alone; adaptation of machines to more universal

use, allowing several operations to be performed on the same piece of material without dismounting it; construction of portable machinery; increase in rapidity of motion of the tools; and a general improvement in the execution of small tools; and greater simplicity in the means of transmitting motion.

Apparatus was shown for processes in carding, spinning, weaving and the preparation of textile fabrics generally. Sewing-machines, machines for shoemaking and for making of felt hats, were especially noticeable—an entire revolution in the machinery for the latter industry having been made within a few years. Machinery for furniture manufacture showed great improvement, and printing-machines of all varieties—for our daily morning paper, for lithographic work, for stamping of textile fabrics, for various kinds of printing and decoration on paper, etc.—were displayed in profusion.

There was a very interesting exhibit of Railway Apparatus, and thirty-two locomotives were exhibited; the Grant locomotive, from Paterson, New Jersey, attracting much attention from the general observer, owing to its exceedingly handsome appearance, being covered with polished brass and German silver, with ivory handles to the different cocks, and various other details of fine workmanship, which, by the more practical men, were considered out of place and not particularly adapted to actual service. American ingenuity and invention again occupied a prominent place in the exhibition of telegraphic apparatus and processes.

In Civil Engineering, Public Works and Architecture, the display of France was simply superb. There were handsome models—complete in every detail—of bridges, viaducts, reservoirs, docks, etc. In the Italian Department were plans and sections of the Mount Cenis Tunnel—then not completed;—and in the American Department plans were exhibited showing the method adopted, and now in use, for supplying the city of Chicago with water from Lake Michigan—a bold and most successful scheme of engineering. The Suez Canal exhibit was full of detail and of great interest.



The seventh, and outer gallery of the buiding, was devoted to food, either fresh or preserved; and in almost every instance, a restaurant was connected with each country, where the various foods could be practically tested. Visitors were waited upon by young girls in the costumes of the different nationalities, and one met here the blondes of Bavaria, the gay Austrian, the pretty Russian, crowned with a tinsel diadem, the Mulatto offering cocoa and guava, Greeks, Swiss, Neapolitans, Italians, Indians, and even the Chinese women, with their little tea shop. All languages mingled strangely together on this promenade, and all nationalities elbowed each other, from the elegant Parisian to the Bedouin in his burnous; and the animated aspect of the surroundings of the Exposition will always be remembered by those who were fortunate enough to see it.

Down on the banks of the Seine were displayed models of all kinds of naval artillery, from enormous steel cannon for iron-clads, to little bronze pivot-guns for gunboats, and every specialty in reference to maritime affairs, pleasure and life-boats, yachts that were *chefs d'œuvre* of great beauty and elegance, gondolas, Egyptian caïques, painted, and gilded and manned by their Oriental crews, steamers, monitors, etc. A complete history of naval constructions was exhibited in a temporary building, by means of models in relief.

We have already spoken of the Agricultural annexé on the island of Billancourt, and this deparment was on a much more extensive scale than ever given before at any international exhibition, in fact, forming an exhibition of itself, presenting exhibits of all kinds of agricultural implements, and the finest breeds of live-stock—horses, cattle, sheep and other domestic animals—the exhibits being changed every fortnight, and making a succession of fourteen competitive exhibitions.

The distribution of prizes took place at the Palais of the Champs Elysées,—the permanent building which remained after the Exhibition of 1855,—on the 1st of July, and was accompanied by all the pomp and ceremony characteristic of the Empire. The building had been decorated for this occasion with great magnificence. The stage was hung with velvet, covered with gold bees, and surmounted by a gigantic imperial crown.

Down the centre of the nave were placed ten trophies, formed of the principal products in each department of the industries to which prizes were awarded. The glass roof was covered with white vellum striped with green and starred with gold, and from it hung ten banners bearing the colors corresponding to the ten groups into which the exhibits were divided. The columns of the gallery were decorated with the flags of the various nations represented at the exhibition. On the imperial platform were seated the Emperor and Empress and the Prince Imperial, accompanied by the grand dignitaries of the crown. Around their Majesties were the Sultan and three young princes of his family, the Prince Napoleon and the Princess Clotilde, the other members of the Imperial family, the Prince of Wales and Prince Arthur, of England, the Prince Royal of Prussia and various others of the royal visitors, including a brother of the Tycoon of Japan. The audience was composed of representatives from all nations, and numbered about seventeen thousand persons. At the moment of the entry of their Majesties, the orchestra executed the "Hymn to the Emperor," a work composed expressly for the occasion by Rossini. M. Rouher, Minister of State, then presented his report on the Exposition, and after an address by the Emperor, the names of the persons, the establishments and the localities to which were decreed the new order of awards for "Social Harmony," were read. This order of awards had been instituted by the Emperor in favor of persons, establishments, or localities where, by special institutions, good harmony had been promoted among those who carry on the same labors, and the material, moral and intellectual well-being had been thus secured among the operatives. These awards were ten prizes of one hundred thousand francs each and twenty honorable mentions. Following, were read the names of the exhibitors who had obtained the grand prizes for the groups of Beaux-Arts, Agriculture and Industry.

The awards granted by the juries of the Exposition were, sixty-four grand prizes, eight hundred and eighty-three gold medals, three thousand six hundred and fifty-three silver medals, five thousand five hundred and sixty five bronze medals, and five thousand eight hundred and one honorable mentions. The number of these awards is not surprising when it is recollected that the exhibitors numbered forty-five thousand, and that they were comprised of the élite of the artists and industrial workers of the entire world.

There were at this exhibition over twelve millions of entrance tickets recorded, representing at least four millions of different visitors. The total cost of the main exhibition building was $2,356,605, or $1.43 per square foot of surface covered. The total expenses of every kind from the commencement of the construction of the buildings—February 1st, 1865—to, and including the restoration of the Champs de Mars after the close of the exhibition, were $4,688,705, and the total receipts, including the subsidies from the government and from the city of Paris of $1,200,000 each, were $5,251,361, leaving a net profit of $562,654, of which dividends were declared of $553,200, and the balance of $9,456 was held for unforseen events and finally used for the public good.

During an interval of several years after the Paris Exposition of 1867, a number of minor local and general exhibitions were held in various places, among which we may mention that of the Central Union of the Fine Arts applied to Industry, in Paris, in the old Palais de l'Exposition, in 1869; an exhibition in Dublin, and also one at Leeds, the latter a purely fine art and loan exhibition, similar to the one held at Manchester in 1857. Exhibitions were also held at Copenhagen and Moscow, in 1872, and one of Domestic Economy in Paris, the same year. These exhibitions were all more or less of a local character, that at Copenhagen being confined to the products of Sweden, Norway and Denmark. The Moscow Exhibition, which was on a considerable scale, was held under the auspices of the Moscow Polytechnic Society, with the favor and protection of the government. It was too far distant to receive much attention from this country.

In England, a series of annual international exhibitions were organized in 1871, and held regularly afterwards, in a permanent building erected for the purpose at South Kensington, flanking the Royal Horticultural Gardens. These exhibitions were only moderate in size, but of special interest, great care being taken in the selection of exhibits, and the trade interests always set aside in favor of the encouragement of progress.

Awards have been given at these annual exhibitions with great judgment and discretion, very much enhancing their value, and the exhibitions have resulted in considerable benefit to England.

Austria, anxious to keep pace with the other great powers of Europe, had early had her attention drawn to the consideration of the subject of International Exhibitions, even previous to the time of the Paris Exhibition of 1867. Various causes, however, had combined to prevent any special action in the matter for several years, until the subject again came up in 1870. The city of Vienna within the last decade had changed from an old time town to a modern metropolis. The ancient fortifications had been taken away and replaced by the magnificent Ringstrasse. Inducements of every kind had been offered to those who would improve and embellish the city, and splendid buildings had grown up in all parts, especially along the Ringstrasse and its tributaries;

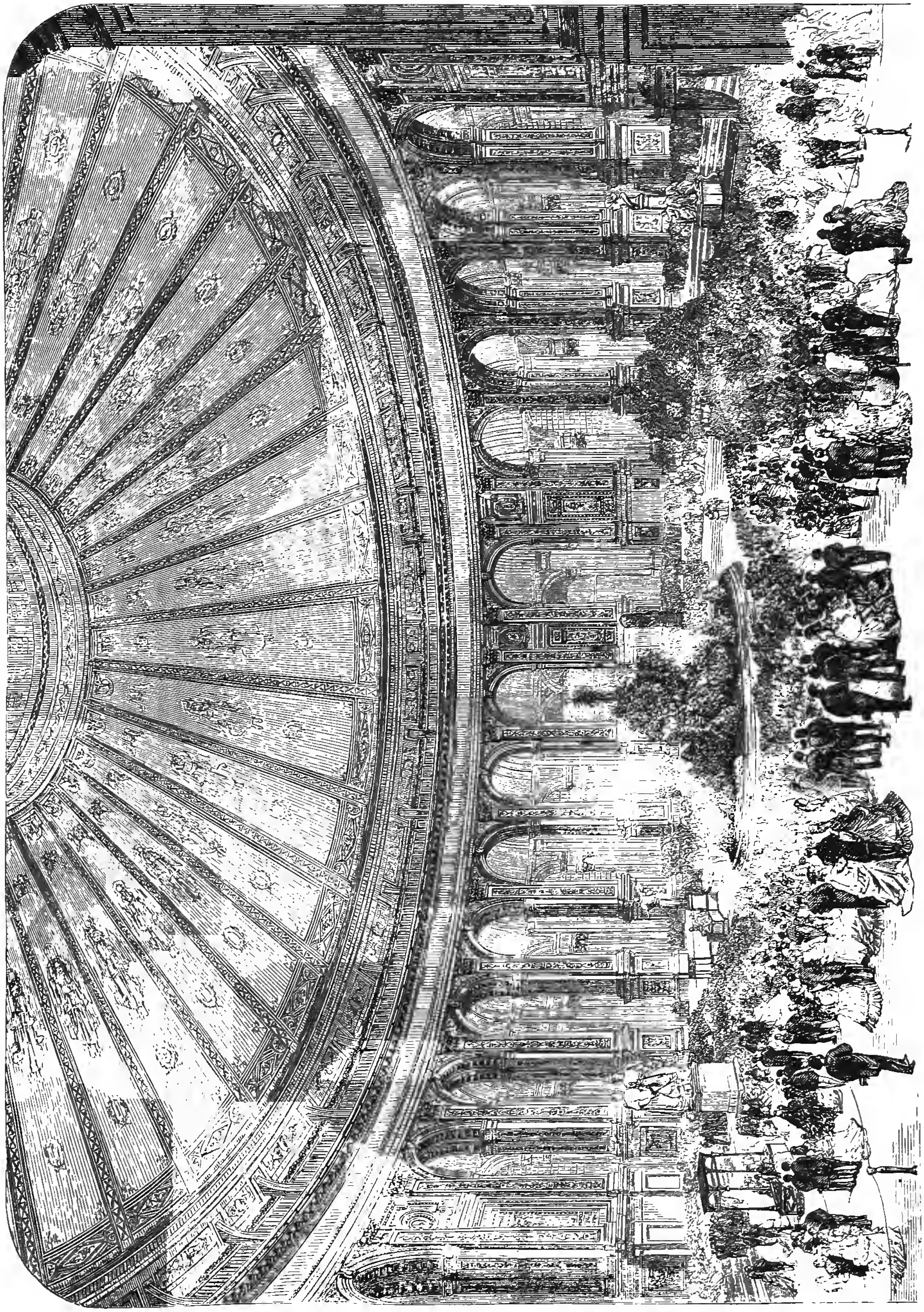
a noble opera-house had been built; a New Vienna had arisen and a time had arrived to display its glories to the world by devising an exhibition which it was proposed should outrival all previous efforts in this direction.

Active measures for an international exhibition to be held in Vienna in 1873, were first taken by the Trades' Union of the city, an organization of great opulence and influence, having Baron Wertheimer—a wealthy manufacturer—at its head. According to the original arrangement, a guarantee fund was formed of $1,500,000, and subscriptions to this amount were obtained—chiefly among members of the Society—it being supposed that the receipts from the exhibition would nearly, if not quite, meet the expenditures, and that this fund would cover all possible deficiencies. At this stage of the proceedings, the government was induced to give its patronage and support to the undertaking, and a decree was issued by the Emperor—May 24th, 1870,—announcing that "under the august patronage of His Imperial and Royal Majesty, the Emperor, an International Exhibition would be held at Vienna in the year 1873, having for its aim to represent the present state of modern civilization and the entire sphere of national economy, and to promote its further development and progress."

An Imperial Commission was formed with Archduke Charles Louis as Protector, Archduke Régnier, President, and Baron William von Schwarz-Senborn as Director-General; the total number of members being one hundred and seventy-five, and selected from the chief officers of the departments of the government, and from the leading men of science, art and industry in the empire. Money was appropriated by the government to the amount of $3,000,000 towards an exhibition fund, to which was added the guarantee fund previously obtained by private subscription, and all income from the exhibition itself. One-half of the amount furnished by the government was considered a regular appropriation, and the other half an advance made, without interest, and it was provided that if the total receipts from the exhibition and the government appropriation were not sufficient to cover the total expenses, the government would call in the guarantee fund. As the work progressed, it was found that the cost was greatly underestimated, and a supplemental grant of $3,000,000 additional was made by the government, although given under strong protest.

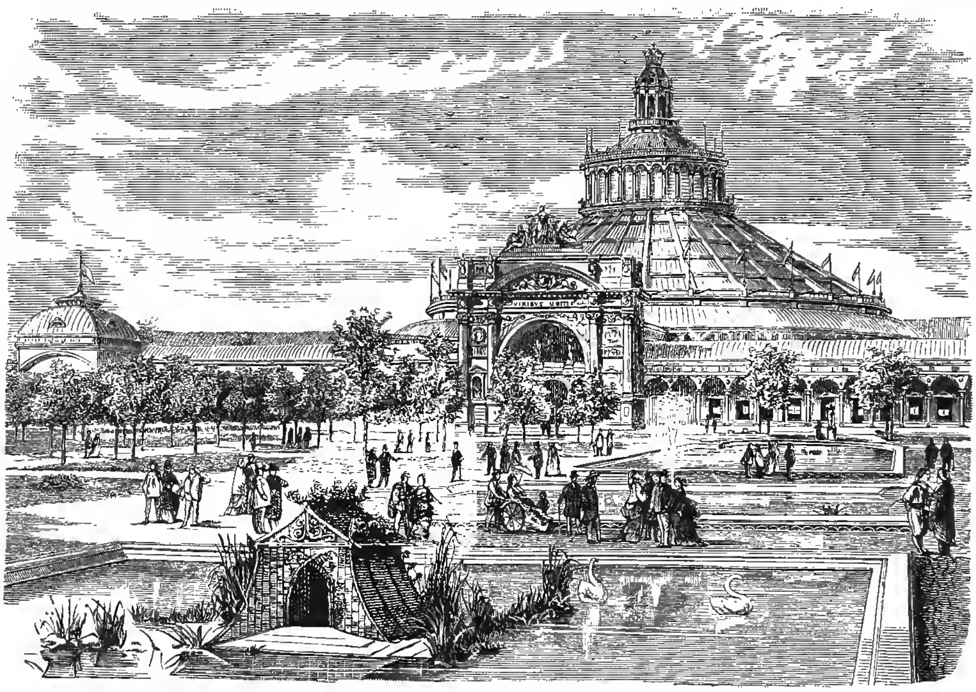
At no previous exhibition had so much interest been evinced by foreign governments, and their commissioners were chosen from their most talented and eminent men.

The site selected for the buildings was the Imperial Park—called the Prater—situated just outside of the city; as convenient a location as could possibly have been obtained, possessing within itself many attractions, and a favorite resort of all classes of citizens. On the north side flowed the Danube River, spreading out into numerous arms, some so



The Rotunda, Vienna Exhibition, 1873.

shallow as to be entirely unnavigable, others so full as to flood the flat country for miles around upon the least rise in the water. To the south lay the Donau Canal, a natural arm of the river, improved by art to a uniform width of one hundred and fifty feet, and the only available channel for navigation. Great improvements were in progress at this time, consisting in straightening and forming a new bed for the river nearly a thousand feet broad and one-half mile nearer the city, reclaiming land from floods and properly protecting the same by embankments, constructing docks, quays, warehouses, etc., and increasing the facilities for navigation and commerce in a marked degree. The work performed for the exhibition was expected to be of permanent value to the Danube improvement, and it was this, more than anything else, which induced the government to lend its aid to the enterprise. The Machinery Hall was intended to be used eventually as a freight or grain depot for the Great Northern Railway, and the grand rotunda of the main building was considered



Main Entrance, International Exhibition, Vienna, 1873.

the future corn market of the city. The total area of ground for exhibition purposes comprised within the surrounding fence was about 280 acres.

In arranging a method for grouping the exhibits, the double classification—as used in Paris in 1867—was not considered entirely satisfactory, and it was finally decided to adopt a purely geographical arrangement—each nation to be kept to itself—and no systematic classification to be recognized except such as might be obtained by providing separate buildings for specific purposes, and exemplified in the Machinery Hall, the Art Gallery, etc.

The principal buildings for the exhibition were the Palace of Industry, or main exhibition building, for miscellaneous manufactures, the Gallery of Fine Arts, the Machinery Hall and the Agricultural Building. In addition to these were various other buildings for minor purposes, similar to those distributed around the Main Exposition Building of Paris in the Champs de Mars. These were of unprecedented variety and importance, representing on a scale of great splendor and completeness the habits, manners, customs and methods of construction of various nations. At the Paris Exposition of 1867 this idea was first worked out as an international feature; here, it was on a still grander scale, and the rivalry of the nations of the Orient resulted in producing especial magnificence. The Palace of the Viceroy of Egypt was one of the most noticeable of these buildings. Designed by an Austrian architect long resident in the East, and constructed by native Egyptian workmen with great skill and truthfulness, it presented an appearance at once interesting and instructive. One saw here a sumptuous mosque, decorated in the richest manner, an ordinary dwelling-house, and then a regular farm and stable department stocked with dromedaries and other domestic animals of Egypt. Then there were also on the grounds specimens of the national habitations of Turkey, Persia, Morocco, Japan, Sweden, etc. Farmers' or peasants' homes from all countries, restaurants and refreshment saloons, the Imperial Pavilion, the Jury Pavilion, and special exhibits of all sorts, amounting in the aggregate to more than two thousand buildings, each one presenting something novel and pleasing.

The Palace of Industry was designed in the style of the Italian Renaissance, elaborately ornamented and finished on the exterior with that plaster-work which in Vienna has attained such perfection. It had for a main central feature a grand rotunda, covered by an immense

conical wrought-iron dome or roof of 354 feet in diameter, a *chef d'œuvre* of its designer, Mr. Scott Russell, of England, and the largest by far that had ever been constructed before, that of St. Peters, at Rome, being only 156 feet in diameter, and those of the London Exhibition of 1862 only 160 feet. It was supported upon 32 wrought-iron rectangular columns resting upon base-plates and founded upon concrete, and it was crowned by a central lantern of 101 feet in diameter and 30 feet high, provided with side-lights and a similar conical roof to the main dome. On top of this was another lantern 25 feet in diameter and 30 feet high, which was surmounted in turn by a gigantic copy of the crown of Austria, formed of wrought-iron plate, gilded, and decorated with glass imitations of the crown jewels.

Extending east and west from this central rotunda was a nave of 82 feet 10 inches in width and 22 feet 6 inches in height, with a total length from east to west through the rotunda of 2953 feet. A circular corridor or passage, half the width of the nave, ran all around the rotunda, connecting with the nave on both sides, and the columns carrying the dome, standing between this passage and the rotunda, were finished in ornamental plaster on wooden framing, with arches from one to the other, producing an exceedingly handsome effect. The floor of the rotunda was lower than that of the rest of the building, and in the centre was a highly ornamental fountain, adding very much to the general appearance. The interior of the conical roof was covered with canvas, stretched as a velarium over the whole of its under surface, divided into panels and decorated with colors in oil, each panel having painted on it in the centre an angel twenty-one feet long, and the whole of the interior work being elaborately picked out in gold and neutral colors.

There were cross-transepts, thirty-two in number, at intervals throughout the whole length of the nave, extending through both on the north and south sides, and having a length from face to face of 246 feet 3 inches. At the east and west ends of the nave the pairs of transepts adjoining were connected together next to their outer faces, and treated architecturally as one, producing an effective exterior appearance. The four transepts next to the circular passage around the rotunda, were also joined together by courts parallel to the nave, forming with these transepts a square of 676 feet exterior to the rotunda. The main entrance of which we give a view on page lxvi, was in the middle of the south side of this central square. It was designed like a grand triumphal arch, having a central arched opening, flanked on the sides by pairs of pilasters decorated between with niches, figure-subjects and medallions of the Emperor and Empress, and the whole crowned by a group of emblematic figures in plaster. The wings on the sides were arranged as arcades, and at the ends or corners of the square were small pavilions designed in the same general style although on a smaller scale, as the central entrance.

Concrete foundations were used under the permanent portions of the building, consisting

of the central dome and its surrounding courts, but the balance of the building was founded upon timber piles. The framing of the side walls of the nave and transepts consisted of vertical wrought-iron lattice columns of the lightest possible construction, standing on cast-iron foundation-plates, which rested upon the piles below. Upon these columns were fixed the trusses of the roof, consisting of segmental arches of the same lattice construction, connected by timber purlins covered with sheathing braids and zinc roofing-metal. The spaces on the sides of the building, between the vertical columns, were filled in with brickwork, plastered on both sides, the outer flanges of the columns being encased in the brick. The weight of the brick caused the outer foundations to settle more than the inner, consequently bulging the inner flanges of the columns out of position, which was remedied by fixing solid pieces of circular timber to them to stiffen them. These were finished with light wooden pedestals and mouldings, and plaster capitals painted to resemble bronze, the smooth portion of the columns being covered with crimson canvas ornamented with spiral lines of gold. Each transept was lighted by twenty-six windows of 11 x 14 feet each, and in the nave were five windows of 15 x 16 feet in each wall-space between the transepts, no skylights being used in any part of the building.

The iron-work of the interior was painted an olive-green, the wooden cornices a creamy gray color picked out with gold, and the under side of boarding of roof was calsomined.

The lower portion of the side walls under the windows was painted in panels of a light neutral green, and the parts between the windows covered with canvas in its natural color, on which was printed an arabesque pattern in dark blue and orange. The interior decorations were largely executed with colored canvas, the architect availing himself of an invention of an Italian—M. Bossi, of Milan—who discovered how to print patterns on canvas with great rapidity, producing, when put in position, all the effects of fresco at a very reasonable cost. This style of decoration was exceedingly gorgeous in appearance and accorded well with the tastes of the Vienna people.

The exterior effect of the temporary part of the edifice was not very striking. The plaster work was moulded and laid off in blocks to represent stone, and the general appearance was that of a long low line of gray buildings, broken at intervals by the transepts, the whole covered by the monotonous, arched zinc roof. The transepts were of much smaller dimensions than the nave, the crown of the roof coming just under the eaves of the roof of the nave, and in the end of each transept was a doorway surmounted by the coat-of-arms of the particular country exhibiting within. The grand central rotunda was a necessity, not only as a great hall for the opening and other ceremonies, but as the one redeeming feature in the architectural effect to relieve the tameness that would otherwise have been produced. After the construction of the building, many of the garden courts, between adjacent transepts, were covered over to provide additional room for the vast influx of exhibits.

In reference to the arrangement of the articles exhibited, the southern half of the central courts and a portion of the nave and eight transepts east of the centre were occupied by Austria. The other countries were arranged according to their geographical positions, east or west of Austria. Thus, Germany took the central courts north and west of the rotunda. Then, going west, came Holland, Belgium, France, etc., to the United States, which occupied the extreme west end; and on the east—next to Austria—were Hungary, Russia, etc., to Japan which occupied the extreme east end. Any one possessing a knowledge of geography could thus easily find the exhibits of any country he desired. The effect was to make a little exhibit in itself of the display from each nation, the whole being a continuation of a series of small exhibitions. The system adopted, however, made it extremely difficult to make comparisons of similar products from different countries, especially those at a distance geographically from each other.

To the east of the Palace of Industry was situated the Gallery of Fine Arts, entirely disconnected from it except by two galleries of communication. It was a building of brick, covered with cement and plaster so as to produce an ornamental appearance, and about 650 feet long by 115 feet wide. It proving too small to contain all the exhibits, two annexes were built, connected to it by covered passages, these passages containing works of sculpture. Western Europe, Austria, Hungary, Germany, America and Greece were accommodated in the Main Art Gallery; Italy and Northern Europe in the annexes. The arrangements for lighting were very successful and a great credit to the architect.

To the north of the Main Building and lying parallel to it, was the Machinery Hall, a building 2615 feet long and 164 feet wide, consisting of a nave about 92 feet wide and two side aisles of 28 feet width in the clear each, the balance of the total width being taken up by the walls, which were very heavy. The nave was used for machinery in motion and the side aisles for machinery at rest.

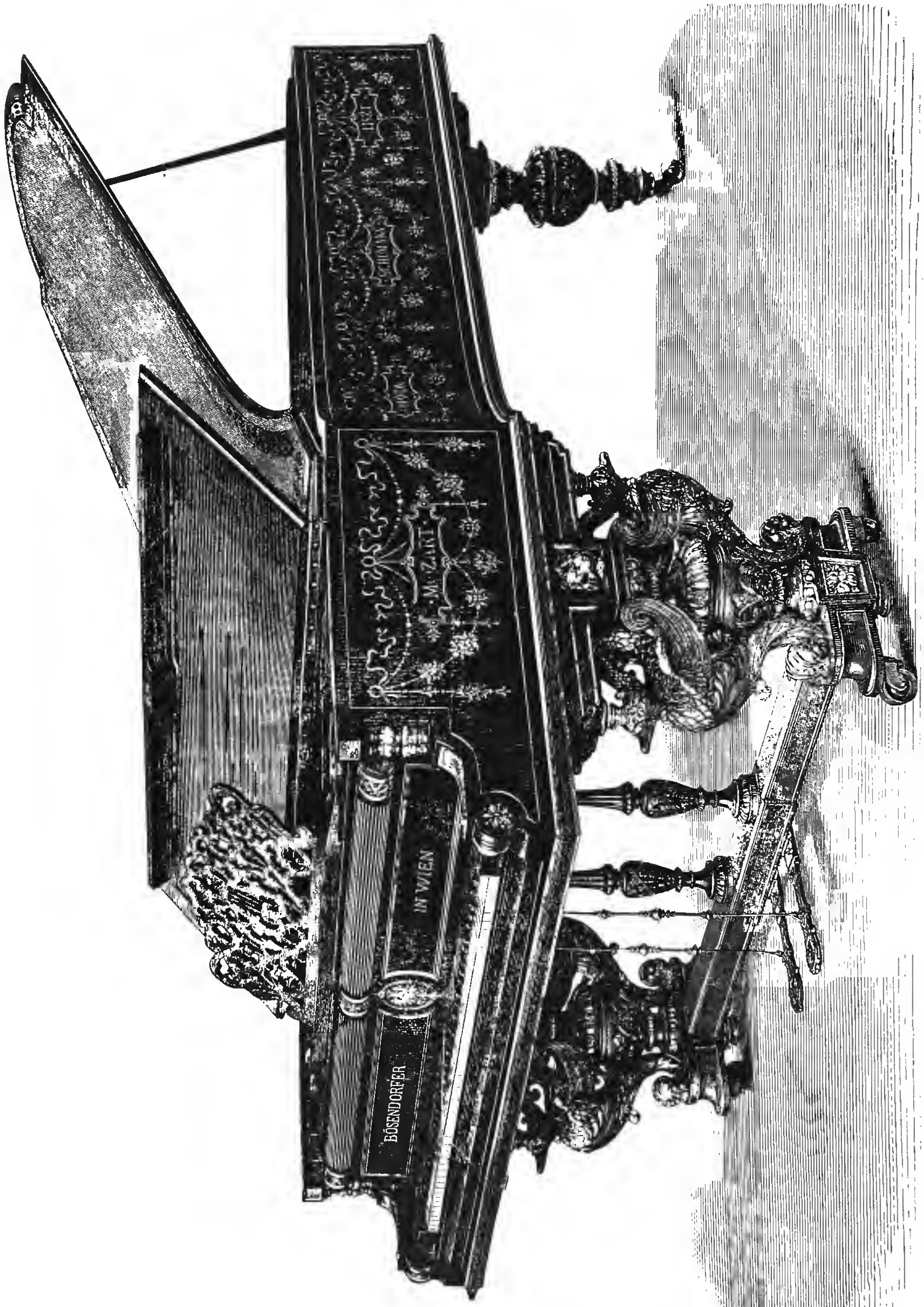
The Agricultural Department was divided into two separate buildings, occupying together

about 426,500 square feet. They were built of timber, upon pile foundations and answered their purposes very well.

Although the exhibition was far from being ready, yet it was opened at the time specified, at twelve, noon, May 1st, with great splendor, notwithstanding an unfavorable state of the weather. At the dawn of day immense crowds of people wended their way to the grounds, every street and alley leading to the Prater being thronged. By nine o'clock an uninterrupted string of carriages blocked the avenues, and many a man who desired to be present, and had spent the whole morning on the road, was obliged—notwithstanding the rain and wind—to leave his carriage and go on foot in order to reach the site in time for the opening. Thousands of people filled the enormous space under the dome, and precisely at the given hour, the coming of the Emperor was announced, and amid hymns from the United Musical Societies of Vienna and the acclamations of the people, he passed into the splendidly adorned entrance, escorted by the Director-General—Baron Swartz-Senborn—and accompanied by the Crown Princess of the German Empire. Following in the train came the Crown Prince of the German Empire and the Empress of Austria, then the Prince of Wales, the Crown Prince of Denmark,

the Duke of Flanders, and numerous other royal personages. The Grand Duke, Carl Ludwig, as Protector, then addressed the Emperor and handed in his report of the undertaking. The Emperor replied, followed by music. The President-Minister and the Mayor of Vienna then addressed the Emperor, thanking him in the name of the people of Austria for the foundation of the Exhibition and the assistance extended by the government to the great work. A chant composed by Joseph Weiler and set to the "Song of Victory," in Handel's *Judas Maccabeus*, was then executed by the United Societies and the Exhibition was declared open.

In making a cursory review of the articles exhibited at Vienna, we may state that the display was the most extensive that had ever previously been made in any part of the world, and



the admirable way in which the exhibition had been carried out gave to it additional interest.

An examination of the departments of all the nations gave evidence of the rapid extension of the knowledge of practical art and science to all parts of the world, equalizing civilization, increasing the energy and creative power of mankind in general, and tending to ameliorate the condition of the human race.

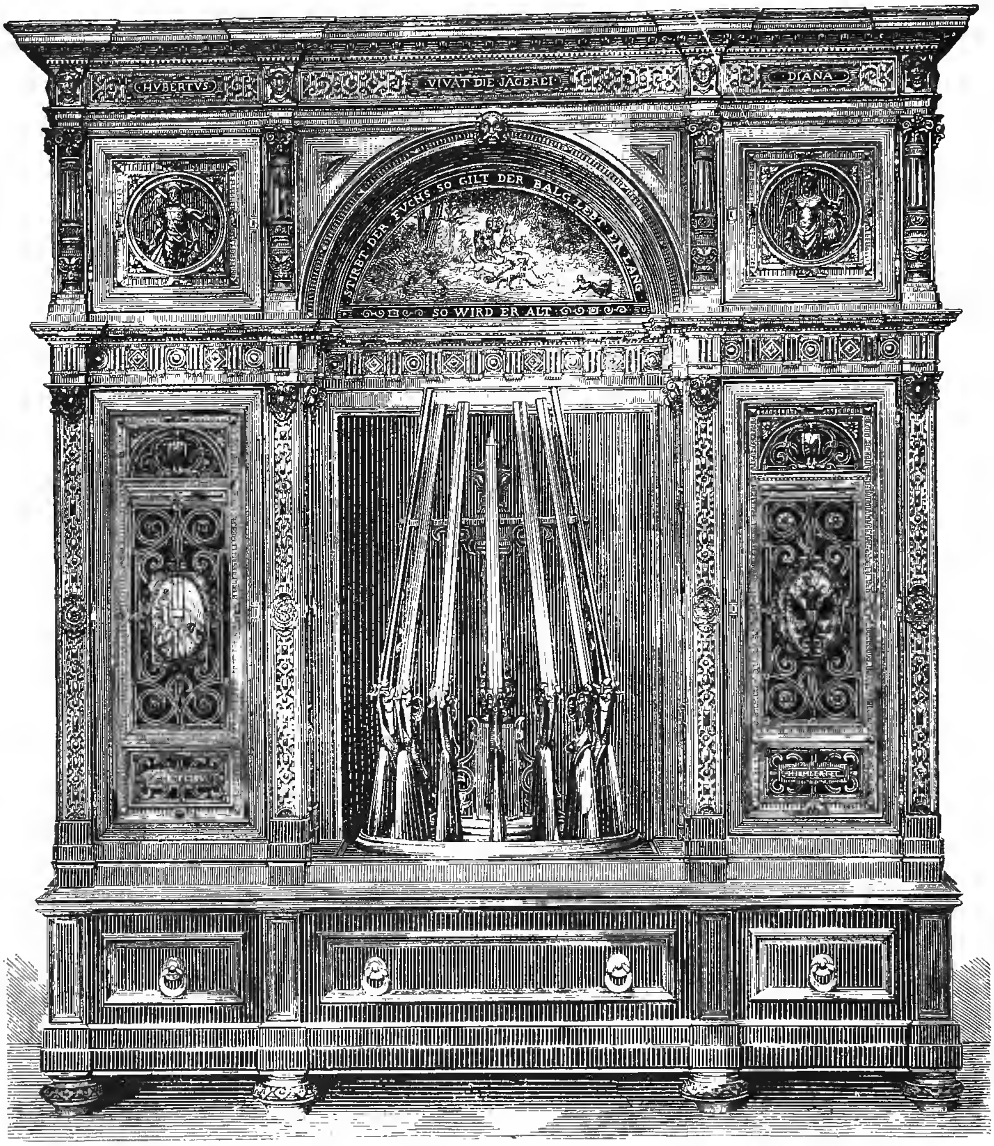
In reference to the machinery exhibits, great improvements had been made since the exhibition of 1867. Germany came out in great force, and the American display, although much smaller than that of many other countries, was full of original ideas and devices. Messrs. Sharp, Stewart & Co., of the Atlas Works, England, and Messrs. William Sellers & Co., of Philadelphia. stood as the typical machine manufacturers of their respective nations, and made

most admirable displays. The American productions, generally, were noted for originality, the novelties being all improvements leading towards precision of work and saving of labor. In drills, America still took the lead, and the Sellers' drill-sharpening machine was a work of especial merit.

France made great displays through Deny and Arbey, of Paris, and the finest pair of marine engines, perhaps, ever produced by any country were those exhibited by Schneider & Co., of Paris. Switzerland exhibited a most remarkable lace-making machine capable of working a hundred needles, and an object of great attraction both to experts and the general public. Probably the finest and most beautiful heavy lathe was that of F. Zimmermann, of Buda-Pesth, in Hungaria.

In those special and peculiar tools required in the manufacture of sewing-machines, revolvers, firearms of every variety and fine instruments of all kinds, two firms, those of Pratt & Whitney, of Hartford, and Brown & Sharpe, of Providence made unexcelled displays.

Messrs. Jones & Laughlin, of Pittsburgh, exhibited specimens of cold-rolled shafting that attracted universal attention. A tub or bucket-making machine, by Baxter D. Whitney, was one of the most interesting American exhibits, manufacturing a bucket complete in the short time of five minutes. In reference to the exhibit of Stationary Engines, one of the most noticeable facts was the great favor which the principle of the American Corliss Engine



seemed to have obtained in Europe, and the numerous imitations and modifications of it displayed.

Never before had there been so fine an exhibit of Agricultural Machinery made as at Vienna, and the display from Great Britain was very superior. The American Department consisted more particularly of reapers and mowers.

In Pottery and Porcelain Ware the display was remarkable, and no branch of art had shown so much improvement and the beneficial effects of international exhibitions as this did.

We illustrate on page lxvii two elaborate specimens of plates by the Messrs. Mintons, whose ceramic display was immense and in the highest style of art. A curious and interesting collection of Moorish pottery was exhibited by Dr. Maximilian Schmidl, Austro-Hungarian Consul in that country, showing the soft, friable pottery manufactured there in every different

style of decoration, from the refined moresque to the bizarre mixtures of green, yellow and blue enamels. Hans Macht, of Vienna, exhibited a beautiful little box in Limousine enamel, of which we engrave a side view on page lxviii. Some beautiful water-jars and mugs were exhibited by F W. Merkelbach, which are shown on page lxix, the designs of which were considered remarkably fine. An enameled vase by Christofle & Co., of Paris, engraved on page lxx,—very graceful in form and beautifully ornamented with birds and flowers, was admired by all who saw it.

In reference to Ornamental Terra-Cotta for building and decorative purposes, the establishment of Herr Paul March, of Charlottenburg-by-Berlin, had no superior. His principal exhibit was a raised garden-alcove seat, the floor laid in encaustic tiles of the most harmonious colors and tasteful designs, the seat and its back in glazed *faïence*, arranged in a semicircle and decorated with fruit and leaves in majolica, and on a low wall, terra-cotta columns of the most exquisite design, upon which was placed a wooden trellis for climbing plants.

Among the most remarkable of the Porcelain specialties from France were the decorative plaques shown by M. Léon Parvillée, a celebrated architect of Paris. The designs were made after the very best period of Moorish art, and M. Parvillée's reputation is so great in this respect that even Turkey itself has made use of his skill. The peculiarity in the enamels he uses is such that they will not run, however highly they are fired, and the result is that the outlines of the designs are preserved in all their beauty, producing almost the effect of cloisonné enamels. Japan made one of the most creditable, interesting and instructive displays of porcelain and pottery exhibited by any nation, and obtained many medals of award.

In the Department of Glassware, no previous exhibition ever made a display equal to this. Situated as Vienna is, with Hungary, Bohemia, Venice and Bavaria in proximity, it was but natural that all should strive to attain great excellence, and anticipation in this matter was not disappointed. France and Great Britain, perhaps owing to their greater distance from the scene of action, did not make the display that might have been expected of them, although what Great Britain did send was good. The exhibits of Mr. James Green and Messrs. Pellatt & Co., of London were unsurpassed. A superb chandelier, by the former, and a large ewer and wash-hand-basin, by the latter,—probably the largest piece of cut flint-glass ever manufactured in England—were among the specimens. Many of the designs exhibited gave evidence of the high position which Japanese art has gained within the last few years in the tastes of the European world; and some of the specimens designed in this style were exceedingly charming and artistic.

M. Constant-Valés, of Paris, exhibited imitation pearls so perfect as to deceive the eye completely, and for which he obtained a progress medal. MM. Regat & Sons, of Paris, also received a medal for their exquisite imitation gems.

In the Italian Section, the Venetian glass of Dr. Salviati was one of the greatest attractions of the Exhibition. By using the works of the old masters as models, studying by every means in his power to equal them, Salviati has, year by year, approached nearer and nearer to perfection.

Nothing approaches the Venetian glass in its creative fancy. Professor Archer, in his official report on Glass to the British Government, says: "The glass-blower of Venice, like a child blowing bubbles, throws them off with ease and rapidity, producing with every touch of his fingers new forms of beauty, which gladden his own eyes as much as the ever-differing rainbow hues of the child's soap-bubble. In everything appertaining to the blown, pinched and moulded glass of the Venetian artist there is an exuberance of fancy, and he conjures up forms always new, and always graceful and beautiful."

The greatest specialty of the Salviati Company was their mosaics, of which they exhibited some magnificent pieces. Tomassi e Gelsomini, of Venice, also displayed some beautiful glass cloths of spun glass and beads, resembling embroideries.

Among the German exhibits of glass, which, as a general thing, were not specially remarkable, we may mention those of H. Wentzel & Son, of Breslau, of which we engrave specimens on page lxxi.

The display of Austrian, Hungarian and Bohemian glass was immense; but the Bohemian glass, although very superior, was not equal to the Venetian, lacking the beautiful transparency of the material, and the artistic forms which may be produced.

We present from the Furniture Department an engraving—shown on page lxxii—of an exceedingly ornate grand-piano in ebony and gilt, after a design by Storcks, executed by Boesendorfer, in Vienna. Some chairs in stamped-leather work by B. Ludwig, of Vienna,—which we engrave on page lxxiii—were among the handsome exhibits. We also give an engraving on page lxxiv of a cabinet or case for hunting apparatus, of excellent design, executed in stained oak by H. Irmler, of Vienna, from drawings by C. Graff.

The display of Carpets was very great and varied. We engrave on page lxxv a design exhibited by Shuetz & Juet, of Wurzen, which shows great taste.

A beautiful flower-vase in gilt-bronze, executed by Hollenbach from a design by Claus, of

Vienna, was among the exhibits, and we are glad to be able to give a picture of it, which is represented on page lxxvi.

We close the very few engravings of the exhibits which our limited space has allowed us

to present, by a representation—seen above—of an Album-cover, in enamel painting, in possession of the Grand Duke Rainer, the design for which was made by J. Storch and F. Laufberger, of Vienna, and fully explains itself.

There were five different medals awarded at Vienna:—

1. Medal for Fine Arts.
2. Medals for Good Taste.
3. Medals for Progress.
4. Medals for Co-operators.
5. Medals for Merit.

These medals were all of the same size and of bronze, bearing on the obverse the portrait of His Majesty, the Emperor, with the inscription, "Franz Joseph I, Kaiser von Oesterreich, Kœnig von Boehmen, etc. Apost. Kœnig von Ungarm;" and on the reverse side artistic emblems, varying with the different medals.

The announcement of awards was made August 18th, with very little ceremony. There were in all two thousand six hundred and two awards, as follows:—

421	Diplomas of Honor
3,024	Medals for Progress.
10,465	Diplomas of Honorable Mention.
8,800	Medals for Merit.
326	Medals for Good Taste.
978	Medals for Fine Arts.
1,988	Medals awarded to Workmen, etc.

The Society of Arts and Manufactures in Vienna also distributed, on the 27th of September, in the beautiful hall of "Gewerbevrein," in the presence of Arch-Duke Charles Louis, Arch-Duke Rainer, several Ministers of State, Baron Schwarz-Senborn and others, a number of silver medals to deserving foremen of all the countries represented at the Exhibition. There were one hundred and thirty-four silver medals, with diplomas, awarded, exercising a most excellent moral effect.

The Exhibition closed on November 2d, the total number of exhibitors being about seven thousand.

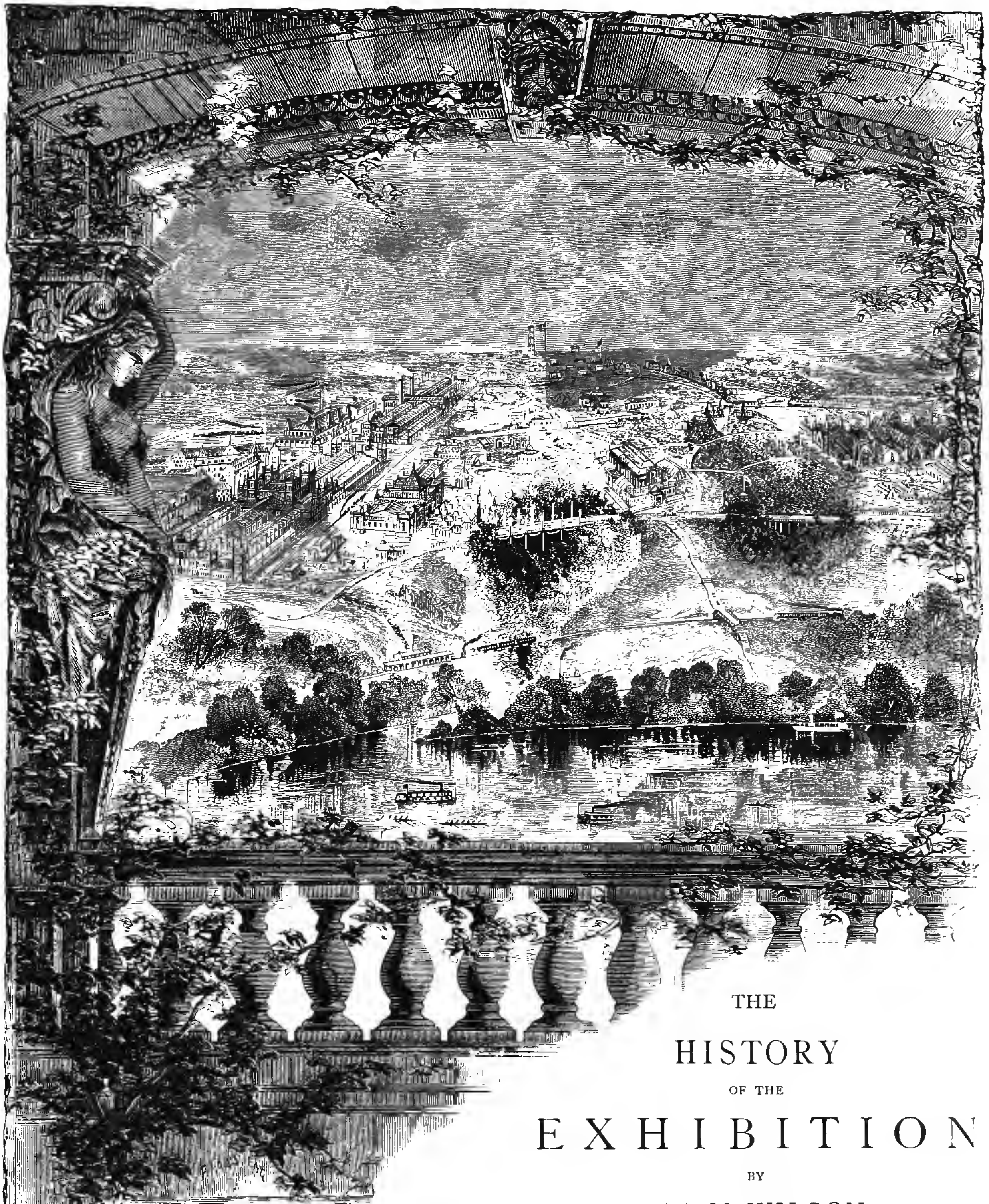
The total cost of buildings and accessories amounted to $7,850,000, and the total receipts for visitors, from the opening until the close, amounted to $1,283,648.78. There were considerable additions to the revenue from other sources—rents for space, concessions for various purposes and the sale of the buildings—but far from enough to cover the total cost and expenses, and a heavy deficit had to be met by the government. The Main Building itself, from its peculiar form and mode of construction, was unnecessarily expensive, and was not a success either in interior or exterior effect.

While the indirect benefits to Vienna and the rest of Austria may have been great, the direct result was a positive loss and a considerable disappointment.

In the United States, local exhibitions had been a common event for many years. The Franklin Institute, of Philadelphia—founded in 1824—early initiated a system of exhibitions for the purpose of promoting the Mechanic Arts, awarding medals and premiums to inventors, manufacturers and mechanics. Its first exhibition was held in Carpenters' Hall, in the autumn of 1824, attracting large crowds of people, and was attended with most fortunate results.

These exhibitions were continued, at intervals, for many years, increasing in public favor and usefulness. The last was held on the fiftieth anniversary of the Institute in 1874, in a building covering an area of two acres available space on the ground-floor, with a large cellar for storage, and a four-story corner building for offices. It was the largest exhibition ever held in Philadelphia, the profits added greatly to the revenues of the Institute, and in every respect it was a complete success.

The American Institute, of New York, has for many years held similar exhibitions with the most satisfactory results; and, of late years, both Cincinnati and Chicago have held annual Expositions of Industrial Art in large, permanent buildings erected for the purpose, resulting in great success, both financially and in regard to the advantages derived from them by the exhibitors.



THE

HISTORY

OF THE

EXHIBITION

BY

JOS. M. WILSON.

THE INTERNATIONAL EXHIBITION, 1876.

RATHER more than two hundred and fifty years ago, a veteran navigator from the old world, in voyaging along the coasts of the then newly-discovered Western Hemisphere, drifted into a magnificent and hitherto unknown inlet, the exit of a noble river. The navigator was Henry Hudson—the inlet was Delaware Bay.

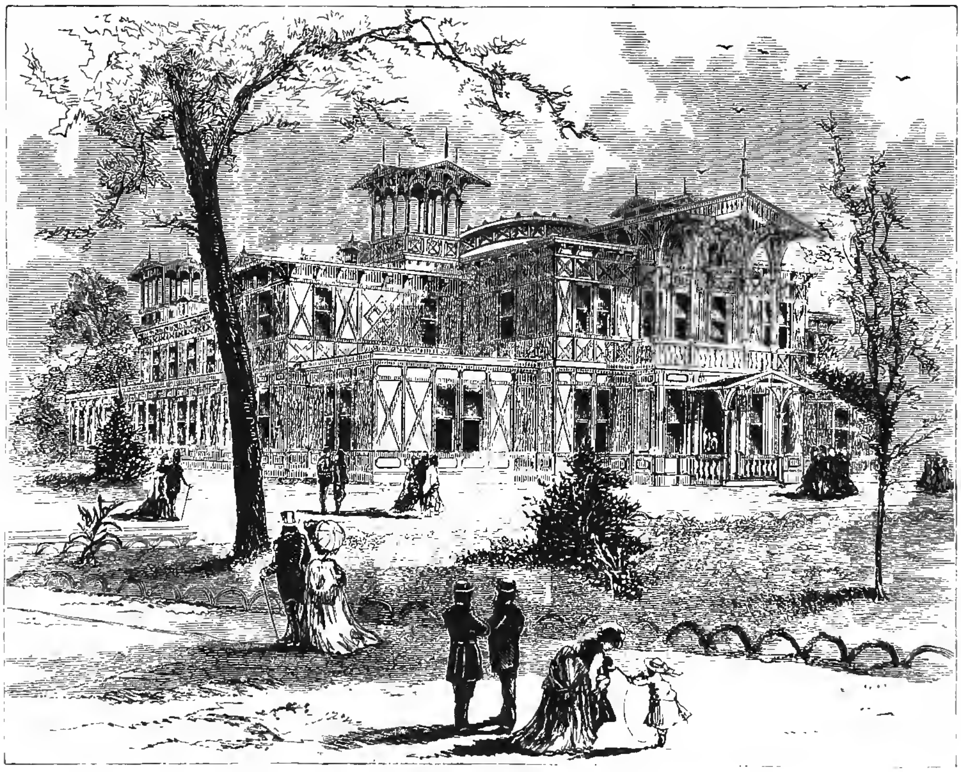
A few years later, the Dutch Government—at that time the great commercial nation of the age—perceiving the great advantages that might accrue by the ownership of this location, acquired the right to it by purchase, and incorporated a company for trading purposes, taking possession of the ground and erecting a stockade called Fort Nassau, at a place now known as Gloucester, on the east shore of the river, some three miles below the site of the present city of Philadelphia.

The banks of the river and bay were rapidly colonized, principally by Swedes and Dutch, each party claiming for its own government the land upon which it settled, and contentions continually took place between the two nationalities, until, finally, the whole west bank of the river passed under the control of the Dutch, who held possession of it until 1664, when it came under the jurisdiction of the English government, on articles of capitulation to Sir Robert Carr for his Royal Highness, the Duke of York, afterwards King James the Second. In 1672, by the fortunes of war, it again fell into possession of the Dutch, but only for a few months, when, by the terms of a treaty of peace between England and the States General, the country came back once more under British rule.

In the early part of the seventeenth century, a religious sect had arisen in England under the guidance of one George Fox, whose adherents were remarkable for their simplicity of manner and dress, great mildness and forbearance, fine moral nature, mutual charity, the love of God, and a deep attention to the inward motions and secret operations of the spirit. They were characterized by great disposition to peace and opposition to violence and warfare, and were in every way a veritable "Society of Friends." Suffering persecution in their own country, they desired rest and happiness on a foreign shore.

In the year 1680, a distinguished member of this fraternity, William Penn, whose father had been an admiral in the British Navy, petitioned King Charles the Second, in consideration of large public debts due his father by the Crown, to grant him from his possessions in the New World that tract of land now known as Pennsylvania, and bounded on the east by the Delaware River, including, therefore, the possessions of the Duke of York on the west shore, and already settled by Swedes and Dutch. Here he hoped to establish a settlement where the members of his society could obtain that peace which they were unable to procure at home.

The King granted the desired letters-patent in 1681, and the considerations under which

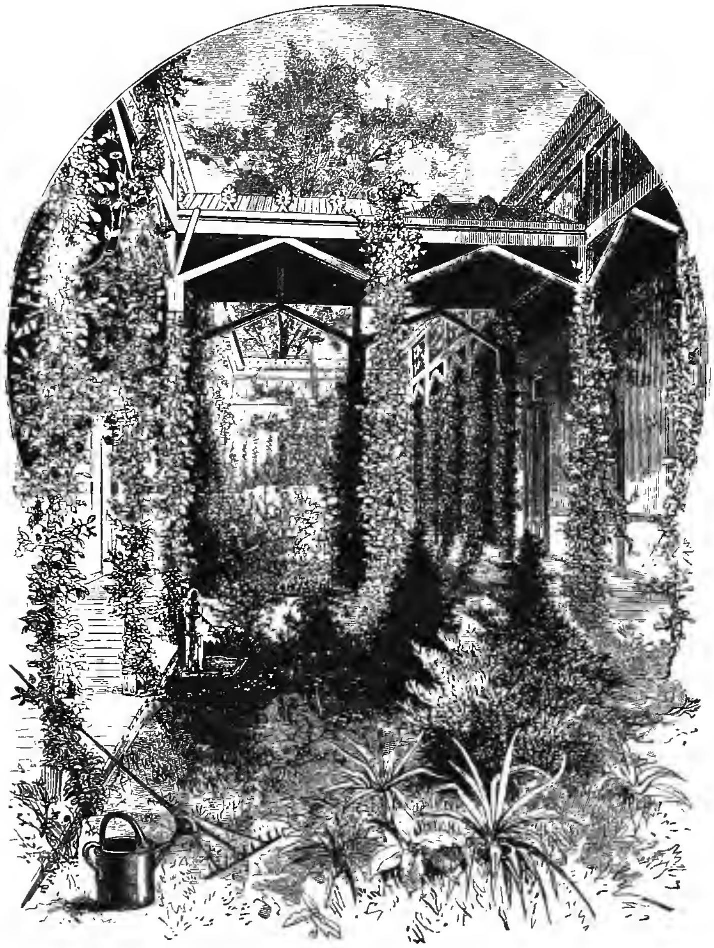


Jury Pavilion.

the grant was given were "the commendable desire of William Penn to enlarge the British Empire and promote useful commodities; to reduce the savage natives by just and gentle manners to the love of civil society and Christian religion," together with "a regard to the memory and merits of his late father."

Penn—having obtained a release from the Duke of York of his previous claim upon the province—immediately despatched a small number of emigrants to take possession of the country, and the following year sailed himself, landing at New Castle, in Delaware, on the 24th of October, 1682. The original settlers—of which there were quite a number at various points along the coast, the Swedes predominating—received him with every manifestation of welcome, "judging that all conflicting pretensions to the soil would now cease," promising to "love, serve and obey him," and adding "that it was the best day they had ever seen." On the 4th of December he called an assembly at Upland (now Chester), and passed all the laws which had been agreed upon previously, and also others, the law concerning "Liberty of Conscience" being placed at the head of the list.

Philadelphia, the city of "Brotherly Love," was immediately laid out, and as the site selected was already in possession of the Swedes, an exchange was proposed and accepted



Court of Finance Building.

by them for other land in the vicinity. The plan, covering a space of twelve and a-half square miles, was afterwards considered on entirely too extensive a scale, and it underwent considerable modifications in 1701, reducing the area to two square miles and limiting the boundaries to the Delaware on the east, the Schuykill on the west, Vine Street on the north, and Cedar (now South) Street on the south. Beyond Cedar Street were the Swedish settlements, and some of their old landmarks remain to the present day, notably the old Swedes' Church, consecrated on the 2d day of July, 1700.

Time has proved that Penn was wiser than those who came after him, since, in less than two hundred years, the city has stretched out far beyond the limits imposed upon it in 1701, and now the thickly-inhabited portion alone occupies more than four times the space originally determined upon for its area by Penn.

The city grew and prospered under its friendly and liberal rule, and although it received accessions to its inhabitants from all countries and of all sects, yet the Quaker influence predominated, and gave that solid, steady tone to society and aversion to mere outward display for which Philadelphia was so famous, traces of which may be found to the present day. When the troubles arose with the mother-country—nearly a century after its foundation—the city took an active part in colonial affairs. It had at this time increased to a population of 28,000, contained nearly 5,500 dwellings, had an extensive commerce, and ranked as first among the cities of the Colonies. The first Continental Congress assembled here in 1774, holding its meetings in Carpenters' Hall, a building situated south of Chestnut Street, between Third and Fourth,—still standing and kept in excellent preservation by the Carpenters' Company, to whom it belongs.

During the Revolution, Congress continued to hold its meetings in Philadelphia with but few exceptions, and the Declaration of Independence was adopted here July 4th, 1776, and first read publicly from a stand in the State-House yard by John Nixon, July 8th, following. The old Independence Bell, cracked and out of use, is still preserved in the hall of the State-House, as a memento of the times when it "proclaimed liberty throughout the land, and to all the inhabitants thereof." In this place the present Constitution of the United States was adopted by the Convention which met for the purpose in May, 1787; the first President of the United States resided here; and on this spot Congress assembled for some ten years after the adoption of the Constitution, until the removal of the seat of government to Washington.

When, therefore, the Centennial Anniversary of this great Republic approached, and the success of its form of government had become no longer an experiment, even in the eyes of the old monarchies of Europe, but an established fact, it seemed expedient that some effort should be made to properly celebrate this great event,—this birthday of freedom. A hundred years ago this young nation had struggled for existence; now she has established her position as one of the great powers of the world. What more fitting, then, than that she should commemorate this centennial of her life by an International Exhibition of Arts, Manufactures and Products of the Soil and Mine.

Inviting all the other principalities of the globe to unite with her in a competitive display, she could show for herself the greatest progress that had ever been made in the world's history in the same length of time,—an advancement without a parallel, fully entitling her to a foremost position among the nations of the earth. And what locality more eminently suitable for this celebration than Philadelphia? the birth-place of the nation, and the hallowed site of so many passages in her early history.

As the anniversary approached, the project was discussed in an informal way by many, and it only needed a move to start it into action. This initiatory move was taken by the Franklin Institute, the subject having been first brought forward at a regular meeting of the Board of Managers, held August 11th, 1869, and the discussion which followed led to the appointment of a special committee for the purpose of considering the question, and the advisability of memorializing Congress in regard to such an exhibition, to be held in Philadelphia in 1876 under the auspices of the Institute. At the next regular meeting of the Board, the month following, this committee reported, and stated that it did not consider it expedient for the Franklin Institute to place itself in the prominent position of patron to this enterprise, although at the same time it was of opinion that the Institute should use its utmost efforts to secure the proposed National Exhibition in the city of Philadelphia, and the committee also stated that "if such a celebration were combined with an exhibition of those arts and manufactures for which this country is so justly celebrated, and to which she owes so much of her material prosperity and greatness, there would be an additional reason for adopting this site, as no other city possessed such advantages as are afforded by the vast industrial works of Philadelphia." The action taken by the Board resulted in the appointment of a new committee to take the subject in charge, and this committee was instructed, on December 8th, to prepare a letter to the Select and Common Councils of the city of Philadelphia, explaining the action of the Institute and the reasons therefor, and requesting Councils to memorialize Congress on the subject. This letter, which was duly presented to each chamber of Councils through the mayor of the city, so clearly enunciated, even at this early date of the enterprise, the objects which are now being carried out, that we consider it worthy of reproduction in full, as follows:—

"The Franklin Institute of the State of Pennsylvania (the first founded of institutions of its kind in this country), being mindful of what may conduce to the credit and prosperity of the city of its location, has resolved through its Board of Managers that it will be expedient to celebrate the Centennial Anniversary of our national existence by an International Exhibition of Arts, Manufactures and Products of Soil and Mines, to be held upon grounds which, it is hoped, may be obtained within Fairmount Park for this purpose.

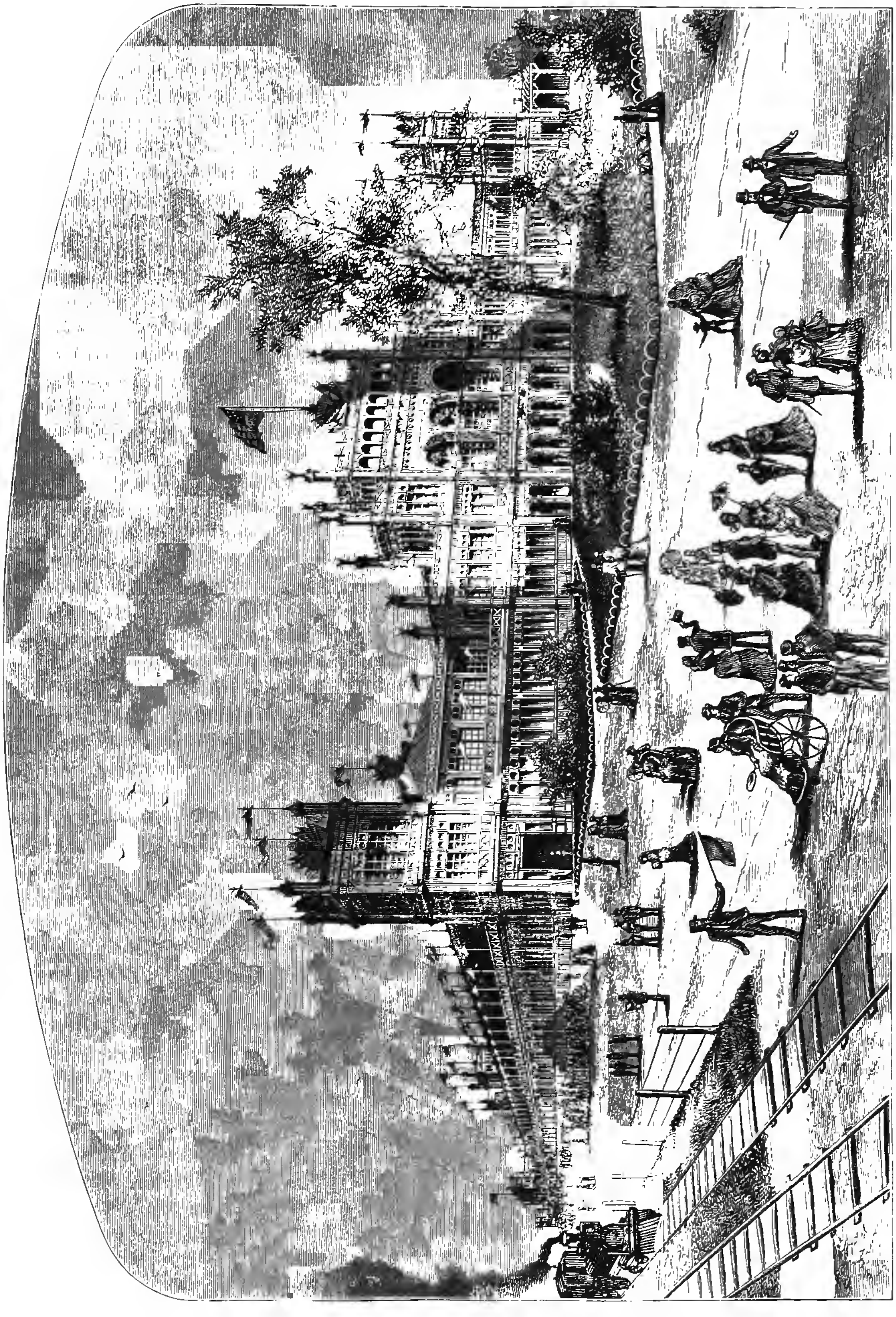
"It would seem eminently proper that such an Exhibition should be the form of celebration selected, and that this city should be the spot chosen by the nation for a national celebration at that time. There, was written and given to the world that Declaration which called our nation into existence; there, the laws which guided its infancy first took place; there, it began its march to benefit the human race. Under the laws there established, and in the nation there created, all arts and sciences have progressed in an unparalleled degree, and it is believed that the form of celebration indicated would be emblematic of their progress. The historical relations alone of our city should entitle it to selection for such a celebration; but apart from its claim as the birthplace of our Government, its geographical position, its railroads and navigation facilities, and its abundant means of accommodation for large numbers of strangers, all add to its claim and fitness to be selected for such a purpose.

"In consequence of these conditions the subscribers have been appointed a committee to bring the subject to your notice, and to request that your honorable bodies will memorialize Congress upon the subject for the purpose of obtaining that aid which will make such an Exhibition truly international in its character.

(Signed), WILLIAM SELLERS,
FREDERICK FRALEY,
ENOCH LEWIS,
COLEMAN SELLERS,
B. H. MOORE."

Entrance, Main Building.

The communication was received with favor by Councils and warmly supported, a committee of nine being appointed from each chamber to take charge of the matter, and to arrange for laying it before Congress. The question was also brought up before the State Legislature at Harrisburg, and similar action was taken, a committee being delegated from each House to act in conjunction with the committee of City Councils. These committees and also a special committee from the Franklin Institute, acting jointly, visited Washington and had an interview with the House Committee of Congress on Manufactures, presenting a memorial prepared for the occasion, which was favorably received, and



View of the Main Building from the Jury Pavilion.

a draft of an Act prepared and presented to Congress through the committee, resulting in the passage of the following Act of Congress, approved March 3d, 1871:—

"An Act to provide for celebrating the One Hundredth Anniversary of American Independence by holding an International Exhibition of Arts, Manufactures and Products of the Soil and Mine, in the City of Philadelphia and State of Pennsylvania, in the year eighteen hundred and seventy-six.

"Whereas, the Declaration of Independence of the United States of America was prepared, signed and promulgated in the year seventeen hundred and seventy-six in the city of Philadelphia; and whereas, it behooves the people of the United States to celebrate, by appropriate ceremonies, the Centennial Anniversary of this memorable and decisive event, which constituted the fourth day of July, Anno Domini seventeen hundred and seventy-six, the birthday of the nation; and whereas, it is deemed fitting that the completion of the first century of our national existence shall be commemorated by an exhibition of the national resources of the country and their development, and of its progress in those arts which benefit mankind in comparison with those of older nations; and whereas, no place is so appropriate for such an exhibition as the city in which occurred the event it is designed to commemorate; and whereas, as the exhibition should be a national celebration, in which the people of the whole country should participate, it should have the sanction of the Congress of the United States; therefore—

"SECTION 1. Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That an exhibition of American and foreign arts, products and manufactures shall be held under the auspices of the Government of the United States, in the city of Philadelphia, in the year eighteen hundred and seventy-six.

"SECTION 2. That a Commission, to consist of not more than one delegate from each State, and from each territory of the United States, whose functions shall continue until the close of the Exhibition, shall be constituted, whose duty it shall be to prepare and superintend the execution of a plan for holding the Exhibition; and, after conference with the authorities of the city of Philadelphia, to fix upon a suitable site within the corporate limits of the said city, where the Exhibition shall be held.

"SECTION 3. That the said Commissioners shall be appointed within one year from the passage of this Act by the President of the United States, on the nomination of the governors of the States and territories respectively.

"SECTION 4. That in the same manner there shall be appointed one Commissioner from each State and territory of the United States, who shall assume the place and perform the duties of such Commissioner and Commissioners as may be unable to attend the meetings of the Commission.

"SECTION 5. That the Commission shall hold its meetings in the city of Philadelphia, and that a majority of its members shall have full power to make all needful rules for its government.

"SECTION 6. That the Commission shall report to Congress, at the first session after its appointment, a suitable date for opening and for closing the Exhibition, a schedule of appropriate ceremonies for opening or dedicating the same, a plan or plans of the buildings, a complete plan for the reception and classification of articles intended for exhibition, the requisite custom-house regulations for the introduction into this country of the articles from foreign countries intended for exhibition, and such other matters as in their judgment may be important.

"SECTION 7. That no compensation for services shall be paid to the Commissioners or other officers provided by this Act, from the treasury of the United States; and the United States shall not be liable for any expenses attending such Exhibition, or by reason of the same.

"SECTION 8. That whenever the President shall be informed by the Governor of the State of Pennsylvania that provision has been made for the erection of suitable buildings for the purpose, and for the exclusive control by the Commission herein provided for, of the proposed Exhibition, the President shall, through the Department of State, make proclamation of the same, setting forth the time at which the Exhibition will open, and the place at which it will be held; and he shall communicate to the diplomatic representatives of all nations copies of the same, together with such regulations as may be adopted by the Commissioners, for publication in their respective countries."

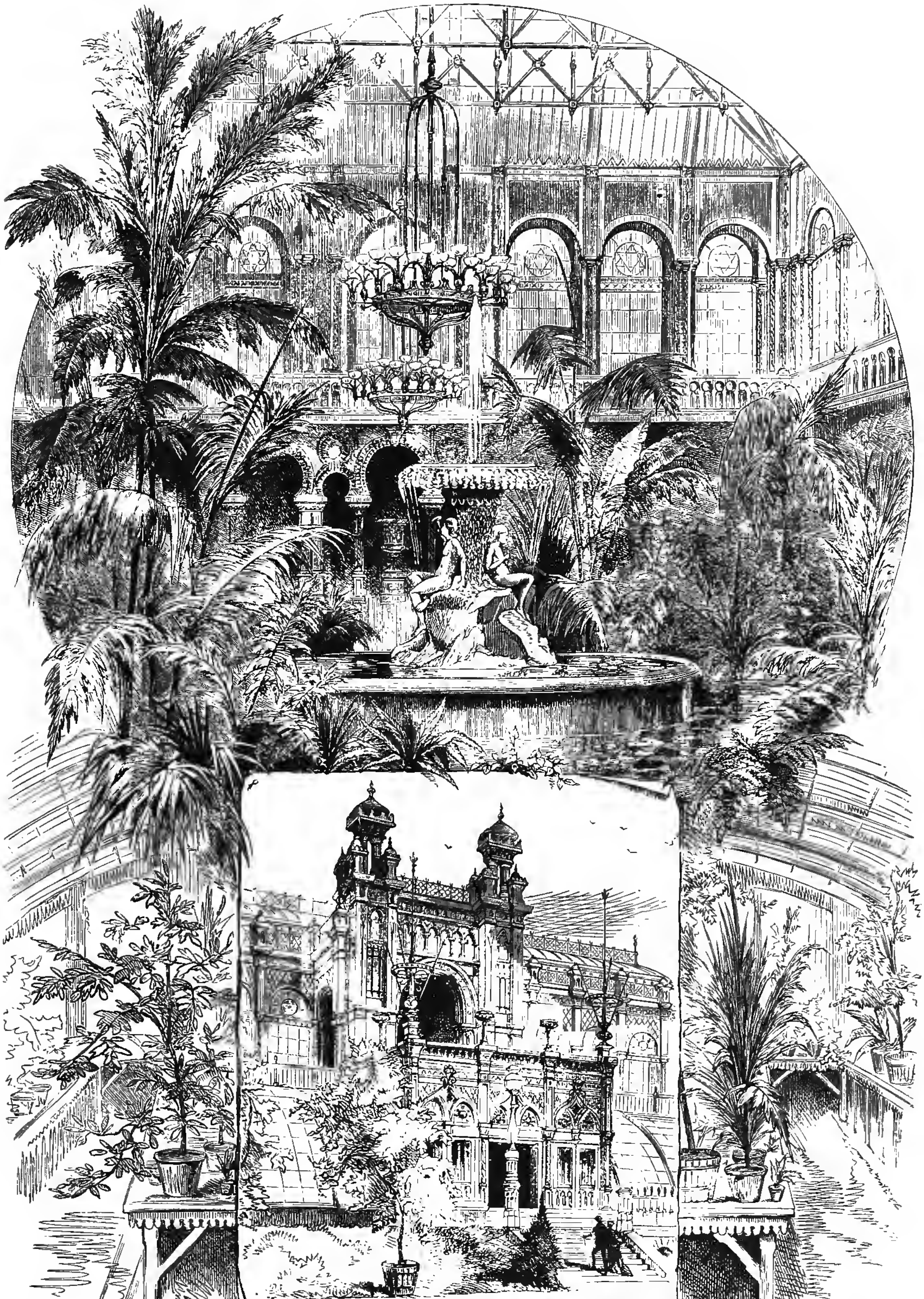
The enterprise had now been placed upon a foundation, and the first really progressive step had been made in the work. The various Commissioners were in due time appointed, but no provision had been made to call them together until the city of Philadelphia, in October, 1871, issued an invitation for them to meet in March, 1872, and made an appropriation to cover their expenses. This invitation was accepted, and the first meeting of the Commission was held March 4th, 1872, at the Continental Hotel in Philadelphia. It continued in session until March 11th, a thorough organization being effected, the Hon. Joseph R. Hawley, of Connecticut, elected President, and the necessary special committees appointed and assigned their respective duties. The location for the proposed Exhibition was also fixed at Fairmount Park, and a Committee on Plans and Architecture instructed to report at the next session, and furnish sketches of plans for a building adapted to a double classification, similar to that of Paris, 1867, and to cover fifty acres of floor-space, estimates of cost to be furnished at the same time.

The second session commenced on May 22d following, and continued until May 29th. It was discovered that very little material progress could be made without pecuniary means, and that the first requisite was to take some measures for obtaining the funds required. This, as the special work of the Executive Committee, the Hon. D. J. Morrell being chairman, received most attentive consideration, and on the recommendation of this committee it was decided not to ask for National or State aid, but to rely upon the people, trusting that their patriotism, ability and will could be depended upon, under a proper and systematic business organization, to provide the money needed for the enterprise, and also to furnish that general support and coöperation so essential to secure nationality and success to the Centennial celebration.

To this end "It was concluded to apply to Congress for the charter of a corporation to be called the 'Centennial Board of Finance,' which should have power, under the direction of the Centennial Commission, to raise money upon the sale of stock, and to attend

Horticultural Hall.

to all duties necessary to bring the work of the Exhibition to a successful issue." The Act creating this corporation passed Congress and was approved June 1st, 1872. Its distinct purpose was declared to be that of raising funds for the preparation and conduct



H. Bisbing, Del. J. Dalziel, Eng.

Horticultural Hall.

of the Exhibition, and it was empowered to secure subscriptions of capital stock not exceeding ten millions of dollars, to be divided into shares of ten dollars each, the proceeds from the sale of this stock and from all other sources to be used for the erection of suitable buildings and fixtures, and for all other expenses required to carry out the Exhibition as designed. The Centennial Board of Finance to prepare the grounds and erect the buildings, all plans, however, to be previously adopted by the Centennial Commission, and the Commission also to fix and establish all rules or regulations governing rates for "entrance" and "admission" fees, or otherwise affecting the rights, privileges or interests of the exhibitors or the public. No grant conferring rights or privileges of any description connected with the grounds or buildings, or relating to the Exhibition, to be made without the consent of the Commission, which would have the power to control, change or revoke all such grants, and appoint all judges and examiners, and award all premiums. It was also provided that the Centennial Board of Finance should, as soon as practicable after the close of the Exhibition, convert its property into cash, and, after the payment of all liabilities, divide its remaining assets among the stockholders pro-rata, in full satisfaction and discharge of its capital stock.

At the close of the third session of the Commission, which took place in December, 1872, very little real progress had been made in the organization of the Centennial Board of Finance. The Executive Committee had been occupied in this work, and in publishing and issuing circulars and addresses to the people, informing them what had been done, and calling their attention to the mode of making stock subscriptions. A design for a seal was at this time adopted by the Commission, it being circular in shape, about two inches in diameter, with the official title, "The United States Centennial Commission," between inner and outer concentric circles, and in the centre a vignette view of Independence Hall as it appeared in 1776, and beneath the vignette the prophetic sentence, "Proclaim liberty throughout the land unto all the inhabitants thereof," which was cast on the State-house bell that rang out the first announcement of the adoption of the Declaration of Independence.

Nothing had been accomplished by the Committee on Plans and Architecture, as no funds were at its disposal, and nothing could be done without them. The Committee received instructions, however, to advertise for plans whenever the necessary funds could be obtained, expending a sum as they deemed best, not exceeding twenty thousand dollars.

To cover the incidental expenses of the Commission, Philadelphia appropriated the sum of fifty thousand dollars, and permanent offices were secured and books opened for subscriptions to stock in accordance with the provisions of the Act creating the Centennial Board of Finance. At the end of the year 1872, the prospects of the Exhibition looked very discouraging, many of those best qualified to give an opinion declaring its success exceedingly problematical, and some going so far as to say it was impossible. Fortunately, however, the Commission possessed an Executive Committee of great ability and tenacity of purpose, who were determined to give the matter a vigorous trial.

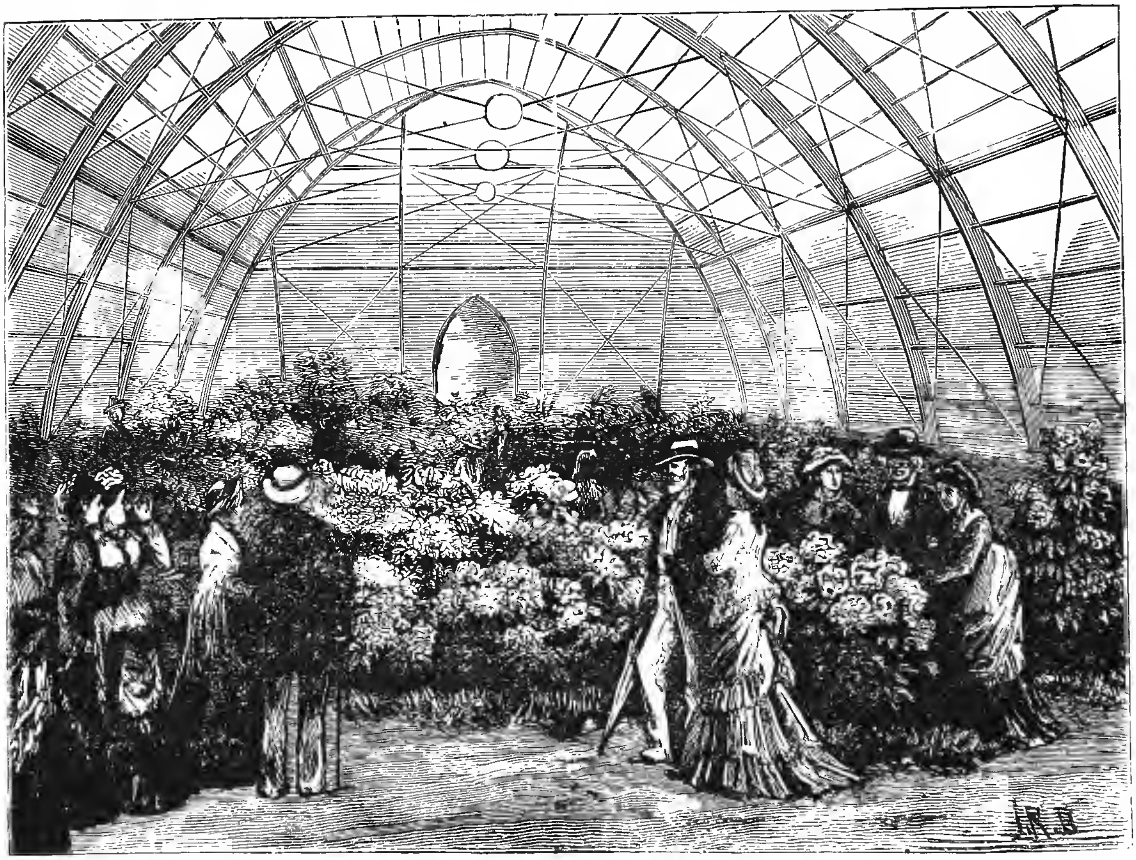
The Citizens' Centennial Finance Committee, which had been previously organized, and through whom had been obtained the above-mentioned appropriation of fifty thousand dollars from the city of Philadelphia, was given charge of the work, and under this Committee were placed sub-committees of the citizens of every trade, occupation, profession, and interest in Philadelphia, whose object was to obtain subscriptions to the Centennial stock. Every means was used to awaken the interest of the city, and through it, that of the country at large, and within sixty days all doubts were dispelled and success assured. The city of Philadelphia promptly subscribed one-half million of dollars, and the State of Pennsylvania one million, conditioned upon the subscription of the city, the whole to be appropriated for the erection of a permanent building in Fairmount Park, to remain perpetually as the property of the people of the State for their improvement and enjoyment, a depository of articles valuable either on account of association with important national events, or as illustrating the progress of civilization and the arts in this new country, and a worthy memorial of an event of which any nation might be proud.

On the 22d of February, 1873, an imposing mass-meeting was held with the most beneficial results, and before the time of the fourth session of the Commission in May, more than three millions of dollars had been subscribed, including the State and city donations; public interest had been aroused everywhere; information had been scattered by the press in all directions, and inquiries as to what was proposed to be done came pouring in from all quarters, and even from foreign countries. The question was taken up by the various States, a number of them strongly commending the project, promising their hearty coöperation, and issuing instructions to their members of Congress to support all measures requisite for making the Exhibition a success worthy of the nation and of the great men and events it was intended to commemorate.

It seemed especially desirable that full information should be obtained by the Commission in reference to the organization and working of the Vienna Exhibition then in progress, and the Executive Committee for this purpose sent abroad early in March one of their own members, Prof. W. P. Blake, a gentleman who had been principally in charge of the work of classification, and who was thoroughly conversant personally with all details of the Paris Exhibition of 1867. It was important also in connection with this that complete plans should be obtained of the buildings of the Vienna Exposition, and thorough data as to their mode of construction, adaptability to their purposes, &c., and that similar information should be procured concerning all previous great exhibitions. For this object Mr. Henry Pettit, an accomplished civil engineer, highly recommended, was appointed and sent abroad about the same time as a special agent. It may be mentioned in this connection that Mr. Pettit generously gave his services gratuitously to the Commission, with an allowance of only actual expenses.

In the winter of 1873 one of the most effective helps that the cause ever had was organized under the auspices of the Citizens' Centennial Finance Committee, in the shape of the "Women's Centennial Committee of Pennsylvania." Thirteen patriotic women, residents of Philadelphia, were appointed an executive committee and officially recognized on February 24th. Mrs. E. D. Gillespie, a lady of wonderful talent and administrative ability, a descendant of Franklin, was elected president, and continued to occupy that position, throughout the entire time of its organization, with marked skill and surprising success—the great work accomplished by Mrs. Gillespie and her zealous aids being one of the most prominent features in the history of the Centennial.

The organization of the Centennial Board of Finance was fully completed in April, 1873, a board of twenty-five directors being elected by the stockholders—John Welsh appointed president; William Sellers, first vice-president; and Thomas Cochran, temporary secretary; and the Exhibition work was fairly started upon a sound business footing, with a considerable capital already subscribed, a corps of officers of remarkable efficiency and ability and the highest standing, and every prospect of success. Mr. Frederick Fraley, of Philadelphia, a gentleman distinguished for his abilities and integrity, was afterwards regularly appointed secretary and treasurer, and continued to hold that position permanently.

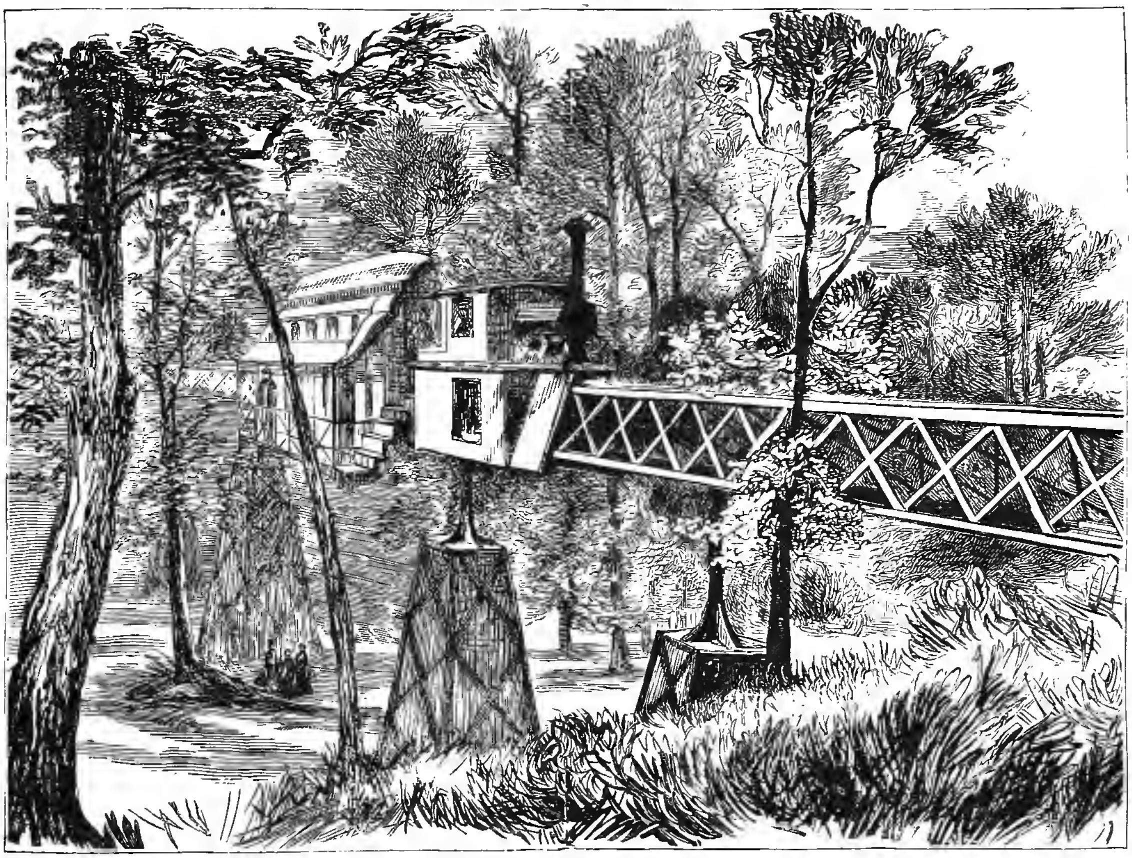


Exhibition of English Rhododendrons.

Funds being now provided, invitations were issued on the first day of April of this year for preliminary designs for the Main Exhibition Building and Art Gallery. In order to induce any one who had an idea on the subject to bring it forward, so that the Commission could, if it wished, avail itself of every suggestion that might be offered, whether by a professional man or not, this invitation was made as broad as possible, and architects and others were requested to submit sketches and plans under an unlimited public competition. A detailed specification of what was desired was issued to competing parties, and it was requested that the designs be handed in before noon on the 15th day of July following.

It was during the fourth session of the Commission in May that the position of director-general was created, the Hon. Alfred T. Goshorn of Ohio being chosen at the annual election to fill the place.

The eventful public ceremony of this year was the formal transfer by the Park Commission, on the 4th of July, of the grounds which had been selected for the use of the Exhibition, at Fairmount Park, to the Centennial Commission. The ceremonial was performed in the presence of the various official dignities of the Government, the State



The Elevated Railway across the Ravine.

and the city, the members of the Centennial and Park Commissions, and numerous invited guests. After assembling at Independence Hall, and being formally presented to the mayor of the city, they were driven out to the Park, where a handsomely decorated stand had been erected on the site intended for Memorial Hall, and in front of which was a flagstaff, with a flag furled at the top and ready to be thrown to the breeze at the proper moment. Beyond lay the Lansdowne plateau, scattered over with crowds of people and troops.

After the ceremony had been opened with prayer by Bishop Simpson, the Hon. Morton McMichael, President of the Park Commission, delivered an eloquent address and made a formal transfer of the grounds to the United States Centennial Commission. President Hawley in accepting the transfer, replied by an able speech, closing as follows: "In token that the United States Centennial Commission now takes possession of these grounds for the purpose we have described, let the flag be unfurled and duly saluted." As the last words fell from the speaker's lips, the flag of the nation was thrown to the breeze and saluted by thirteen guns. Announcement was then made by Governor Hartranft, of the State of Pennsylvania, to the effect that in accordance with the conditions of the Act of Congress in relation to the Centennial Celebration, as sufficient provision had been made for the erection of suitable buildings for the purpose of the International Exhibition, he felt it his duty to certify the same to the President of the United States, and had forwarded him a certificate to that effect duly signed. The Hon. George M. Robeson, Secretary of the Navy, and delegated representative of the President of the United States, who was absent on account of the death of his father, then presented, in the President's name, a "Proclamation," announcing the holding of an International Exhibition in the city of Philadelphia in 1876, and commending the same to the people of the United States and to all nations who might be pleased to take part therein. The ceremonies were concluded by Secretary Robeson, who stated that "in making this proclamation the President desired to express his deep personal interest in the objects of the great enterprise, his sympathy with the patriotic endeavors being made, and his appreciation of the fitness of the place and the occasion designated, his earnest desire that 'all nations' would take part in this triumph of human industry and skill, on the great memorial occasion of a people whose energies are drawn from every land, and his hope and confidence that in its spirit and its success the 'Exhibition and Celebration' would remain a lasting illustration of peace and civilization, of domestic and international friendship and intercourse, and of the vitality of those great principles which lie at the foundation of human progress, and upon which depend our national strength, development and safety." The proclamation and a copy of the general regulations of the Commission were forwarded officially to each foreign Government and also to each minister of the United States accredited to a foreign Government.

In response to the invitation issued for plans, it was announced on July 16th that forty-three plans had been submitted. Of these, ten were selected as admitted to a second competition and worthy of the award of $1000 to each. The names of the successful competitors were made known on August 8th, and the conditions, requirements and awards of the second competition on August 11th, not differing materially from those of the first competition, which were still in force.

The second competition designs were put in on September 30th, and the awards upon them were decided about the end of October, as follows:—

Collins and Autenrieth,	1st award,	$4000
Samuel Sloan,	2d award,	$3000
John McArthur, Jr., & Joseph M. Wilson,	3d award,	$2000
H. A. & J. P. Sims,	4th award,	$1000

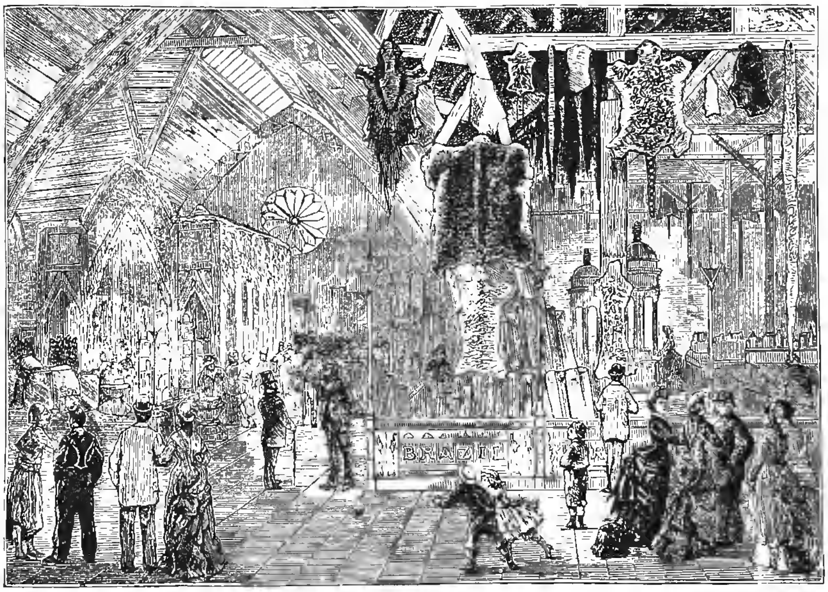
The Committee reported that all of these designs showed great care, skill and labor on the part of the several engineers and architects in carrying out the requirements of the specifications, each possessing so many points of excellence that the Committee was very much embarrassed in its efforts to arrive at a practical conclusion in the matter. It stated that many additional points of great importance had presented themselves in regard to the buildings, after the issue of the specifications for the second competition, which would necessitate more or less modification in any design adopted. In making the awards, however, the relative merits of the different designs were decided upon, solely with regard to their meeting the requirements stated in the specifications. This action was, of course, the only just one to the competing parties, but resulted in giving the awards to some designs which were radically different from what the Committee at the time of the award deemed it advisable to erect. No one of the designs, "in its judgment, could be considered as representing in an entirely satisfactory manner what was required for the Centennial buildings;" and the Committee, in examining the designs and considering the subject in all its bearings and requirements, came to the following conclusions: That it was not feasible to erect an Art Building and Memorial Hall as two distinct structures, but that the Memorial Hall should be built separate from the Main Exhibition Building, and used during the Exhibition for the purposes of an Art Gallery, a building covering one and a half acres of ground being ample for the requirements (the original specification required five acres of space in the Memorial Hall); that the Main Exhibition Building should be a temporary construction, covering at least thirty acres of ground, and capable of extension if required, rectangular in plan and without galleries, the interior arrangement to allow of vistas and attractive promenades, and in the construction the reduplication of parts to be an essential feature, iron and brick being largely used to secure against risk of fire, and the material to be worked up in such details of construction that it could be sold for fair prices after the Exhibition closed; vertical side-light to have preference to overhead-light; domes, towers and central massive features to be ignored as too ambitious and expensive, and the building to trust for its impressiveness to its great size and proper treatment of its elevations, and to its interior vistas and arrangements, and not to any central feature erected at great expense for only a few months. They also decided that there should be a separate building for a Machinery Hall, covering ten acres; one for the Agricultural Hall, covering five acres; and a Conservatory.

The Committee had a modified plan prepared for the Main Exhibition Building and presented for adoption, being an adaptation of a plan submitted by Messrs. Calvert Vaux and George Kent Radford, of New York, for the first competition, and to which no award was given in the second competition, owing to the requirements of the specifications not being complied with. This adaptation also embodied the principal idea presented in the design of Messrs. H. A. & J. P. Sims.

In reference to the Memorial Hall, the Committee stated that they "now entertained grave doubts as to whether the Centennial Commission had, or were even intended to have, any supervision over the plans or construction of the 'Permanent Centennial Exhibition Building,' or any interest in the manner of the expenditure of the appropriation made by the State and city." They considered this a matter for the State Centennial

Supervisors, and recommended that the plans for the Memorial Hall be transferred to them, with the suggestion that if they approved of a plan it should as nearly as possible conform to the requirements indicated by the Committee; and if they determined not to proceed with the construction of a "Permanent Centennial Exhibition Building," as provided, then the Committee would at once prepare and submit a design for an Art Gallery.

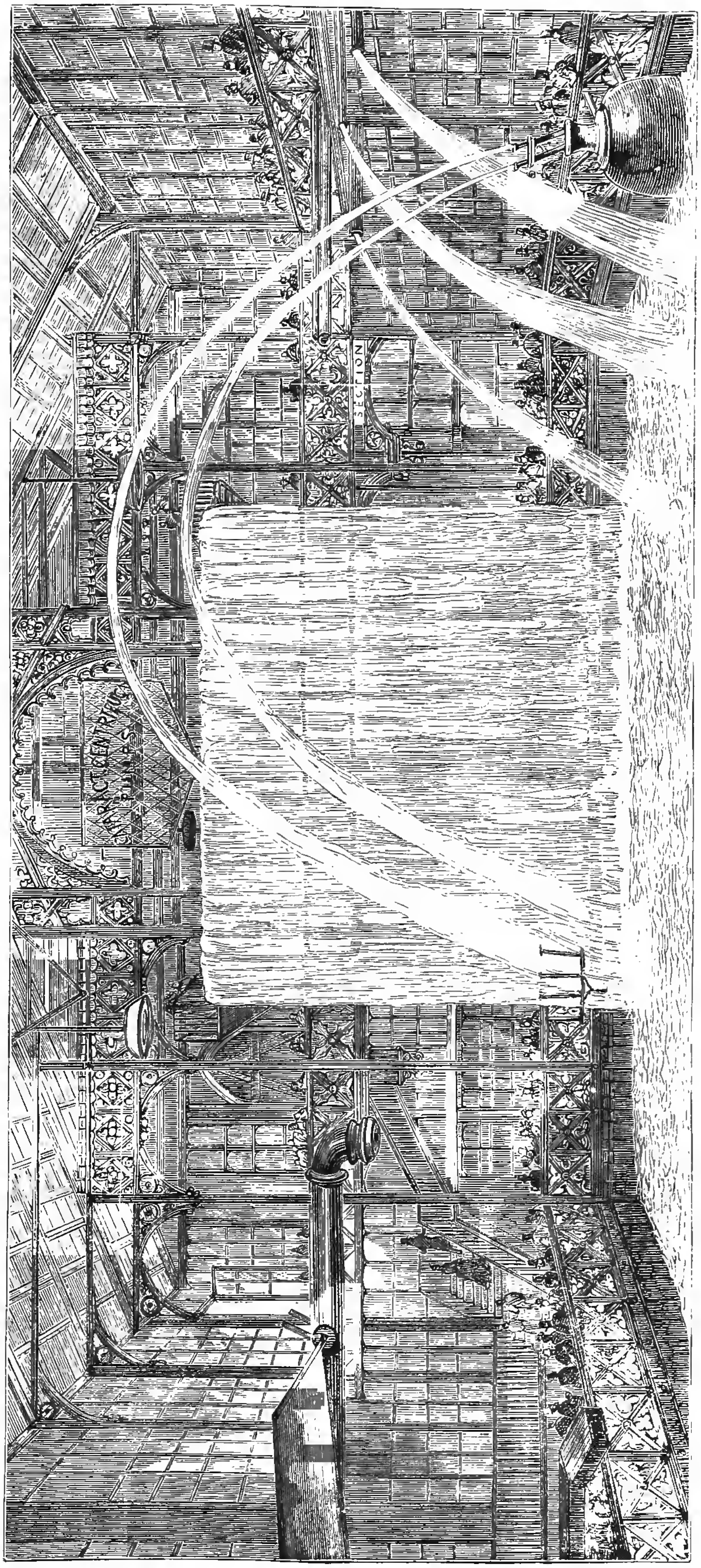
The plan for the Main Exhibition Building, as submitted November 6th, 1873, to the Executive Committee, was accepted and approved. At the same time the Board of State Centennial Supervisors communicated its desire that the plan for the Memorial Building should be prepared under the direction of the Commission, and upon this request the Director-General procured a design from Messrs. Collins and Autenrieth, of Philadelphia, which was submitted to the Executive Committee, December 17th. The Committee



Interior Agricultural Hall: Department of Brazil.

approved of the plan in its general features, but the estimated cost was in excess of the appropriation, and it recommended that it be erected only upon the condition of its cost being within the appropriated sum, and requested the Director-General to transmit the design to the Board of the State Centennial Supervisors, where it remained without farther action until the spring of 1874.

As soon as the Executive Committee had approved of the modified plans submitted for the Main Exhibition Building, they were placed in the hands of Messrs. Vaux and Radford, who were selected as the architects, for further elaboration and estimates, the results of which were given to the Committee. It was claimed by these results that Messrs. Vaux and Radford's system of construction throughout would be preferable, and not more expensive, than if combined with that of Messrs. Sims. This arrangement was



Cataract, Machinery Hall.

approved of, and the architects were instructed to obtain propositions from various iron firms for the furnishing and erection of the building in iron material, and also for the purchase and removal of the building after the close of the Exhibition.

About this time, the Secretary of State of the Government saw fit to give such construction to that portion of the Act incorporating the Centennial Commission which related to the participation of foreign nations at the Exhibition as would necessarily cause serious embarrassment, and probably entirely defeat the international features connected with it. His interpretation of the Act was, that while it stated "that an Exhibition of American and *foreign* arts, products, etc., shall be held," and instructed the President "to make proclamation, through the Department of State," and to communicate the proclamation and regulations of the Commissions "to the diplomatic representatives of all nations," yet it did not really authorize the government to invite anybody from abroad to attend; and he considered it necessary to issue special instructions to this effect, directing the diplomatic officers that they must confine themselves carefully to *commending* the celebration to all nations who might be pleased to take part therein, without *inviting* them to do so. That "with the exception that Congress created the Commission into a body corporate, and that the Commissioners were confirmed by the President, and that Congress authorized the proclamation made by the President and sympathized with the people in the success of the Exhibition, the national government had no connection with the Commission, no control over it, and was in no way responsible either for its management or its results." This interpretation was at entire variance with the understanding of the Commission on the subject and called for immediate action. A bill that would cover the whole question clearly and without doubt was at once prepared and introduced into Congress, passing the House almost unanimously, but meeting with delay and postponement in the Senate, until June 5th, 1874, when it was finally passed and approved, and the proper invitations were extended to the foreign governments. They met with a prompt response, and the international features were fully and firmly secured. In the autumn of 1873, that great financial panic, of which the effects are still seen, swept over the country, embarrassing all business operations and very seriously interfering with the procurement of subscriptions to Centennial stock. It was deemed, therefore, by the Executive Committee, of the utmost importance that pecuniary aid should be obtained from the Government. Every effort was made in this direction, a bill for the purpose being introduced into Congress on April 16th, 1874, but it failed to pass, and the Commission was obliged to place its dependence only upon voluntary subscriptions, which, up to May 1st, 1874, had amounted to $1,805,200, and the appropriations, which had been made by the State and municipal corporations, which were as follows:—

State of Pennsylvania, for permanent building, .	$1,000,000
City of Philadelphia, " "	500,000
City of Philadelphia, for a conservatory,	200,000
City of Philadelphia, for a machinery hall, . .	800,000
State of New Jersey, conditional upon a sufficient sum being obtained from other sources to carry out the Exhibition,	100,000
Total municipal and State appropriations,	$2,600,000

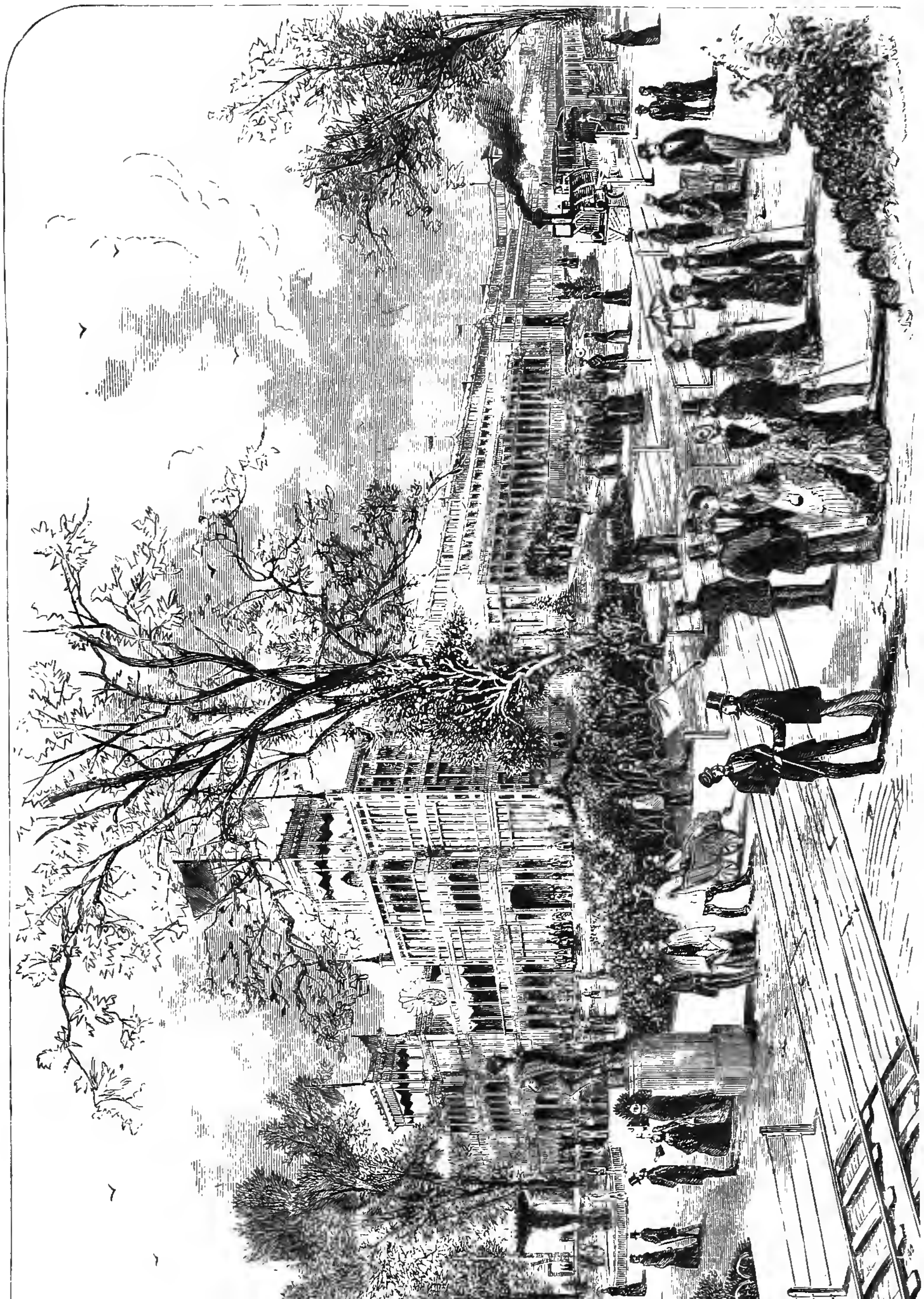
It was, therefore, absolutely essential that the cost of the Main Building should be kept to a minimum. Acting on this, bids were received for the work in both wood and iron construction, and the excess in cost of iron precluded its use. Another plan was then prepared by the architects for wood protected partially by galvanized iron, the cost of which was found to be about $103,000 per acre. This plan was approved and handed over to the Board of Finance for execution, but the Building Committee refused to erect it on account of its combustible nature, and referred it back to the Executive Committee, who instructed Messrs. Vaux & Radford to re-design the structure in wrought iron, and by a reduction of the spans endeavor to keep within a more reasonable cost. The architects were unable, however, to get the cost below about $182,000 per acre, and attention was accordingly directed to the consideration of some more simple form of building than had as yet been presented. Two prominent manufacturers of iron constructions combining together then came forward and laid before the Committee plans and proposals upon two separate designs, one of which would cost $182,000 per acre—the same amount as for the architects' last plan—and the other $128,000 per acre. The latter was a simple shed construction of too monotonous and ordinary appearance to be acceptable, and the former was not considered so desirable as the architects' plan, although costing the same sum. The Executive Committee, therefore, approved of Messrs. Vaux & Radford's last design and transmitted the drawings to the Board of Finance, requesting that the work be placed under contract by May 15th, 1874, if possible. The Board, however, anxious to decrease the cost still further, obtained yet another plan from the architects, the cost of which was now reduced to $124,000 per acre. As successive efforts had resulted in successive reductions of cost, it seemed feasible to do still more in this direction, and it was decided that the building should in no event exceed in cost $100,000 per acre. Messrs. Vaux & Radford were then instructed to prepare new plans on this basis, and while these were being furnished Mr. Henry Pettit, the consulting engineer of the Commission, rcommended to the architects and advised the adoption of yet another modification of design for the building, embodying pavilions in the centre with wings of shed construction, allowing of any extension that the future wants of the Exhibition might make desirable. Messrs. Vaux & Radford not working up this idea satisfactorily, Mr. Pettit was requested to prepare plans and procure estimates at the same time as the architects. This he refused to do, as the Board of Finance already had a contract with Messrs. Vaux & Radford to prepare any plans they required, but he willingly offered to co-operate with these gentlemen in every way possible to further the work. The designs of the architects were three in number, as follows:—

No. 1. Pavilion plan throughout, with groined arch ribs in iron.

No. 2. A design consisting of three parallel galleries, each 150 feet span, with intermediate aisles, the roof of the 150 feet spans being flat arches with parallel extrados and intrados filled in with diagonal bracing, and the main tie-rod curved and supported from the arch by radial rods.

No. 3. Same as No. 2, except that straight, triangular roof trusses were used, the design being represented by a single tracing, and intended to embody the suggestions of Mr. Pettit.

Music Pavilion, Central Transept, Main Building.



Machinery Hall from the Jury Pavilion.

The Building Committee, after a full examination of these plans, again requested Mr. Pettit to work up a design according to his suggestions, and, under the circumstances, he could do nothing else than acquiesce. He accordingly furnished sketches and specifications which were designated as Design No. 4.

These four designs were presented to the public for bids, from June 17th to 25th, 1874. In comparing the amounts given by the lowest bidder for the several designs, there appeared to be a difference of only $2,824 between Nos. 2 and 4—in favor of the former—but the Committee decided that No. 4 possessed advantages over No. 2, which made it preferable even at the same price. The cost of Plan No. 1 was in excess of No. 4 by $520,733, and although the Committee was of opinion that the interior effect of No. 1 would be superior to that of No. 4, still, it felt that the great difference in cost would outweigh any advantages in this respect, and it therefore adopted Mr. Pettit's plan on June 30th, the Director-General giving his approval on July 4th, by order of the Executive Committee. This was the first design upon which the Board of Finance and Executive Committee both agreed, and was the final result of the successive efforts of many talented in their profession, developing step by step from the grand ideas of the original requirements to a practical basis which could be met by the resources at hand. All those who contributed towards the attainment of this end—be it more or less—are entitled to due credit for it.

The contract was awarded to the lowest bidder, Mr. Richard J. Dobbins, of Philadelphia for $1,076,000—exclusive of drainage, plumbing, decoration and painting—the area to be covered being eighteen acres; and Messrs. Vaux & Radford were authorized to proceed with the execution of the design. A professional issue arising, Messrs. Vaux & Radford declined to execute the work, and their contract with the Board of Finance was closed. Arrangements were then made with Mr. Henry Pettit and Mr. Joseph M. Wilson to act as joint engineers and architects to the Centennial Board of Finance, for the Main Exhibition Building and for the Machinery Hall.

Actual work commenced immediately, prospects became encouraging from this day forward, and it was soon evident that the space allowed for the Main Building was too little. It was therefore increased to twenty acres, and, at the same time, the central portion of the building was raised and towers added for exterior effect, the cost being increased to $1,420,000.

According to the agreement made with the contractor, it was provided that one wing of the building should be erected by September 1st, the other by October 1st, and the central portion by November 1st, the whole building to be completed by January 1st, 1876.

In reference to the Memorial Building, the designs as so far prepared by the selected architects did not appear satisfactory, considerably exceeding in cost the appropriations at command, and a plan presented by Mr. H. J. Schwarzmann, one of the engineers of Fairmount Park, was finally adopted, a contract being effected with Mr. Richard J. Dobbins on July 4, 1874, for the execution of the same, at a cost of $1,199,273, the sum being covered by the appropriations of the State of Pennsylvania and the city of Philadelphia.

Messrs. Pettit and Wilson proceeded at once under instructions to prepare a design for the Machinery Hall, which, being completed and adopted, was submitted to bidders, and the contract awarded to Mr. Philip Quigley, of Wilmington, Delaware, January 27th, 1875, for the sum of $542,300, including drainage, water-pipe, plumbing, etc., but exclusive of outside painting, the building to be finished by October 1st of the same year.

A design had already been prepared by Mr. Schwarzmann for a Conservatory Building, and bids being received, the contract fell to Mr. John Rice, of Philadelphia, for $253,937, exclusive of heating-apparatus, the papers being signed January 1st, 1875, and the work to be completed by September 15th.

Mr. James H. Windrim was selected as architect for the Agricultural Building, and his design being approved, the contract was awarded to Mr. Philip Quigley on June 16th, 1875, for the sum of $250,000, the work to be completed by January 1st, 1876.

The area covered by these buildings was as follows:—

Main Building,	21.47 acres.
Art Building,	1.50 "
Horticultural Building,	1.50 "
Machinery Building,	14.00 "
Agricultural Building,	10.15 "
Total,	48.62 acres.

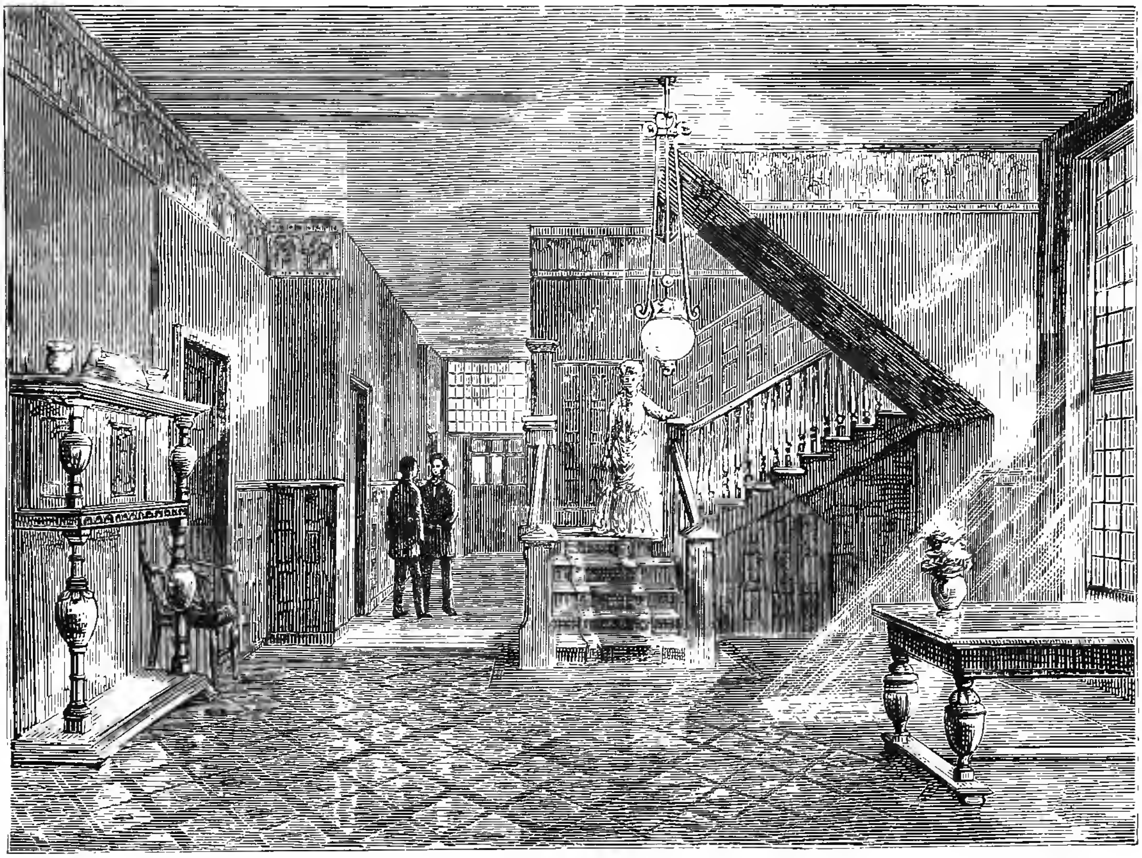
Thus, by indefatigable perseverance on the part of the Board of Finance, the five principal buildings for the great Exhibition were at last fairly under way, and a most important step taken in advance towards a successful issue. The work proceeded rapidly, fully realizing all expectations, and with far greater speed than many even well versed in such matters deemed possible. Additional buildings soon began to spring up; the United States Government commenced the erection of a building, under Mr. Windrim as architect, for the collective exhibits from the different Government departments; offices were projected and started for the Executive departments of the Centennial Commission and the Board of Finance; State pavilions; buildings for special exhibits, etc., etc., began to dot the enclosure at point after point, increasing rapidly in number as the time for the opening of the Exhibition approached, and rivaling those of all previous Exhibitions, at least in multitude if not in architectural variety and national characteristics. A fence-line of some sixteen thousand lineal feet was constructed around the grounds, enclosing two hundred and thirty-six acres, this area being exclusive of the stock-grounds for the display of horses, cattle, sheep, etc., and located at another site. Walks and roads were laid out within the enclosure, comprising a total length of over seven miles; an artificial lake of water formed, covering an extent of three acres; fountains, statuary and vases erected, and shrubbery planted; a complete system of drainage designed and constructed for buildings and grounds, and the whole area so transformed, changed and beautified far beyond the already natural loveliness of the location as to be hardly recognizable even by those most familiar with it.

The necessity of including the Lansdowne and Belmont ravines within the Exhibition grounds required the construction of two bridges for the use of the public park roads, which were designed by and constructed under the direction of of Messrs. Pettit & Wilson. That over the Lansdowne ravine was of considerable engineering pretensions, and afforded an opportunity for quite an artistic construction. In order to secure an abundant supply of water entirely independent of the city department, temporary pumping-works were erected on the west bank of the Schuylkill River, a large and commodious brick building being constructed

Buildings of the British Commissioners.

and furnished with a Worthington steam-pump of a capacity of six million gallons of water per day, and an auxiliary pump of one million gallons additional. The necessary stand-pipe and a circulating system of pipes, amounting to about eight miles in total length, were provided, the designing and erection of the whole being under the care of Mr. Frederick Graff as Chief Engineer. Gas mains were laid out to the principal buildings from the city system, so as to afford the full supply desired.

As to transportation facilities, no previous Exhibition ever had so perfect arrangements. About three and a half miles of tracks were laid within the grounds to the several buildings, and there connected, by means of the Pennsylvania Railroad Company's lines, directly with the wharves on the Delaware and Schuylkill rivers, and with all the railroads entering the city, rendering no transhipments necessary except from vessels to cars.



Interior of British Commissioners' Building.

In the meantime the progress made by the Commission and the Board of Finance in their labors during the year 1875 was most satisfactory. The general classification as arranged was—

I. Mining, III. Education and Science, V. Machinery,
II. Manufactures, IV. Art, VI. Agriculture,
VII. Horticulture,

and the adaptation of this classification to the principal buildings placed the first, second and third departments in the Main Building, the fourth in the Art Gallery, the fifth in the

Machinery Building, the sixth in the Agricultural Building, and the seventh in the Horticultural Building. The public sentiment developed in favor of the Exhibition was such as to warrant the most liberal provision for its success, and the increased number of co-operative agencies established throughout the world tended greatly to overcome all difficulties.

The usual annual report required from the Commission by Congress was made to the President on January 20th, 1875, "setting forth the progress of the preparations for the Exhibition, and respectfully presenting the claims of the Commission for financial aid to properly execute their trust." Appropriations were asked for specific purposes, the expenses of which it was thought should rightly be borne by the Government, as follows:—

For expenses of the United States Centennial Commission, . .	$400,000
Awards and expenses incident thereto, ...	500,000
Protection (police, etc.), ...	600,000
	$1,500,000

But Congress did nothing. It did make an appropriation, however, of $505,000 for the use of the Board representing the United States Executive Departments in preparing a collective exhibition, and the Board, having this appropriation, proceeded to the erection of a suitable Government building, previously mentioned, to contain the exhibits.

The Women's Centennial Executive Committee, under the able direction of Mrs. E. D. Gillespie, greatly enlarged its influence and usefulness, forming one of the most important volunteer organizations which had come to the aid of the Commission. It rendered exceedingly important service not only in procuring stock subscriptions, but in obtaining money by other means, and in awakening popular interest, performing a large share of the labor towards insuring the success of the undertaking. In addition to the large sums collected and handed over to the Board of Finance, this Committee raised by voluntary contributions of the American women the separate sum of $35,000, which it appropriated to the construction of a special building for the exclusive display of women's work, erecting a structure creditable to the enterprise of the ladies, and a useful and ornamental addition to the list of Exhibition buildings. We hope to give more particulars concerning this Committee hereafter.

It was soon found necessary to organize the various administrative bureaus which would be required to properly attend to the direct duties of the Exhibition under the supervision of the Director-General. The bureaus formed with their respective functions and chiefs were as follows:—

FOREIGN—Direction of the foreign representation, ... The Director-General.

INSTALLATION.—Classification of applications for space-allotment of space in Main Building—Supervision of special structures, ... Henry Pettit.

TRANSPORTATION.—Foreign transportation for goods and visitors—Transportation for goods and visitors in the United States—Local transportation—Warehousing and customs regulations, ... Adolphus Torrey.

MACHINERY.—Superintendence of the Machinery Department and building, including allotment of space to exhibitors, ... John S. Albert.

AGRICULTURE.—Superintendence of the Agricultural Department, building and grounds, including allotment of space to exhibitors, . . . Burnet Landreth.

HORTICULTURE.—Superintendence of Horticultural Department, conservatory and grounds, including allotment of space to exhibitors, . . Charles H. Miller.

FINE ARTS.—Superintendence of the Fine Arts Department and building, including allotment of space to exhibitors, ... John Sartain.

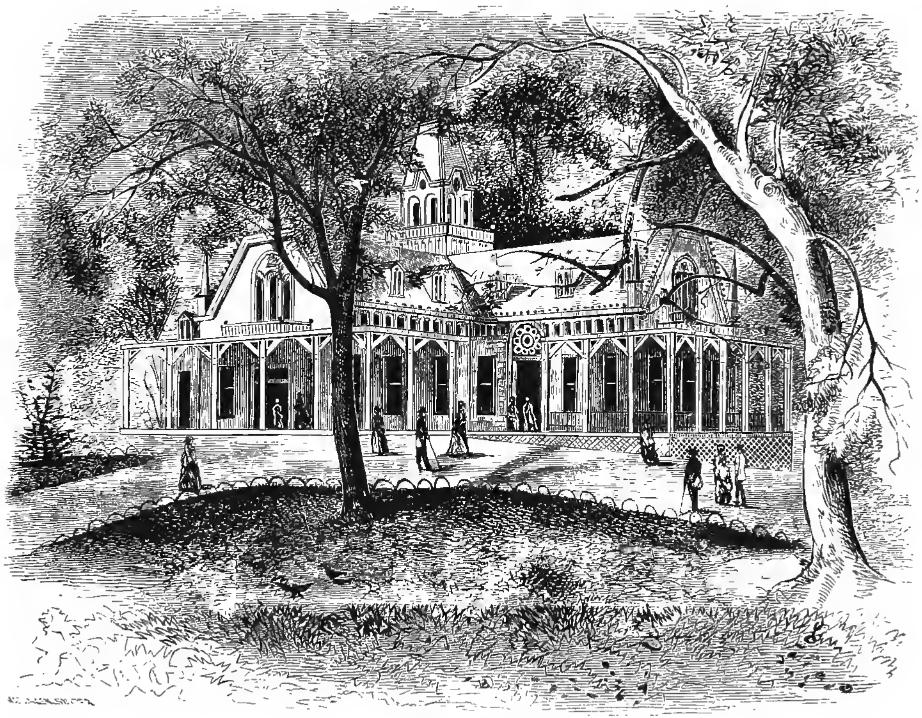
The subject of awards received very careful attention from the Executive Committee, the experience of those connected with previous Exhibitions being solicited and given due consideration. A system was finally decided upon, widely different from any ever used before; and instead of having several grades of awards, causing disputes among the recipients as to their comparative importance, a single uniform medal was adopted, which was in each case to be accompanied by a report and diploma stating the nature of the merit for which it was awarded. It was determined to have only a small body of judges, one-half of whom should be foreign and one-half from the United States, and to insure the presence and attention of men practically conversant with the subjects on which they were to report, it was decided to provide an allowance to each, designed to cover actual expenses.

A final effort was made at the Congressional session of 1875–6 towards obtaining the appropriation asked for at the previous session, and after considerable opposition it was successful, the sum of $1,500,000 being granted on condition of its being paid back to the Government out of the proceeds of the Exhibition in advance of any dividends from profits being given to any other claimants. This gave immediate relief from all chance of pecuniary embarrassment, avoiding the necessity of perhaps mortgaging the buildings or receipts in advance, which might have been required otherwise.

The Centennial year began to draw near; the buildings towards which so many eyes were turned grew up and approached completion; events crowded one on the other until it was impossible for the coolest head to avoid being stirred up with enthusiasm. The 1st of January was ushered in with illuminations and rejoicings such as had never before been known. Foreign representatives, of which there had been a few for some time, now began to arrive in numbers, and exhibits commenced to appear on the grounds. The writer well remembers the interest occasioned by a lot of Japanese goods which were among the first to come, and were unpacked in Machinery Hall. They came by way of San Francisco, and were parts of the building afterwards erected by that Government for the use of its officers, so curiously put together by native workmen, who appeared to do everything exactly the opposite way from which it was done in this country, possibly from living in a reversed position on the other side of the globe.

The winter of 1876 was fortunately very mild. Planting was possible almost continuously, and the erection of the numerous buildings proceeded without interruption. By the time of the opening-day, everything was in readiness with the exception of a few of the exhibits which had suffered detention. The buildings had all been completed and ready for the reception of goods at the dates designated, occasioning no delays on their part, a fact never before accomplished at any previous Exhibition. Patriotism had been fully aroused, and for weeks before the 10th of May the people were busy decorating with flags and draping with bunting, until Philadelphia wore a gala look such as she had never done before and may never do again. Chesnut Street was one mass of color—red, white and blue—as far as the eye could reach. It was a pageant, a raree-show, such as few see twice in a life-time. The poorest little shanty in the town had its penny flag hung out, and even now the thought of those days stirs up one's feelings and bears evidence of that depth of love of country which always shows itself when the occasion arises.

The 9th of May was dark and cheerless, but all were busy placing the last flag and



Kansas Building.

giving the last touch until far into the night. The 10th opened at early dawn still cloudy and uncertain. Nevertheless all were stirring, for was not this the opening-day of our great celebration, where we were to show to the world the progress that a free country under self-government could make in a century of life? The rain held off; the crowds began to gather. The whole area in front of the Memorial Hall facing the Main Building had been arranged with seats on platforms, and apportioned off into sections, and here were grouped the President of the United States and Cabinet, the Senate and House of Representatives, the Supreme Court, the Diplomatic Corps, the Governors and other officers of States, the Centennial Commission and Board of Finance, the Foreign Commissioners, the Women's Centennial Committee, the Board of Judges and Awards, other Boards and Bureaus of the Exhibition, the Army and Navy, the various city officers, etc., etc.—

forming a brilliant assemblage such as only an occasion like this can draw together. In the centre of the front was the platform for the President and those distinguished officers and guests who were to take active part in the ceremonies. At the entrance to the Main Building, opposite and facing Memorial Hall, was the platform for the immense orchestra of one hundred and fifty pieces, under the leadership of Theodore Thomas, and around this was grouped the grand Centennial chorus of one thousand voices, one of the great results of the good work of the Women's Centennial Committee. In the rear, in the interior of the Main Building, but with the large arched windows of the façade open, was

Mississippi Building.

the noble Roosevelt Organ, the first instrument of its kind in the history of International Exhibitions to take part in the opening ceremonies in combination with the grand orchestra, and mingle with it its glorious tones in one melodious whole.

The Main Building, Memorial Hall and Machinery Hall were reserved for officials, invited guests and exhibitors until the conclusion of the ceremonies. Invited guests entered through the Main Building, and other gates to the grounds were opened to the public at nine o'clock A. M., at the established rate of admission, fifty cents. The avenue between the centre exit of the Main Building, on the north side, and the Memorial Hall was kept open, and guests passed by this to their places, which were to be occupied by quarter past ten o'clock.

Let us take our stand of observation in the outside balcony of the Main Building, in the rear of the orchestra, where we can see and be above everything. As the hour approaches the excitement increases. The clouds lighten up, and the grounds become gradually covered with a dense mass of good-humored people, who crowd up towards the platforms until they threaten to entirely close the passage between the two buildings, necessitating the utmost efforts of the police to keep them back, taking the pushing and shoving, however, with that remarkable good nature for which the American citizen is so noted. As far as the eye can reach, the people are seen pouring forward. A perfect sea of heads meets the view on every side. Every one looks pleased, and expectation rises to the highest pitch.

From below, the buzz and hum of the crowd floats up to the ear; the balmy air and freshness of the spring morning delights the senses, and one feels perfectly happy. The seats on the opposite side are gradually filled; distinguished visitors arrive one after the other, and are received with acclamations. There goes His Excellency Dom Pedro, of Brazil, that man who is every inch a true emperor, with the Empress—the only crowned heads who grace our opening. We remove our hats in compliment to these our royal guests. There comes the British Commission in full uniform, and following are the representatives from other countries, all decked in their most gorgeous official dresses, and decorated with their medals and honors; the Japanese Embassy, the French, the Austrian, the Swedish, the German, and all the nations of the earth, to join with us in this our triumphal day. The Emperor and Empress take seats on the central platform reserved for the President of the United States and distinguished visitors. The hour of opening has arrived, and the grand orchestra strikes up the national airs of all nations. The moment we have dreamed of for the past three years of labor and toil has come, and our work is consummated. One feels in his heart, O happy day! that I have lived to see it and had it come in my time! Music is heard in the distance; it draws nearer. It is the President, who comes escorted by Governor Hartranft, of Pennsylvania, with troops. They enter by the rear of Memorial Hall, and passing through to the front, the escort forms in two lines down the passage between the buildings, while the President joins the Emperor and Empress. Acclamations rend the air, and at this moment the clouds break away, and a burst of sunshine illuminates the animated scene—a happy omen for the success of the great undertaking.

The orchestra begins Wagner's Centennial Inauguration March, of which so much was expected, another gift from our noble women. To one who is an enthusiastic admirer of Wagner, it must be confessed that it is somewhat disappointing. Still, it *is* Wagner. None can dispute that. The grand clashes, the sounds from the brass instruments, the volumes of tone swelling up and up until they almost overtop the heavens themselves. Then all is hushed, and Bishop Simpson asks God's blessing on our work, gives thanks for all our past successes, and beseeches his kind guidance in the future. Whittier's hymn follows, with the grand chorus, the orchestra and the organ. The place, the day, the tumultuous feelings within one combine to produce an effect never to be forgotten, as a thousand voices swell up on the bright morning air—

Our fathers' God! from out whose hand
The centuries fall like grains of sand,
We meet to-day, united, free,
And loyal to our land and Thee,
To thank Thee for the era done,
And trust Thee for the opening one.

Here, where of old, by Thy design,
The fathers spake that word of Thine,
Whose echo is the glad refrain
Of rended bolt and falling chain,
To grace our festal time, from all
The zones of earth our guests we call.

Be with us while the new world greets
The old world thronging all its streets,
Unveiling all the triumphs won
By art or toil beneath the sun;
And unto common good ordain
This rivalship of hand and brain.

Thou, who hast here in concord furled
The war-flags of a gathered world,
Beneath our Western skies fulfill
The Orient's mission of good will,
And, freighted with love's Golden Fleece,
Send back the Argonauts of peace.

For art and labor met in truce,
For beauty made the bride of use
We thank Thee, while, withal, we crave
The austere virtues strong to save,
The honor proof to place or gold,
The manhood never bought nor sold!

O! make Thou us, through centuries long,
In peace secure, in justice strong;
Around our gift of freedom draw
The safeguards of Thy righteous law;
And, cast in some diviner mould,
Let the new cycle shame the old!

The buildings are then presented by the Centennial Board of Finance, through its President, Mr. John Welsh, to the Centennial Commission, and the presentation is followed by Sidney Lanier's Cantata—

From this hundred-terraced height
Sight more large with nobler light
Ranges down yon towering years:
Humbler smiles and lordlier tears
Shine and fall, shine and fall,
While old voices rise and call
Yonder where the to-and-fro
Weltering of my Long-Ago
Moves about the moveless base
Far below my resting-place.

Mayflower, Mayflower, slowly hither flying,
Trembling Westward o'er yon balking sea,
Hearts within *Farewell dear England* sighing,
Winds without *But dear in vain* replying,
Gray-lipp'd waves about thee shouted, crying
No! It shall not be!

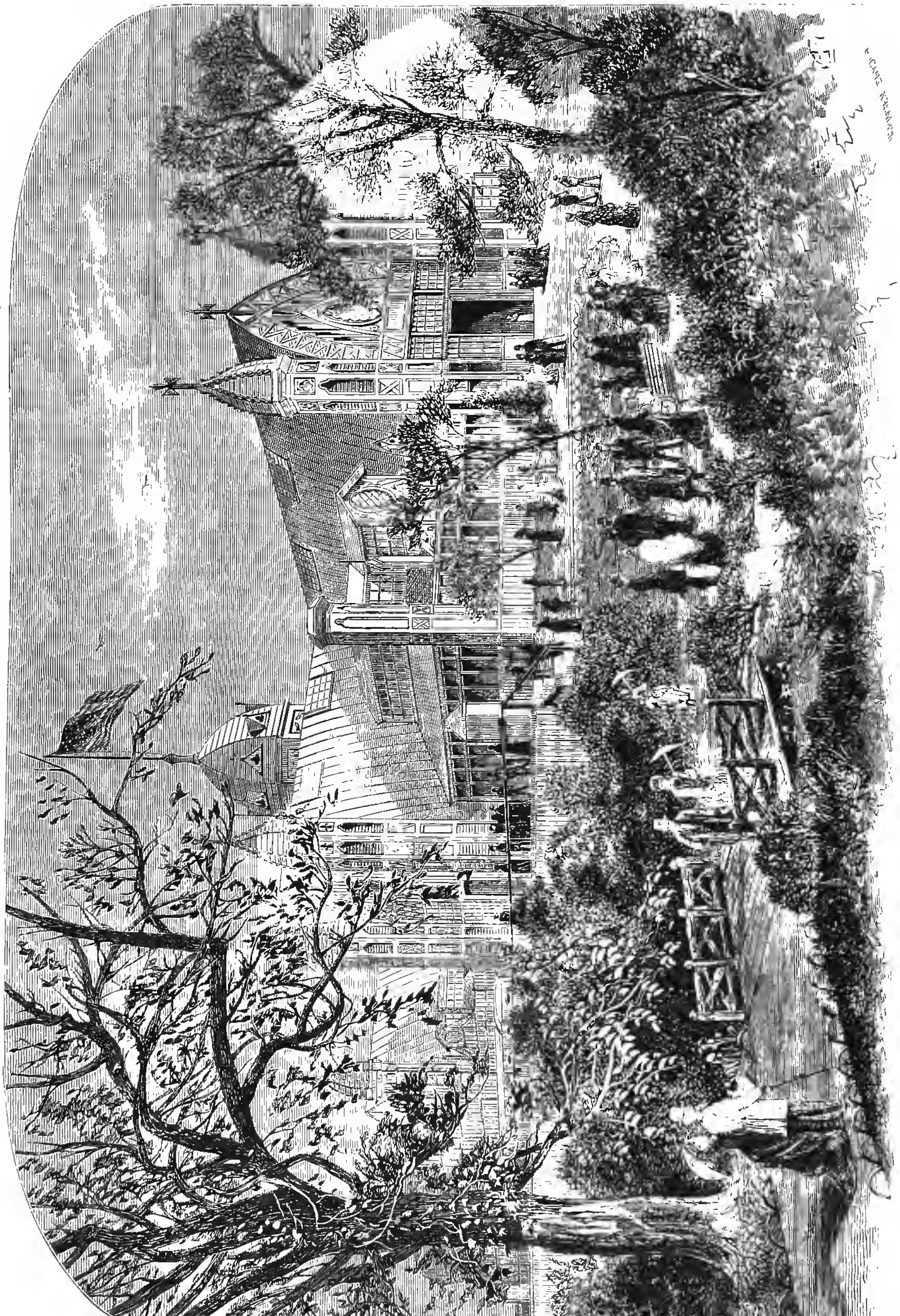
Jamestown, out of thee—
Plymouth, thee—thee, Albany—
Winter cries, *Ye freeze: away!*
Fever cries, *Ye burn: away!*
Hunger cries, *Ye starve: away!*
Vengeance cries, *Your graves shall stay!*

Then old Shapes and Masks of Things,
Framed like Faiths or clothed like Kings—
Ghosts of Goods once fleshed and fair,
Grown foul Bads in alien air—
War, and his most noisy lords,
Tongued with lithe and poisoned swords—

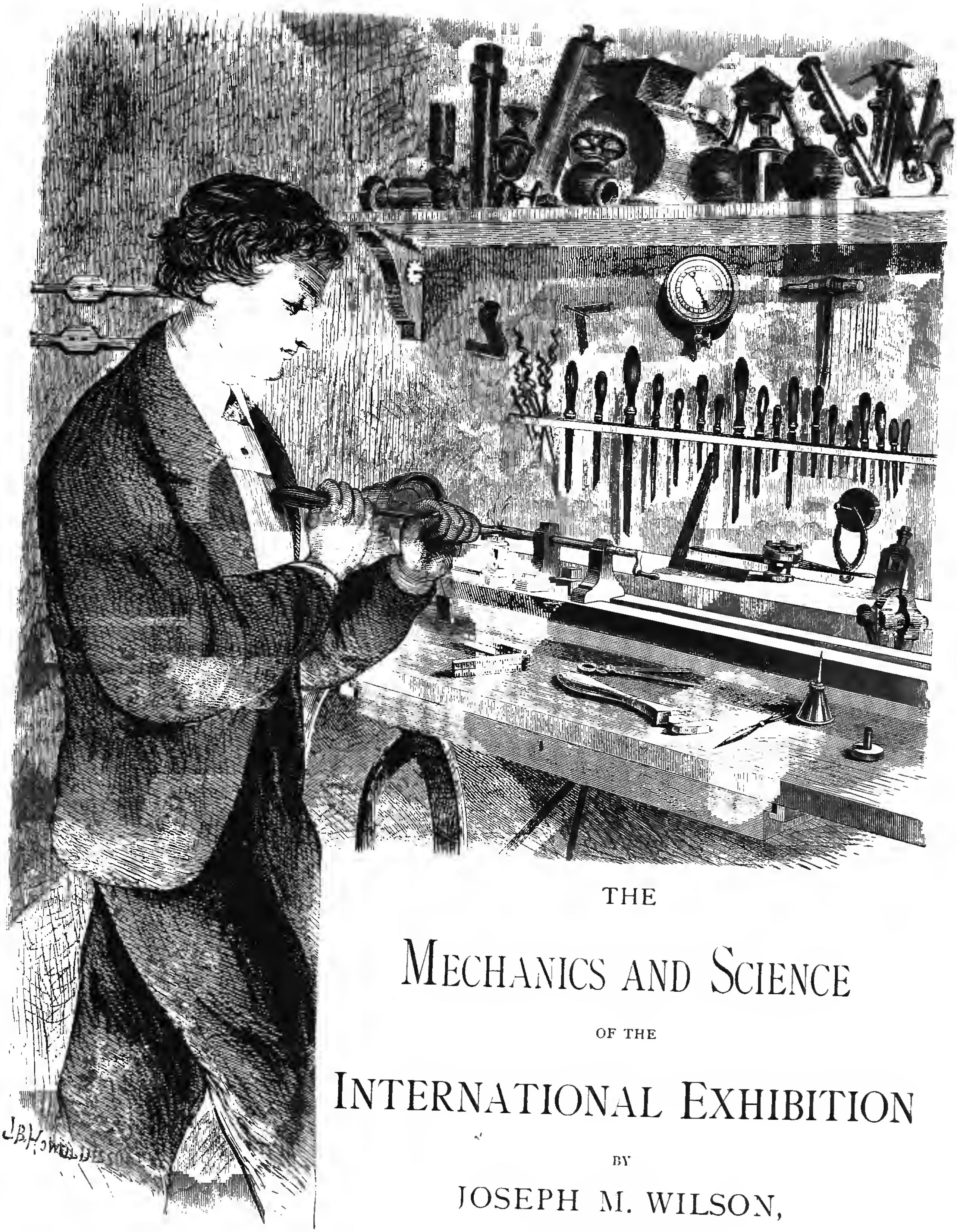
Error, Terror, Rage, and Crime,
All in a windy night of time
Cried to me from land and sea,
No! Thou shalt not be!

Hark!
Huguenots whispering *yea* in the dark!
Puritans answering *yea* in the dark!
Yea, like an arrow shot true to his mark,
Darts through the tyrannous heart of Denial,
Patience and Labor and solemn-souled Trial,
Foiled, still beginning,
Soiled, but not sinning,
Toil through the stertorous death of the Night,
Toil, when wild brother-wars new-dark the Light,
Toil, and forgive, and kiss o'er, and replight.

Now Praise to God's oft-granted grace,
Now Praise to Man's undaunted face,
Despite the land, despite the sea,
I was: I am: and I shall be—
How long, Good Angel, O how long?
Sing me from Heaven a man's own song!



Agricultural Hall.



THE

MECHANICS AND SCIENCE

OF THE

INTERNATIONAL EXHIBITION

BY

JOSEPH M. WILSON,

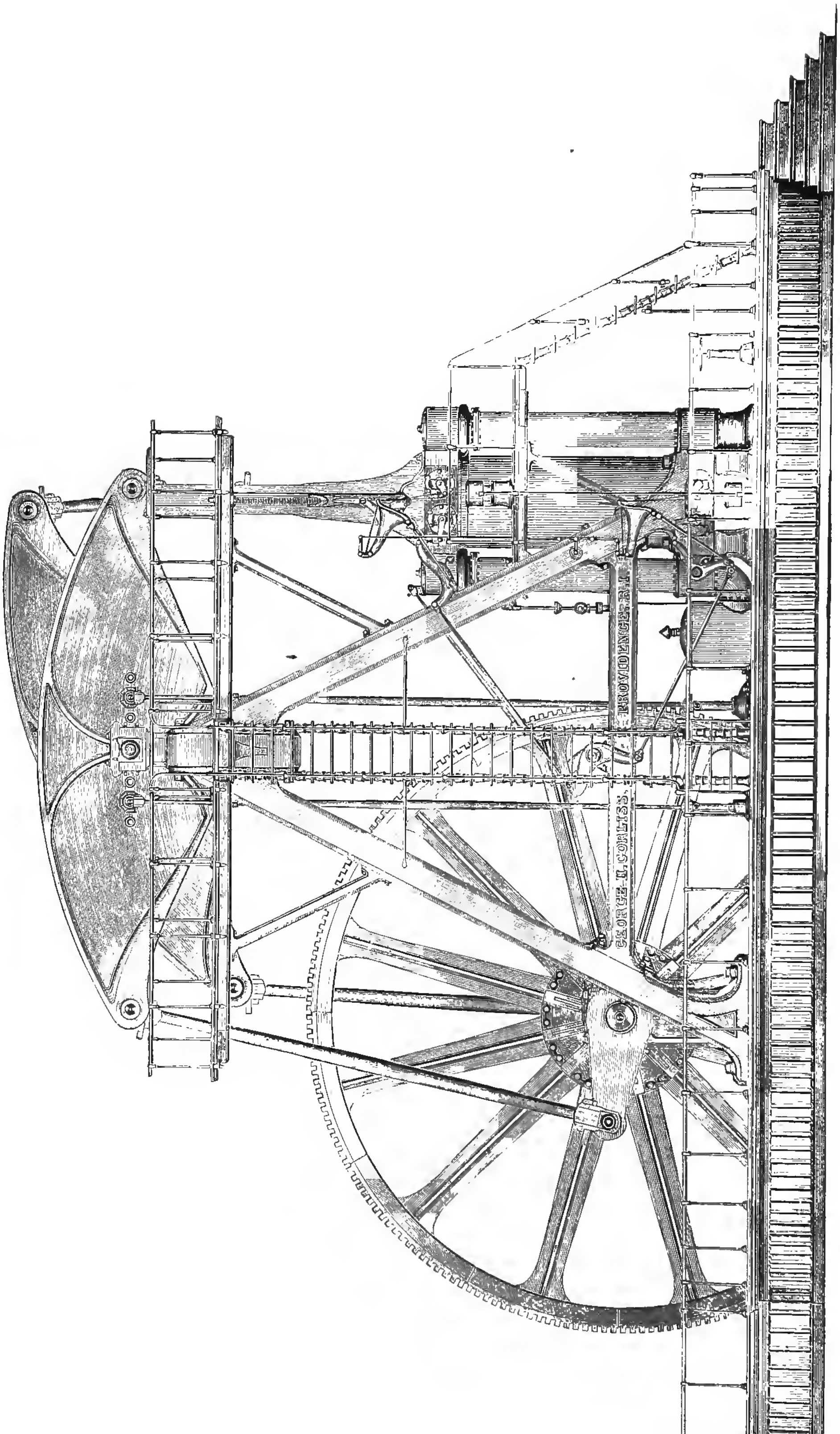
M. I. C. E., Am. S. C. E.

Vol. III.

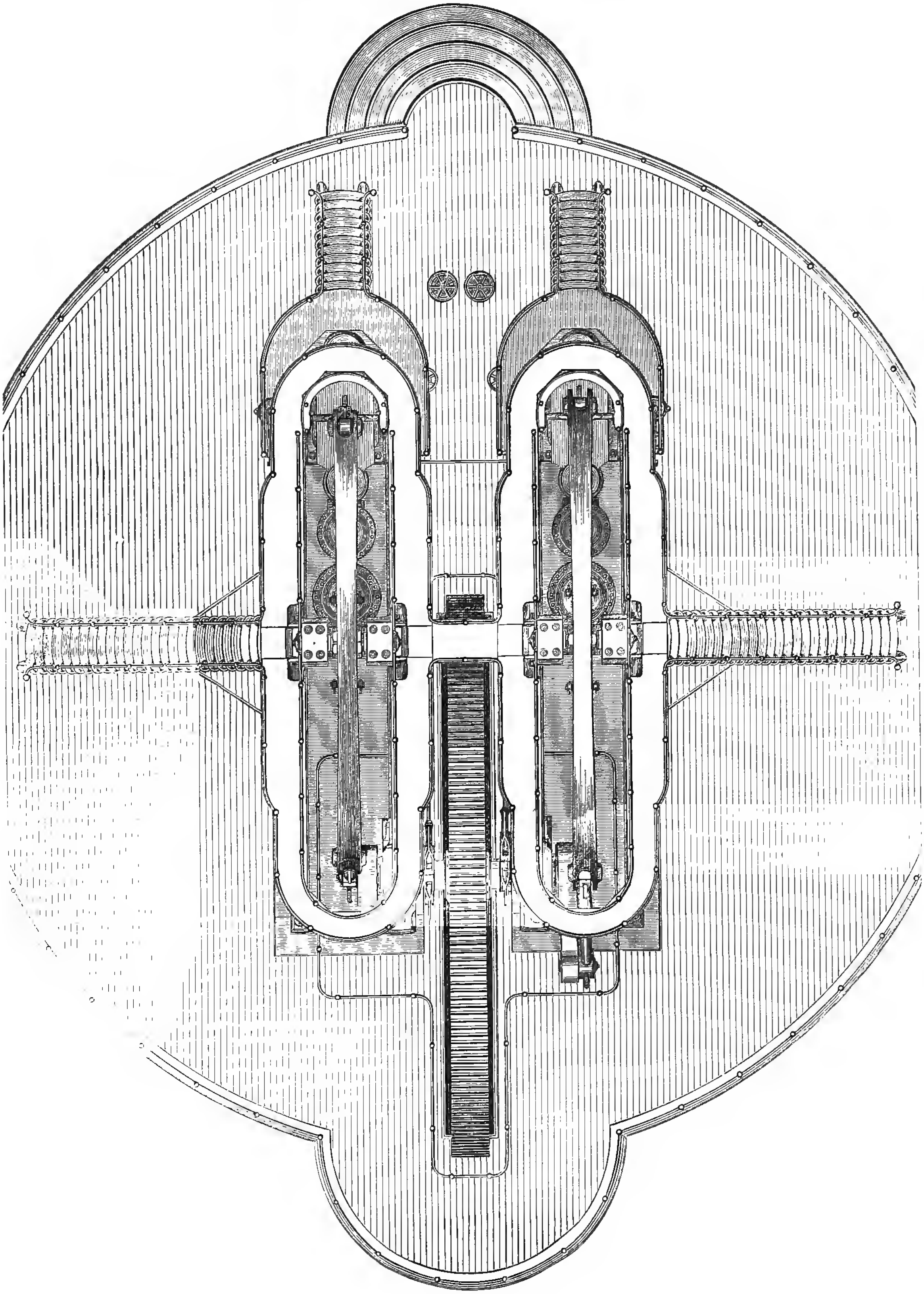
THE INTERNATIONAL EXHIBITION, 1876.

MUCH of the inventive genius for which the people of America have always been noted has been developed by the necessities of the case. When first discovered by the inhabitants of Europe, she was in reality a new world, covered by immense forests, possessing vast mineral resources, with a great extent of territory from temperate to semi-tropical, having a variety and richness of soil adapted to the cultivation of wheat, corn, sugar, cotton, and all the productions most useful to man, destined therefore, to be the future producing market of the world, having great natural facilities for the manufacture of these products, and with all this, lying in a state of nature, inhabited by a savage people, and entirely undeveloped.

The great scarcity of human labor in this new country even to the present day, has stimulated and sharpened the inventive faculties of her citizens towards the designing of machinery which should accomplish that for which hand-labor could not be found, until the talent has become a second nature, and stamped its impress upon the nation. Under these circumstances, it is but natural that we should expect to find in the great Centennial Exhibition of this nation an unprecedented display of machinery. The history of previous exhibitions leads us to anticipate this. Notwithstanding her great distance from foreign countries, requiring her representation at these exhibitions to be always small, yet her exhibits have universally made a marked impression and have been noted for those unexpected labor-saving novelties which so cheapen the cost of manufacture and increase productiveness.



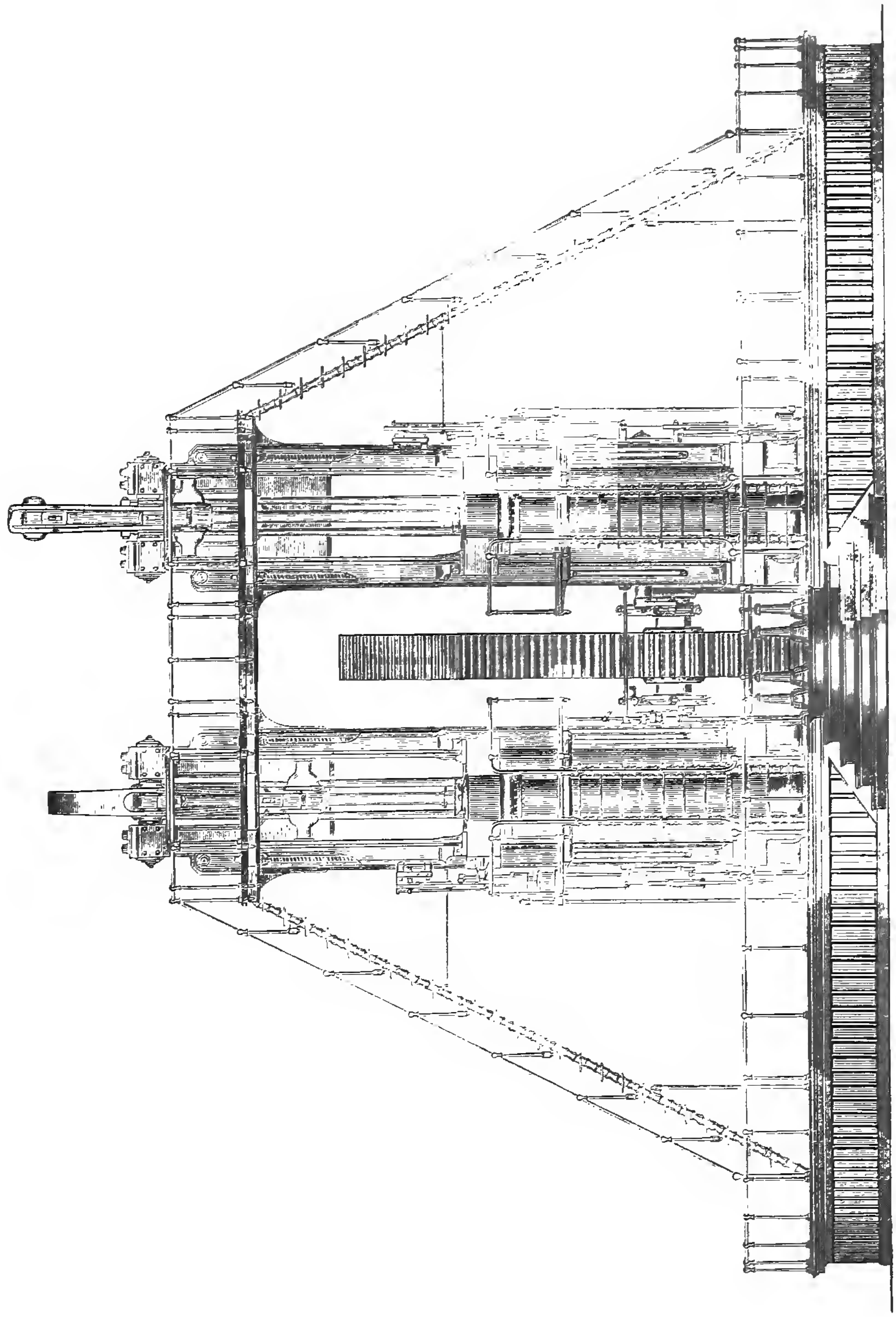
The Corliss Engine; Side Elevation.



The Corliss Engine; Plan.

Greater prominence has been given to the Machinery Department of this exhibition than has ever been the case before, and a building has been erected which has been pronounced by those most competent to judge as the best ever provided for the purposes intended. In the centre of this building stands that wonder of the modern era, that thing which needs but the breath of life—what no human being has yet been able to invent, but must always supply by himself—to be a creation; that invention upon which now depends the daily bread of hundreds of thousands of people; a grand and noble specimen of the "Steam Engine." There it stands, holding its place as a veritable king among machinery, so powerful and yet so gentle, capable of producing the most ponderous blows upon the anvil, or of weaving the most delicate fabrics; that to which all other machines must be subservient, and without whose labor our efforts would be small indeed; the breathing pulse, the soul of the machinery exhibition. This engine, which may be seen from all parts of the building towering up above everything else, comes from little Rhode Island, from the city of Providence, and for its existence the Exhibition is indebted to the energy and perseverance of Mr. George H. Corliss, proprietor of the Corliss Steam Engine Company.

Early in 1875, when the question came up of the power that would be required in the building to run the fourteen acres of machinery which it was expected would be on exhibition, Mr. George H. Corliss, Centennial Commissioner from Rhode Island, conceived the idea of providing a single engine that should furnish this power—estimated at 1400 horses—placing it in the centre of the Machinery Hall, and he made an offer to the Commission to this effect. The Commission feeling that the honor of supplying this power should be distributed among different establishments, did not accept the offer, but invited proposals from prominent firms for what would be necessary to operate either the whole of the shafting in the building, or each line of shafting separately, so that it might be distributed among as many different parties as there were lines of shafting. When the proposals were received, it was discovered that they were not sufficient altogether to cover the requirements of the exhibition, that none of the bidders would agree to furnish the whole of the power, and that none would provide the boilers and connections necessary for the complete execution of the work. It was also found that the cost to the Commission would be much greater, and that the care and attention required in giving out a number of varied contracts to different establishments, with the additional trouble—



The Corliss Engine, Front Elevation.

while the Exhibition would be in working order—of looking to those contractors for proper supply of power, would, in all human probability, be more than by Mr. Corliss' proposition. After considerable delay, Mr. Corliss was then unanimously requested to renew his offer, and in June, 1875, eleven months before the opening, a contract was closed with him for the work, giving him only about ten months to construct that for which there had not as yet been even the first sketch prepared. How promptly the work has been performed, will be apparent when we state that on the day fixed by the contract—April 17, 1876—the engine was up in place, steam was turned on, and it was run for some time with perfect success.

The special characteristics of the Corliss Engine as compared with other steam engines may be said to consist in the valve gear, the form of valve and the peculiar method adopted by which steam is freely admitted at the full boiler pressure and discharged after use, without presenting any resistance to the piston. Independent parts are used for admitting and exhausting the steam with four separate valves, the steam being cut off from the cylinder entirely by the main steam valves without the employment of any supplementary valves. The steam valves are opened against the resistance of springs, and a liberating gear is called into play, disconnecting the valves and leaving them free to be closed by the springs. These springs are brought to rest without shock after closing by means of an air cushion formed by a small cylinder with a closed bottom, in which a piston is fitted to work easily, a certain amount of air being imprisoned just as this piston approaches the bottom, acting as a cushion and preventing any shock. The valves of admission are regulated by direct connection with the governor, thus controlling the speed of the engine without the use of a throttle-valve in the main supply-pipe.

The principal inventions which distinguish the Corliss Engine were devised in 1848 and patented in 1849, a beam engine of 260 horse-power having been constructed with the new improvements for use in Providence. The success of this engine was so great as to induce the parties with whom Mr. Corliss was associated to erect new works in the summer of 1848 for the purpose of extending their business. The machine-shop then built, covering an acre of ground, is yet standing intact. About two years after this time, a course of patent litigation commenced, extending over a period from 1850 to 1865, involving the firm and very much embarrassing its operations. Mr. Corliss from being the defendant in the first place, was afterwards obliged to take the place of plaintiff to maintain his position. The various cases incurred an expense of over $106,000 cash, taking up about one-third of Mr. Corliss' personal time, but in the end he was fully vindicated, and the final judgments of the court rendered in his favor.

In 1857, the Corliss Steam Engine Company was organized under the laws of the State to take charge of the business of the concern, and for more than five years past Mr. Corliss has been the sole owner of the whole of the stock. The engine which we have before us is the result of one individual's effort.

In reference to the special points which distinguish this particular engine, it may be said to be a strictly engineering design, the material of the framework being arranged directly on the constructive lines so as to best resist the action of the forces which come upon it at the least waste and expense. The forms of the lines of curvature of the walking-beams are important in considering the effects of cooling in the castings, and the shape is that best adapted to resist the stresses to which they are exposed. The arrangements by which the keys of the connecting-rods are accessible in any position of the beams, and the cutting away of the lower portions of the beams, making the lower lines different from the upper, are all noticeable. In fact, every detail of the design has been made with a view to the strength, symmetry and accessibility of the parts. The valve-gearing is a very novel and characteristic feature, all the peculiarities having been emphasized and carried to greater perfection than in any previous engine manufactured by the company. The crank-pins are covered with a coating of the best steel, hardened and ground as smooth as glass, and all work on the machine has been carried out with equal thoroughness. The engine is really a double engine formed of two large beam engines of 700 horse-power each, set upon a raised platform fifty-five feet in diameter, and having between them a single fly-wheel (a gear), the cranks of both connecting with the same crank-shaft. Although possessing nominally 1400 horse-power, it may be increased, if found necessary, to 2500 actual horse-power. The cylinders are 40 inches in diameter, and the stroke is 10 feet, the intention being to work with from twenty-five to eighty pounds of steam, according to the requirements of the Exhibition. An engine at the Wamsutta Mills, New Bedford, has a larger cylinder, but it is not so heavy an engine, and will not stand so high a pressure or do as much work as this one. The air-pump and condensing apparatus are fully provided as required. The gear fly-wheel, which is 30 feet in diameter and cast in sections, weighs about 56 tons, and is believed to be the heaviest cut wheel ever made. It has two hundred and sixteen teeth, finished with the greatest accuracy, moving without noise at the required rate of running, viz., thirty-six revolutions per minute. The crank-shaft is 19 inches in diameter and 12 feet long, made of the best hammered iron, and the bearings are 18 inches in diameter and 27 inches long. The cranks are of gun-metal, weighing over 3 tons each. The walking-beams—which weigh about 11 tons each—are cast in one piece, and are 9 feet wide in the centre and 27 feet long. The connecting-rods are of horse-shoe scrap-iron, and the piston-rods, 6¼ inches in diameter and of steel, their velocity at the regular rate of speed being 720 feet per minute. The large gear-wheel, connecting with the gear fly-wheel, is 10 feet in diameter, and is a single casting of 17,000 pounds weight. It is placed on a main shaft 252 feet in length, running crosswise of the building, and connecting at the ends and at two intermediate points by nests of bevelled gear 6 feet in diameter to shafts 108 feet in length, running at right-angles to the main shaft, and extending to points directly under the lines of overhead machinery shafting. These four connecting shafts have at their ends the main pulleys—eight in all—seven of them 8 and one 9 feet in diameter, and each 32 inches across the face. They are connected to the main machinery shafting overhead by double belting 30 inches in width, making an aggregate width for all together of 20 feet, required for the transmission of the whole power of the engine. Each belt drives a line of shafting of over 600 feet in length, with a separate section of the machinery, and where the belts rise from the floor, they are enclosed by glass partitions so that they may be out of the way and yet be visible to the visitor as exhibits.

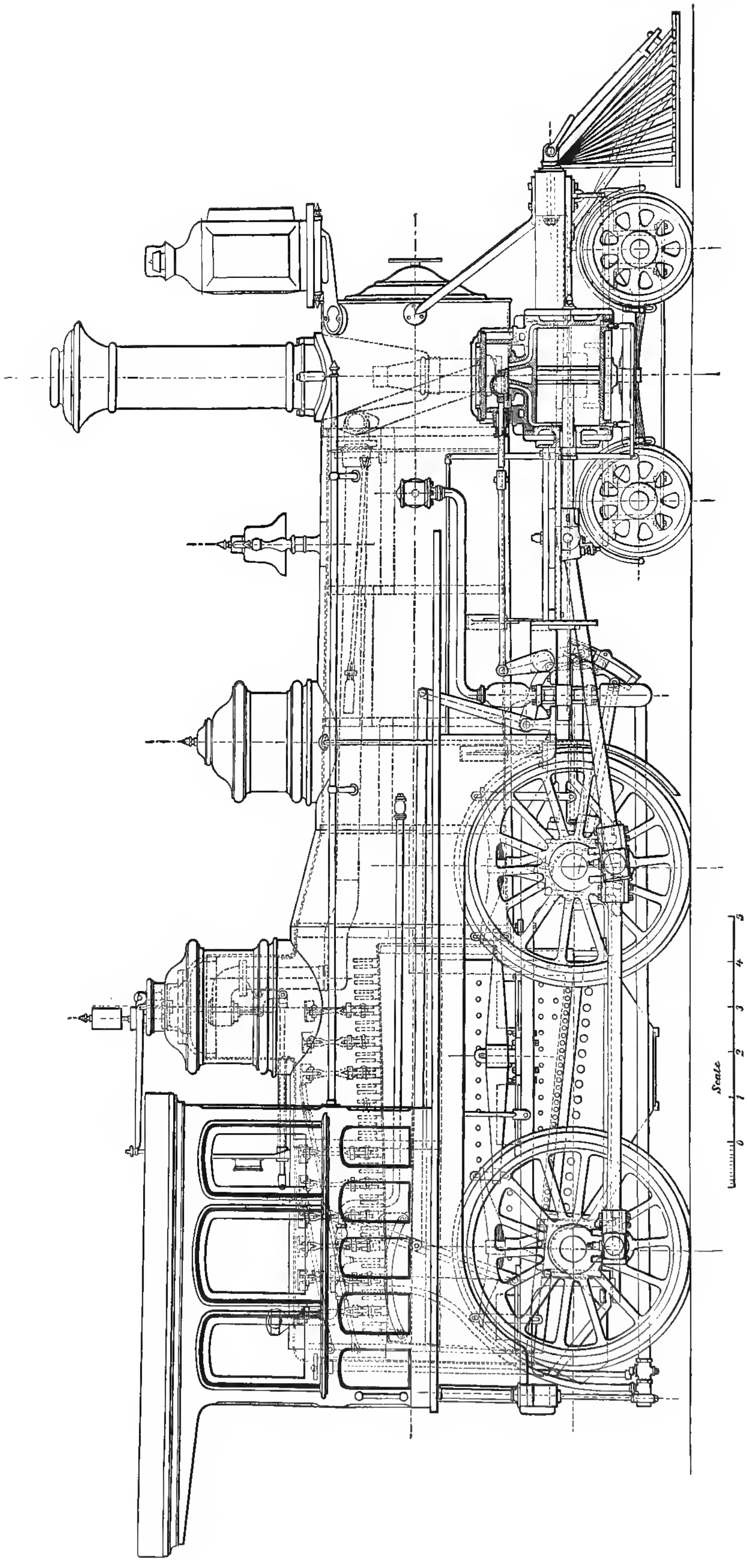
The engine as a whole is 39 feet in height from the main floor of building to the top of walking-beam at its highest pitch, and every part is easily accessible by means of balconies and stairways. Its total weight, including everything connected with it, is about 680 tons. The general proportions are exceedingly harmonious and graceful, and the details simple and in excellent taste, the frame-work, walking-beams, balconies, etc., being painted of a quiet, uniform tint, relieved only by the polished work of the cylinders and moving parts.

The boiler-house—just south of the Machinery Hall—contains twenty Corliss upright boilers of 70 horse-power each, of a simple, vertical tubular type, entirely accessible inside and out. The water rising very rapidly around the tubes in the central part of the boiler is provided with a large return space next to the outside where the current moving more slowly allows an opportunity for the deposit of sediment, which may readily be removed. At the top, each tube is easily reached for cleaning when required. Horizontal flues, lined with fire-brick connect with two brick chimneys, and the steam is conveyed to the engine by means of a double-riveted wrought-iron pipe 18 inches in diameter and 320 feet long, well protected with felting to retain the heat of the steam, and carried through an underground passage, lighted by gas, and sufficiently large for a man to easily walk its whole length.

Among the firms represented at the Centennial Exhibition none occupy greater prominence than MESSRS. BURNHAM, PARRY, WILLIAMS & CO., of the BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA.

This establishment owes its origin to Matthias W. Baldwin, who commenced business in Philadelphia in 1817 as a jeweller, and eight years later entered into partnership with Mr. David Mason, a machinist, for the manufacture of book-binders' tools and cylinders for calico-printing. Requiring a stationary engine for carrying on the work, and not finding a satisfactory one in the market, Mr. Baldwin determined to make one for himself. His efforts were successful, and an engine was built of such excellent design, workmanship and efficiency as readily to procure for the firm orders for similar engines. Thus Mr. Baldwin's attention was turned to steam-engineering and the way prepared for taking up the problem of the locomotive when the time should arrive. The original engine is still in use at the works of the present firm, quietly performing its allotted duty from day to day, and preserved as the germ of the mammoth industry now being carried on by the largest exclusively locomotive-building firm in the world.

Mr. Mason soon leaving the firm, Mr. Baldwin continued the business alone. His first locomotive was in miniature, constructed for Peale's Museum, of Philadelphia, in 1831, and its success was such that he received an order for a locomotive for the Philadelphia, Germantown and Norristown Railroad Company, —then being worked by horses—which he completed and delivered in November, 1832. The "Old Ironsides," as it was called, although constructed under many difficulties, was, compared with others of the day, a marked and gratifying triumph, and it did effective duty for many years afterwards.



Passenger Locomotive: Burnham, Parry, Williams & Co.

Van Ingen & Snyder, Eng.

From this the business has progressed up to the present time, passing through many changes but always with Mr. Baldwin at the head until his death in 1866, when a new organization was effected and afterwards modified to the present firm. Its history corresponds with that of many others of our prominent business organizations, filling an important page in the history of the progress of machine manufacture in this country. The works now have a capacity of five hundred locomotives per year, the total number that have been constructed in all being about five thousand.

Among the exhibits of this firm is a Passenger Locomotive built for the Central Railroad of New Jersey, and represented by the engraving on the preceding page. It has a gauge of road of 4 feet 8½ inches and a total wheel-base of 44 feet 2 inches, including tender, or of locomotive alone, 22 feet 5 inches. The driving-wheels are 8 feet 6 inches to centres and 5 feet 2 inches in diameter, having centres of cast-iron with hollow spokes and rims. The truck-wheels are 2 feet 4 inches in diameter. The Washburn steel tires are used. The total weight of the locomotive in working order is 75,000 pounds, and the weight on driving-wheels 51,500 pounds. The cylinders are placed horizontally, each cylinder cast in one piece with half saddle, right- and left-hand cylinders, reversible and interchangeable, the diameter of cylinder being 1 foot 5 inches, and length of stroke 1 foot 10 inches. The oil-valves to cylinders are placed in the cab and connected to steam-chests by pipes running under jacket of boiler. The boiler is of the wagon-top type, furnished with one dome and made of best homogeneous cast-steel three-eighths of an inch thick, manufactured by Hussey, Wells & Co., the outside diameter at the smallest ring being 4 feet. The fire-box is of cast-steel of the same manufacture, 8 feet 6 inches long by 2 feet 9¾ inches wide, the side sheets being one-fourth and the back sheet five-sixteenths of an inch thick. The tubes are of iron, lap-welded, made by W. C. Allison & Sons, with copper ferrules on the fire-box ends. They are 2 inches in diameter, 11 feet 3 inches long and one hundred and sixty-three in number. The heating surface comprises 1065 square feet, including grate, fire-box and tubes.

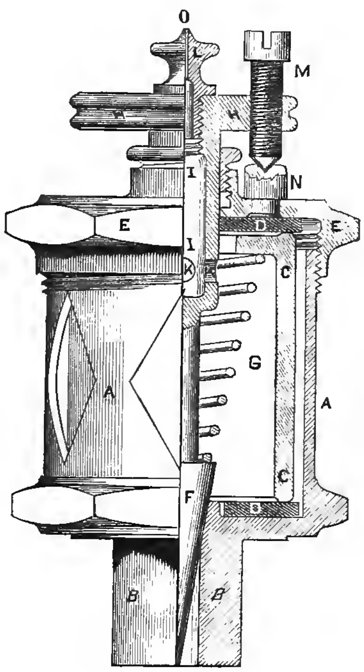
The tender has eight wheels of 2 feet 6 inches diameter, furnished with Taylor's steel tires. The capacity of tank is 2200 gallons, the tank-iron being manufactured by the Catasauqua Manufacturing Company. The engine throughout is finished according to the high standard for which this firm is so celebrated—solid, substantial and neat, with no useless ornamentation, every part fitted to gauges and thoroughly interchangeable, the whole being an excellent specimen of American manufacture.

In connection with the motive-power exhibits we may very appropriately mention Lonergan's Patent Oil-Cups and Automatic Lubricators. The principles upon which they work have been beautifully carried out, resulting in most excellent forms of apparatus for the requirements. The oil-cups are of several varieties to suit different purposes. Our first engraving, on page 15, shows the usual construction for stationary motion, being partly in section and partly an exterior view.

It consists of a metallic cup or casing, A, A, pierced by diamond-shaped openings in the cylindrical part, with a tube, B, to be connected with, and passing to, the part to be lubricated. Inside of this casing is a glass cylinder, C, with cork rings, D, D, at top and bottom. The cap, E, screws down tightly on to the cork, making an oil-tight joint. A plug, F, with ground joint, and held in place by a spiral spring, G, effectually closes the tube B and prevents the passage of oil unless desired otherwise. This plug connects with the handle, H, H, on top, the connection being movable through the cap, E, of the casing and hollow in the upper portion as shown at I, I, there being openings, K, at the lower end of this hollow space, and a cap, L, screwed on at the top, the latter having an air-hole, O, pierced through it. A set screw, M, passes through the rim of the handle, H, with a rest, N, for the same in the cap, E. When it is desired to fill the cup, the cap, L, is unscrewed and the oil poured in, the handle, H, being turned around until the set-screw, M, is off of its rest, N, the plug, F, then tightly closing the entrance to the tube, B. After filling and replacing the cap, L, then by turning the handle, H, and placing the set-screw, M, on its rest, we can, by adjusting this screw, regulate exactly the required amount of opening necessary at F for the proper oiling of the machine. When the machine is at rest and no oiling needed, it is only requisite to raise the handle, H, and turn it so as to move the set-screw from its rest, and the spring, G, at once closes the plug, F, into the opening of B and stops the consumption of oil.

Figure 2 shows a modification adapted to movable parts under rotary motion. The spring, G, is dispensed with and the loose plug, F, has a little stop, P, in it, the set-screw, M, being differently arranged as shown. At each rotation the loose plug, F, is thrown up, the distance of its throw being regulated by the set-screw, and a certain amount of oil finds its way down the tube, B, B.

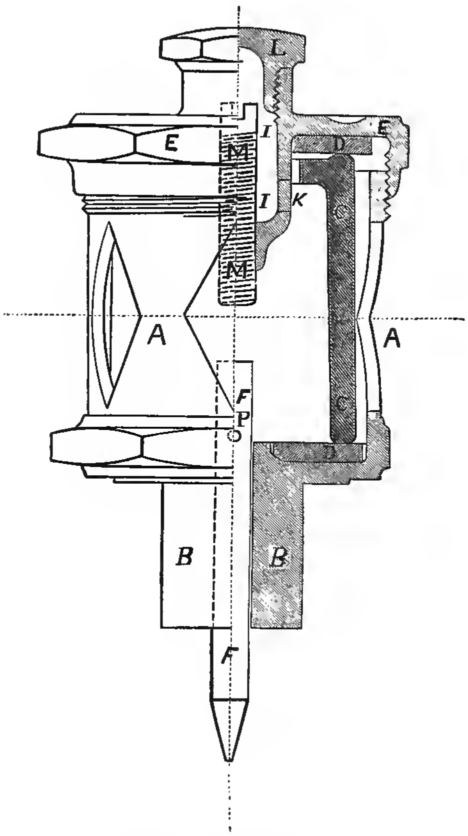
The Automatic Lubricator, as shown by Fig. 3, has a cup composed of the best quality steam metal and made extra heavy, with a regulating arm on top allowing adjustment to any feed desired, there being small holes or rests for the end of the jam-screw of this arm at short intervals all around the circumference of the cap of cup. In arranging it for use, the valve, B, is closed and the cup filled with lubricant through the stem, E. The top, D, which has a lignum-vitæ handle to prevent heating, is then screwed down tight, and the valve, B, opened by turning the handle until the indicator or arm is half-way around the cup. After a moment it is moved partly back to within say six or eight holes from the starting-point. By actual experience, the engineer can adjust this to the exact requirements of his engine. Steam passes into the cup by the valve, B, and condensing into water sinks to the bottom of the oil, lifting an equal amount of the latter to the top, which flows down the pipe to the parts where lubrication is desired. The large opening in the pipe to the top of the feed-valve allows a circulation of steam, keeping the lubricant in a liquid state independent of outside temperature and securing thereby a uniform feed. A waste-cock is provided for drawing off the condensed water and impurities which collect in the bottom of the cup.



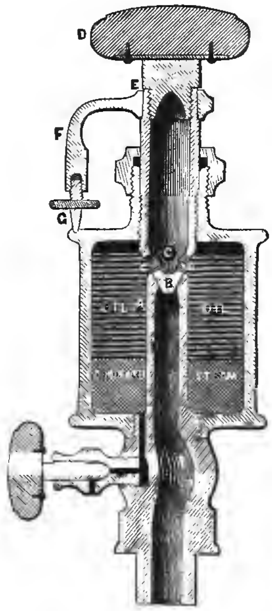
Lonergan's Oil-Cup; Fig. 1.

Especial attention may be called to the ease and precision with which these cups may be regulated to any desired feed and the evident saving in oil thus effected, and in the case of the last form described, the admission of steam into the cup at all times, whether feeding or not, is an important point, keeping the lubricator always in a condition for use without waste or trouble. These oil-cups have been introduced on the engine "Dom Pedro II," of "Baldwin Locomotive Works," on exhibition in the Machinery Hall.

Machine tools, as distinguished from hand tools, are those designed for planing, shaping, drilling, or boring metal, wood, or stone, in which mechanical



Lonergan's Oil-Cup; Fig. 2.



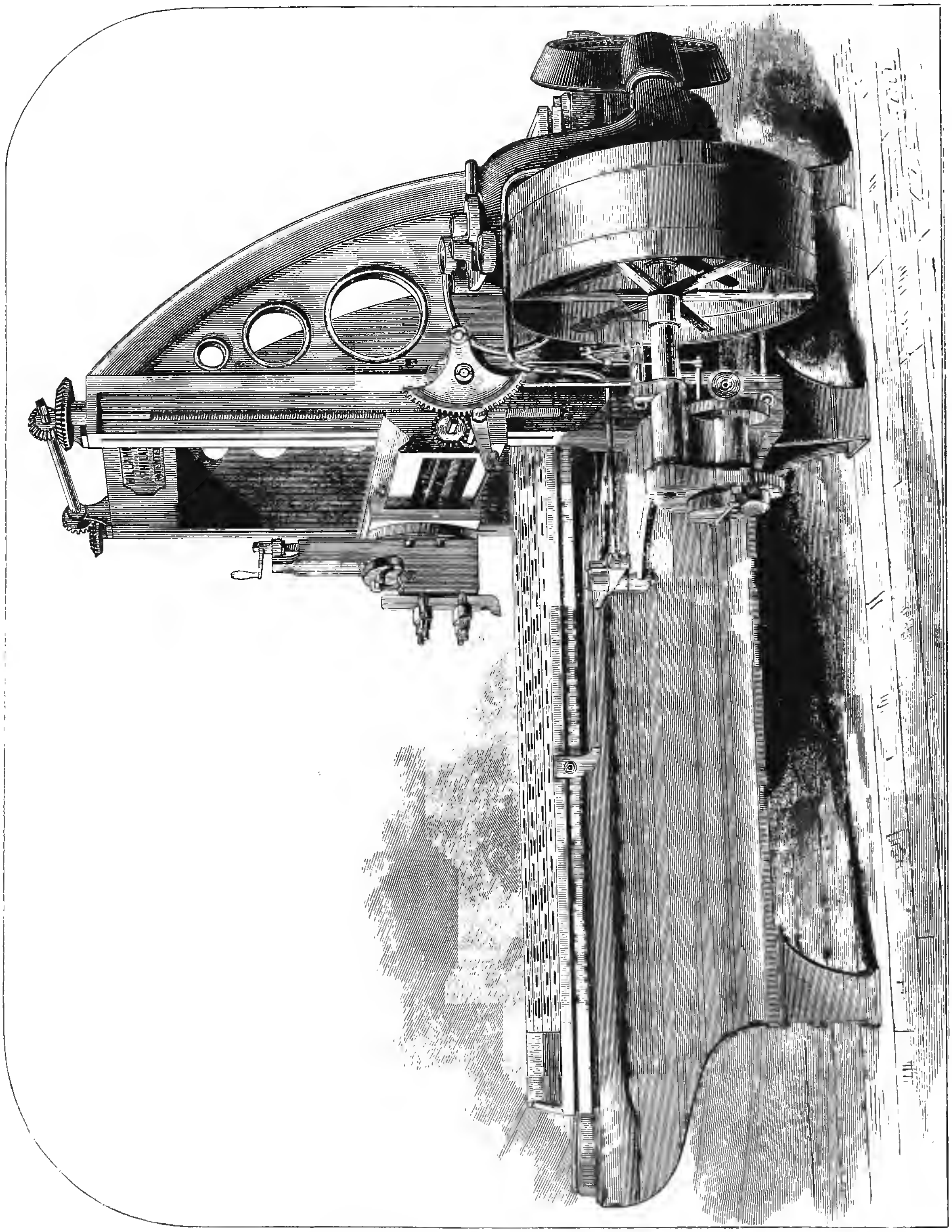
Lonergan's Oil-Cup; Fig. 3.

appliances take the place of manual skill in guiding the tool or cutting edge in its determined path. The term comprises not only turning-lathes and drill-presses, but also hydraulic forging-machines, steam-hammers, riveting-machines, punching and shearing-machines, and, in fact, all those for working metal or other material in which the above condition is fulfilled.

The manufacture of machine tools of late years has become a specialty. The requirements of modern engineering demand an extensive use of these tools, and exact that they shall be made in the greatest attainable perfection, and as far as possible self-acting or automatic, capable when once started at work of doing perfectly what is given them to do, without depending upon the attendant for the result.

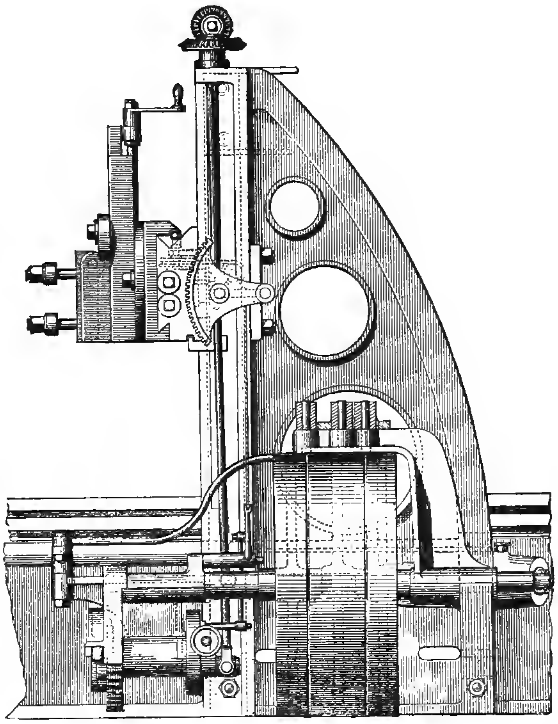
We have already mentioned in the "History of Previous Exhibitions" the exceedingly favorable impression produced by the machine tools of Messrs. William Sellers & Co. as exhibited abroad. This firm has taken a prominent position in the present exhibition, occupying a large extent of space in the Machinery Hall with their characteristic and novel machines. From among the number we may mention a patent self-acting planing-machine for horizontal, vertical and angular planing of any required length. This machine differs essentially from ordinary planers, possessing peculiarities that impress the beholder at once with the amount of master-thought that has been expended upon its design. Attention is first attracted to the method by which motion is given to the table holding the object to be planed. A special form of spiral pinion being used, placed upon a driving-shaft which crosses the bed diagonally, passing out in the rear of the upright on the side next to the operator and connecting with the pulley-shaft by means of a bevel-wheel and pinion. The location of this pulley-shaft, as may be seen from the engravings, brings the driving-belts within easy reach of the workman, and the fact of its axis being parallel to the line of motion of the table permits the machine to be placed side by side with lathes, thus economizing space in the shop. There are four teeth on the pinion, arranged like the threads of a coarse screw of steep pitch, and working into a rack on the table, the teeth of which are straight and are placed at an angle of five degrees to its line of motion, to counterbalance any tendency of the pinion to move the table sideways.

We understand that this arrangement for moving the table has been found to be very durable, the operation of the teeth being more of a rolling action than a rubbing or sliding one. A strong box-shaped connection between the sides of the bed, just at the uprights, holds them very firmly together, an advantage not attainable in most other forms of planers where the methods adopted for giving motion to the table do not allow the required space. The plan of diagonal shaft adopted has another superiority in throwing the bevel-wheel and pinion driving it, out from under the table and allowing the former to be made of any necessary size compared to the latter as may be required to give the requisite reduction in speed and transmission of power from a high-speed belt without the interposition of other gearing, whereas, in the ordinary screw-planer, the projection of the table over the ends of the bed limits the size of the gearing at the end of the screw. The method adopted for shifting the belts constitutes



Planing-Machine: William Sellers & Co.

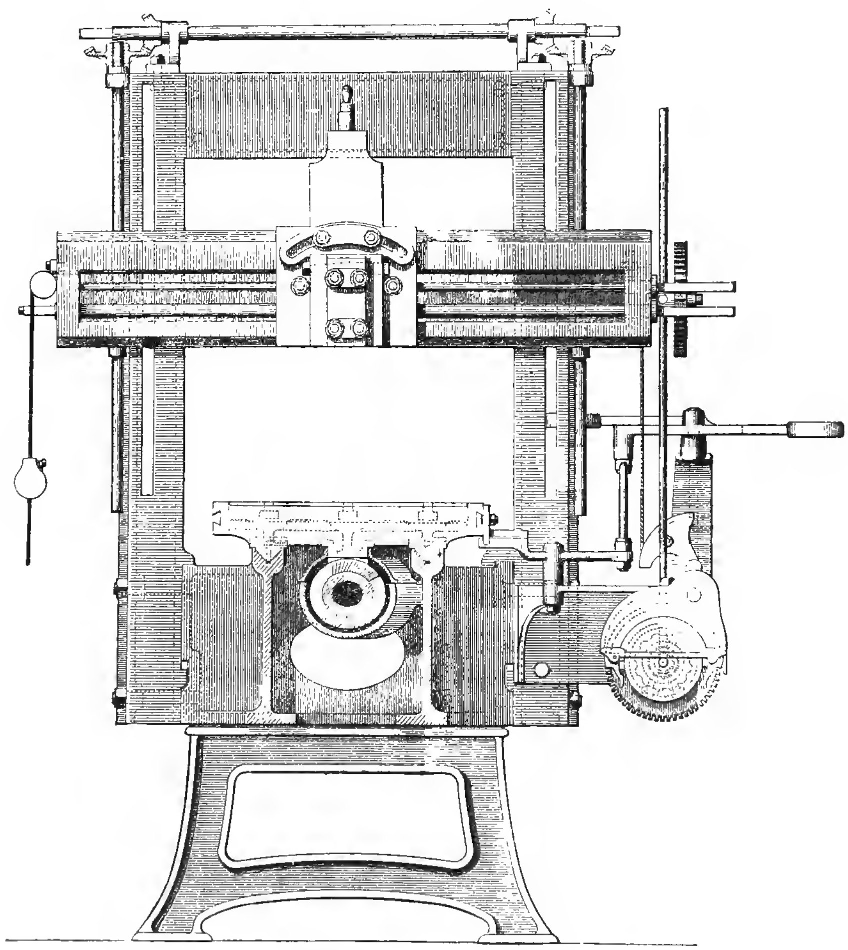
another novelty. An arm rises from the rear bearing of the pulley-shaft extending over the pulleys and supporting three fulcrum-pins. On the centre one is a peculiarly shaped lever, swinging horizontally between the other two upon which are placed the two belt-shifters. The shifters are operated from the middle lever by teeth or projections on each, the arrangement being such that one shifter is always moved before the motion of the other is commenced, one belt always leaving the driving-pulley before the other begins to take hold and reverse the motion, requiring but little power, allowing the least possible lateral



Planing-Machine. Fig. 1. Side Elevation.

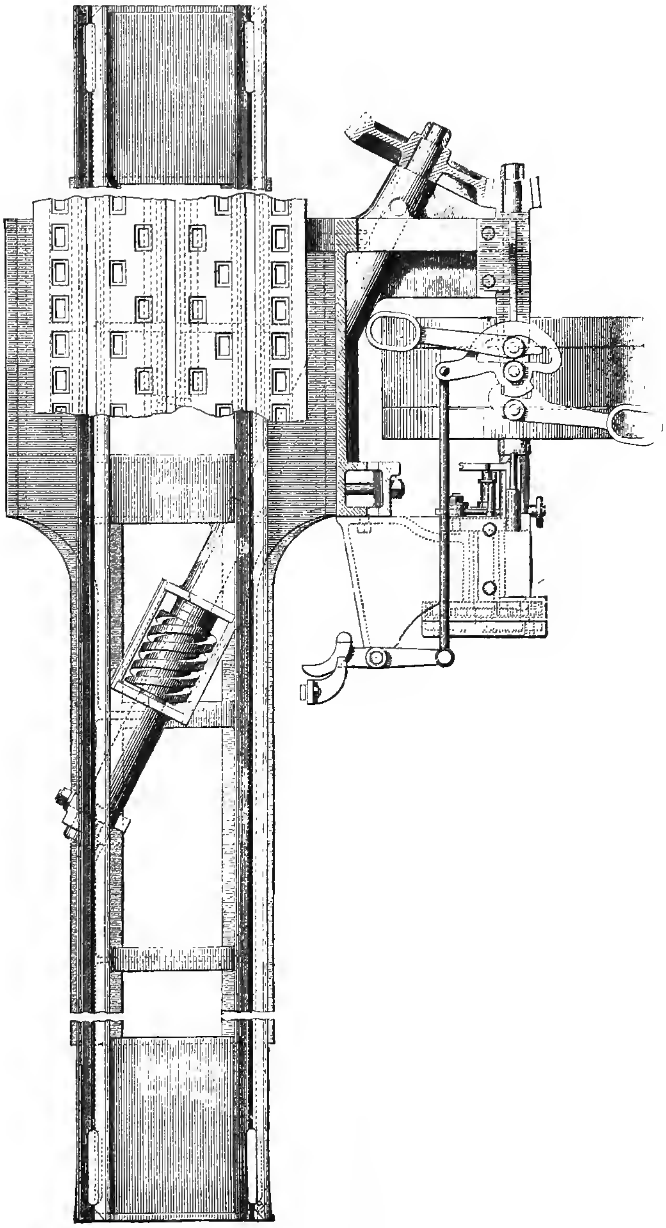
motion of the belts and avoiding all undue straining and shrieking. The usual adjustable stops are provided on the sides of the table, operating the belt-shifting apparatus by means of a double-armed lever and link connection. The position of this apparatus is exceedingly convenient for the workman if he desires to change the belts without reference to the stops, allowing him to easily control and reverse the motion of the table by hand or even to stop it entirely by shifting both belts on to the loose pulleys without arresting the motion of the counter-shaft. This is a great advantage at times when planing surfaces of irregular shape.

The machine has positive geared feeds, self-acting in all directions with tool-lifter operating at all angles. The feed motion of the cutting-tool is obtained in nearly all planing-machines from the belt-shifter, entailing upon the stops on the table an undue amount of work and really resulting in quite limited variations of feed. The usual screw and central feed shafts are provided in this



Planing-Machine. Fig. 2. End Elevation.

machine in the cross-head for horizontal or vertical motion, receiving the variable motion for any required amount of feed through a ratchet-wheel fitted interchangeably to their squared end projections. This ratchet-wheel is operated by a toothed segment, which receives at each end of the stroke of the tool the required alternate movements in opposite directions by means of a light vertical feed-rod from a crank-disk below, on which the crank-pin is so arranged as to allow any variation and adjustment of throw and amount of feed that may be desired to be made during the cutting stroke of the machine. The crank-plate



Planing-Machine. Fig. 3. Plan.

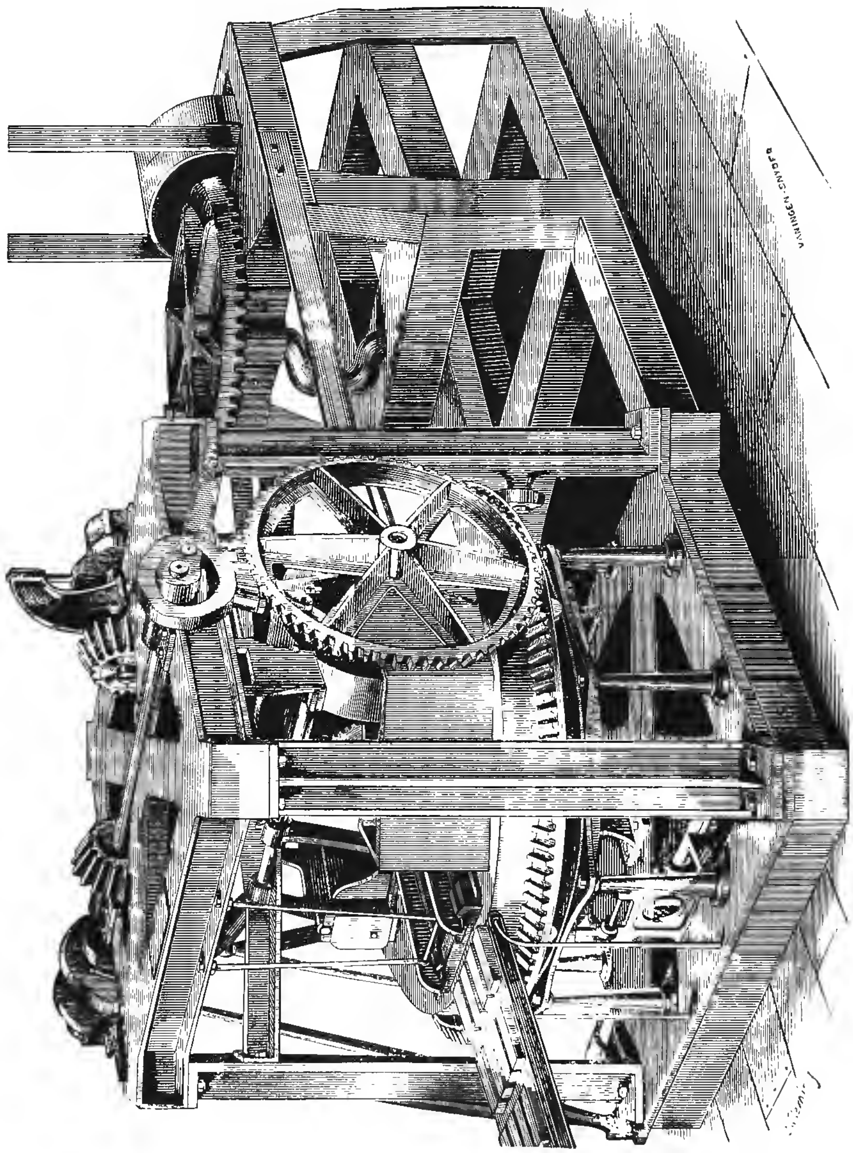
is alternately moved a half revolution and disengaged in either direction at each reversion of the stroke of the tool by means of an ingeniously contrived double pawl and ratchet-wheel, receiving motion from a pinion on the front end of the pulley-shaft. At each change of motion the pawl is thrown into gear by friction, keeping up a positive motion of the crank-disk by the ratchet-wheel until the pawl is disengaged from its teeth by a positive stop.

Messrs. Sellers' method of lifting the tool-point on back motion in this machine merits attention as another improvement on the usual plan, which, in most planing-machines consists in hanging the cutting-tool in what is called an apron, so adjusted as to allow it to swing loose on the back stroke, but to be held rigidly when cutting. This arrangement is very objectionable in all fine planing, and especially in large planers where the tool is quite heavy. Various ideas have been put into practice for actually lifting the tool-point clear of the work on the back stroke and dropping it into place again ready for action on the return, but the method here shown possesses especial ingenuity, lifting the tool in every position of the slide-rest, and doing so from within the cross-head without interfering in any way with the automatic feed motion, the machinery for working the feeds occupying the centre about which the adjustable part of the saddle rotates. This lifting apparatus is operated by a cord attached to a grooved segment which is connected with the crank-plate of the feed motion by a link, a reciprocating motion being imparted to the cord corresponding with the motions of the table, and occurring only at the end of each table movement, beginning with the reversion of each stroke. The cord is guided over sheaves at the ends of the cross-head and passes around a cord-wheel in the saddle, having at its other end a weight to keep it in tension. The cord-wheel, by means of a pinion at the other end of its shaft, operates on a light annular plate-wheel recessed into the saddle, around the central part containing the small feed bevels. In a spiral groove on the face of this plate-wheel slides a block which is attached to the end of a pipe surrounding the vertical feed-screw, and extending upward through the casting, with a pair of elastic clamps at its upper end. These clamps operate by friction on a flat rod which passes the whole length of the vertical slide on its side next to the saddle, and has at its lower end, which is thickened up, a hole. The long arm of a bell-crank lever fits loosely into this hole, and the short arm extends down directly behind the tool-apron. The action of the cord imparts motion to this bell-crank and affects the tool apron, pushing it forward and letting it fall back again into place as required. The action is perfect and beautiful, without interference with any of the functions of the machine in the least. When the vertical slide is turned into any new position upon the horizontal axis of the saddle, the pin in the spiral slot drags the plate-wheel around, the cord-wheel slipping within its encircling cord, and as soon as the machine is started adjustment to the new position takes place at once among the parts, the lifting apparatus operating as before.

The mechanical engineers of this country, as a rule, adopt original methods of design, taking the problem presented to them with certain given conditions, such and such results to be accomplished, and working the whole out from a new basis, without any blind adherence to old-established forms or precedents, and it is this which distinguishes our American practice and is productive of such satisfactory results. No firm has had a greater share in work of this kind than Messrs. William Sellers & Co., and their machinery throughout bears evidence of it. We hope to be able to refer to them again at a future time.

Numerous efforts have been made in reference to the manufacture of bricks by means of machinery which should be equal in quality and finish to those made by hand, but great difficulty has been experienced, especially in the case of face or front brick, in that it has been found practically impossible to supply an equal amount of clay to each of the mould-boxes, thereby producing brick of an unequal size and density, and also that the pressure being imparted to the clay from one side only—as has been the general custom—the bricks are often defective in strength, particularly at the corners and edges, and consequently not of first quality. It is claimed that these serious difficulties have been overcome in "Gregg's Triple Pressure Brick-Machine," of which a working specimen is shown in the Exhibition. The principle of this machine is such that the heavy developing pressures take place while the mould-table is at rest, an advantage not attained in any other machine, to our knowledge. There is, accordingly, but a nominal amount of power required to operate it, and a large amount of wear and tear, strain and breakage usual in other machines is avoided.

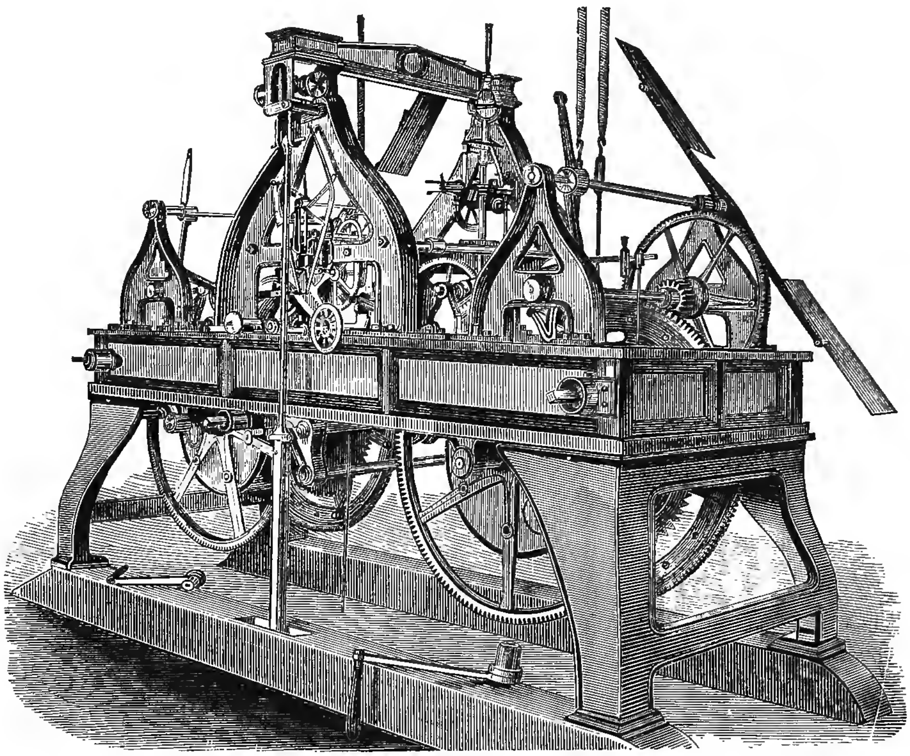
We may designate Brick-Machines under three classes: Dry Clay, Slush, and Crude or Moist Clay Machines. In the first class, the clay after being dried and granulated, is filled into the mould-boxes through "filler-boxes" or graduating measures. When a number of moulds are grouped together it seems to be a practical impossibility to fill them all alike, and the bricks in some are turned out imperfect. The extraction of the moisture in the clay before moulding also destroys its cohesive power, preventing complete fusion in the burning, and producing bricks unable to withstand the action of the weather. In the manufacture of slush-brick, the great amount of water that is used while exceedingly favorable to the production of good brick, is otherwise objectionable on account of the great length of time expended in the slow, out-door process



Triple Pressure Brick-Making Machine: W. L. Gregg.

of drying, and the risk attendant from unfavorable weather, as at least twenty-five per cent. of water must be evaporated from slush-brick before it is safe to burn them. In works producing say thirty thousand of this kind of brick per day, it is stated that upwards of twenty-three tons of water must be evaporated every twenty-four hours.

The present machine occupies a position between the "Dry Clay" and "Slush" machines, and may be designated as a Crude or Moist Clay machine, manufacturing to advantage with crude clay in a state so stiff as to require an evaporation of only about one-eighth that necessary with slush-brick before burning, and yet retaining all the cohesive qualities of the material. The brick, when



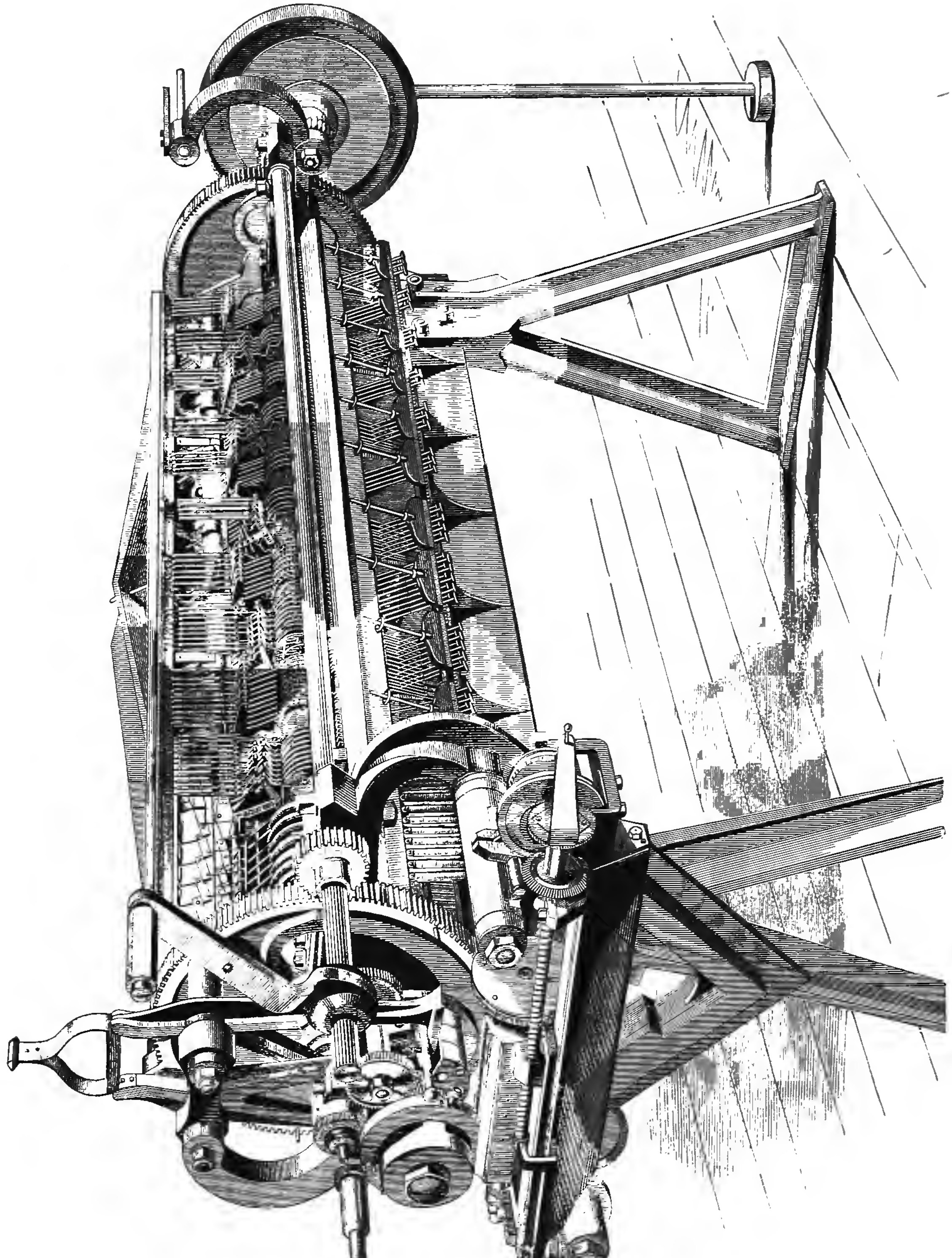
The Great Clock in Machinery Hall: Seth Thomas Clock Co.

burned, are of closer grain, less porous and, therefore, stronger and more durable than those manufactured by the other methods.

The engraving given on page 24 shows the general form of the machine. It is provided with a circular mould-table having an intermittent motion and containing eight sets of moulds, with four to a set, thus making in all thirty-two moulds. There are three distinct places for producing pressure on the clay in the moulds. The first is produced by a pressure-wheel from above, the second by a toggle-joint actuated by cams, and the third from above and below by toggle-joints and cams. The brick are delivered by a sweep-motion on to an endless belt, or carrier. The moulds are of hardened steel and the balance of the machine is of iron worked up in a very solid and substantial manner. A ten horse-power engine, with one of these machines, will produce forty-thousand brick in ten hours, including the preparation of the clay, which is performed by the same apparatus, although not shown in the engraving.

The United States has been noted for many years for the manufacture of cheap, serviceable varieties of clocks, the production of late amounting to over a million annually, and immense exportations being made to all parts of Europe, Asia, Africa, China, Japan, South America, etc., until the "Yankee Clock" has become a household word in every quarter of the known world. It is only within the past twenty years, however, that the construction of Tower Clocks has been undertaken in this country, the supply having hitherto been procured from abroad. Lately, a number of firms have been engaged in this business, with remarkable success, obtaining in a short space of time quite a celebrity, and notably among them may be mentioned the "Seth Thomas Clock Company," one of whose clocks has been placed on exhibition, in working condition, over the east entrance of the Machinery Hall. Its mechanism is shown by the engraving given on the preceding page, and the details of its construction have been carried out in great perfection, bronze metal being used for the wheels, except in the case of the winding-gear, which is of iron, It strikes the hours and quarters upon two bells, the power being sufficient for these to be extra heavy.

An idea may be gained of the size of the clock when it is stated that the main frame is ten feet long by three and a half feet wide and seven feet high from the floor, and that the total weight is seven thousand pounds. In the striking apparatus the main wheels are forty-one inches in diameter and the drums for cords twenty-three inches. The main time-wheel has a diameter of twenty-four inches, and the drum for cord twelve inches. The pendulum has a zinc compensation-rod fourteen and a half feet long and beats once in two seconds, the weight, including pendulum-bob, being five hundred pounds. Dennison's Gravity Escapement is used. Arrangements have been made to run twenty-six electrical clocks from the main clock, to be located in different parts of the building, and to make connection every twenty seconds. The clocks manufactured by this Company are remarkable for their accuracy and the per-

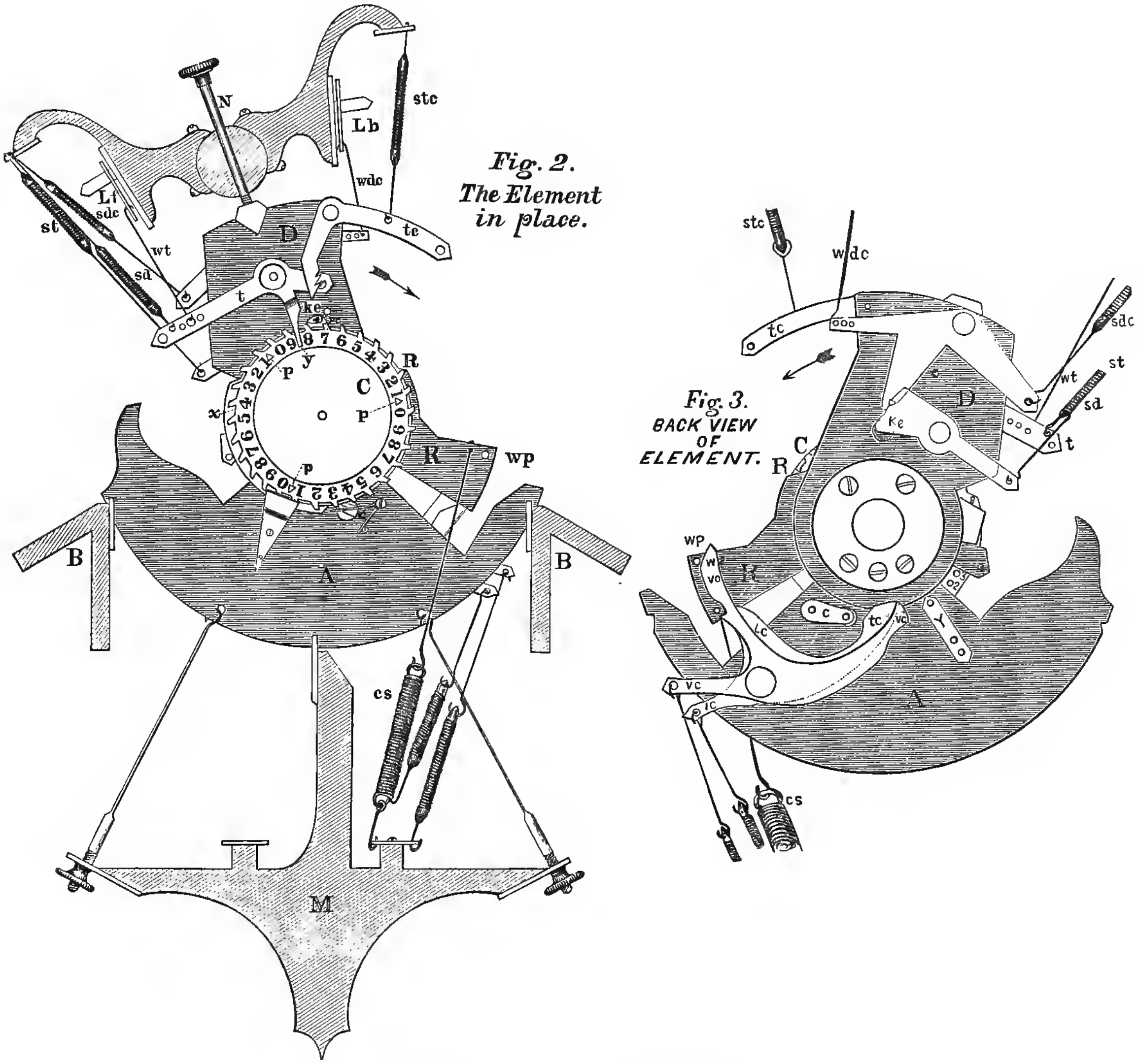


Calculating Machine: Geo. B. Grant.

fection of their mechanism, and have obtained a reputation as first-class time-keepers in every respect.

In a quiet corner of the Machinery Hall, just back of the exhibit of locomotive engines, stands a machine which at first sight would probably puzzle some of our best mechanics to give an opinion as to its use, and even then, would require a master-mind to analyze its mode of action. We refer to the Difference Engine of George B. Grant, designed for the construction of large Mathematical Tables, such as Tables of Logarithms, Sines, Tangents, Reciprocals, Square and Cube Roots, etc., and built for the University of Pennsylvania. All those interested in such subjects are familiar with the Difference Engine of the late Charles Babbage and its failure. Following him came George Schentz, a printer of Stockholm, whose machine, however, never came up to the full requirements of a difference engine, being of slow speed, sensitive and delicate in its details, containing radical defects in the theory of its mechanism and never reaching beyond the entrance to the goal for which its inventor contended. The subject was first taken up by Mr. Grant in 1869, when he was as yet entirely ignorant of the labors of Babbage and Schentz, and the year after, he prepared full drawings of his machine, but met with so much discouragement from those he consulted in the matter that the work was given up. In 1871, however, Professor Wollcot Gibbs—now of Harvard College—heard of his labors on the problem, and after a thorough examination into the subject, approved of the plans and gave so much encouragement to the inventor by his deep interest and constant efforts of support as to contribute largely to the final success that has been attained. After several failures to procure the necessary funds for expenses, a liberal subscription was made by the Boston Thursday Club in 1874, and the same year the means requisite for the construction of a large engine were furnished by Mr. Fairman Rogers, of Philadelphia, to whose munificence science is indebted for the machine now before us, which was finished only a few days before the opening of the Exhibition. When it is remembered how important numerical tables are in practical applications of mathematics, and the great labor and time necessarily occupied in their calculation and publication by the usual methods, involving errors which it seems impossible to prevent even with the greatest care and the most watchful proof-reading, the value of such a machine may readily be seen.

The accompanying engravings—shown on pages 27 and 29—give a very fair idea of the apparatus. It occupies a space of about five feet in height by eight feet in length, and weighs about two thousand pounds, containing, when in full



Views of the Element; Calculating Machine.

working order, from twelve thousand to fifteen thousand pieces. The long body contains the calculating mechanism, while at the front end is an apparatus for printing a wax mould of the results, from which an electrotype may be made directly for printing, requiring no setting of type and no risks of error. The machine is driven either by hand, by a crank at the front end, or by a power appliance at the rear end. The calculating portion of the machine consists of a number of elements placed in the long frame side by side, each element representing one decimal place of the work, and there are from twenty-five to one hundred of these, according to the particular requirements of the problem in hand.

Figures 2 and 3—presented on page 29—show front and rear views of an element constructed of pieces of sheet metal, all in the machine being alike and interchangeable. They are placed in the frame one-half inch apart from each other and arranged in groups, each group representing an order of differences. Referring to the figures, the portion A of the element is fixed and the portion D is a rocking arm revolving upon a bearing at the centre of the plate, C, and and having its upper part—in the case of all the elements—fixed to a long frame, shown in cross-section in the figure at N, which is oscillated back and forth by the driving-gear of the machine. When this frame is moved forward in the direction indicated by the arrow, the arm of each element moves with it and adds to itself the figure that is upon the element of the same decimal place in the group or order below. The pin, k, e, in the figure moves over the teeth of the wheel, C, until a proper point is reached, when it is released by means of mechanism attached to the corresponding element in the order below and falls on to the cogs of the wheel, C, carrying it with it in its forward movement until lifted out from the cogs by the riser at R. As it goes back it sends its figure up to be added to the element of the same decimal place in the next group or order above. The trip, t, striking one of the pins, p, draws down upon the wire, w t, and by means of a longitudinal lever, L f, acts upon a wire that releases the driver, k e, of the element added to in the order above. (See L b and w d c in the figures.) The action throughout is the same, each motion forward adding all the odd orders to the even ones, and each motion back adding the even orders to the odd ones and at the same time printing the tabular number at the front end of the machine, stamping it into the wax plate there for that purpose.

This machine possesses a very great advantage over any previous invention of the kind, in that any wheel may be connected so as to add its number to any wheel of the next higher order. In the machines of Babbage and Scheutz each element was arranged to add its figure to a given fixed wheel in the order above. With a given amount of mechanism, by means of this arrangement, this machine can accomplish work of three times the complexity of any former machine.

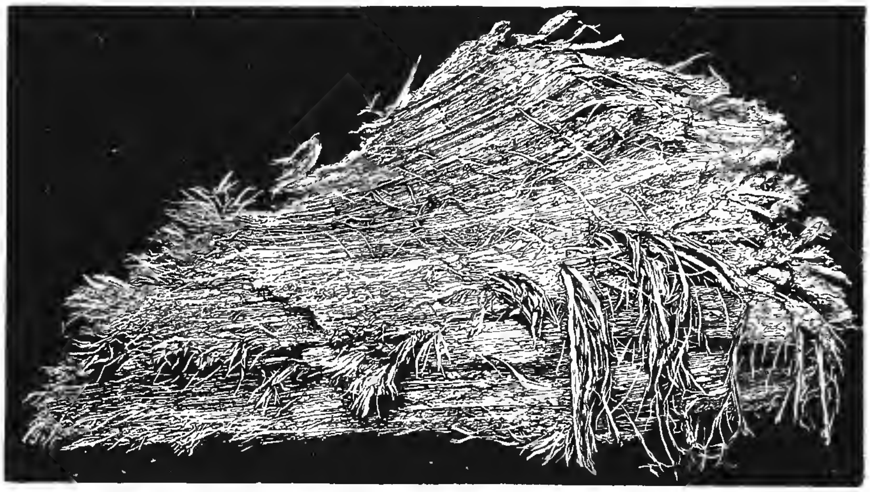
Many of the figures used in an operation are constant. Thus, the last order is constant at various values and many of the other elements are fixed at zero or at nine. To provide for this, each element carries a constant-wheel, consisting of a thin disk of brass, x, which turns on the bearing of the calculating-wheel, and being set at any figure by the spring and pin, y,—Fig. 2—allows the driver, k, e, to drop on the wheel at the same tooth each time and add a constant figure. Thus—see Fig. 2—if set at 8, there are 8 units added at each movement.

The operation of carriage, while simple as to mechanism, is exceedingly complex in theory of action, the apparatus for the same, although by far the most important part of any calculating-machine, being, nevertheless, the most difficult to contrive, and it was to this that Babbage's machine owed its failure, and Scheutz's machine its slow working speed. The riser, R, is hung on the centre-pin of the wheel, C, and it falls as the wheel passes from nine to zero, throwing the driver, k e, out one space further on than otherwise would be done and carrying a unit to its wheel. This riser, R, is held up by two catches which are operated by the pins, p, p, p. On the next wheel below, one catch is drawn aside as the wheel passes from eight to nine and the other as the zero is reached. As the riser drops, a pin, w p, upon it strikes and draws the upper catch of the next wheel above. The arrangement makes a perfect and simultaneous carrying apparatus, acting under any possible combination of requirements.

The construction of the printing apparatus is rather complex as many conditions must be satisfied. Each of the upper ten calculating-wheels is connected by gearing with a die-plate, in the edge of which common printing type are set. While the machine is in motion, these plates are separated slightly and work easily without interference with each other. When an impression is to be taken, they are brought closely and firmly together and a pair of plungers at the same time straightens the line of figures and presents it ready for the plate of wax below, which rises and receives the impression.

The terms of the table can be arranged in almost any way desired for printing, either each under the preceding, or before it, or they may be run across the page, as is generally done, and either forward or backward. It is also possible to adjust the distance between the lines and vary it from line to line as required.

When the machine is worked by hand, a speed may be made of ten to twelve terms per minute, and from twenty to thirty when by power by the attachment at the rear end. All that limits the speed is the imperfection of the mechanism, and in the case of the present machine—the first ever constructed of so complex a character—imperfections are to be expected which will not exist in future machines. Thirty of the elements of this machine were placed in a light wooden frame and worked successfully at a speed of over one hundred terms per minute, and if the whole machine were used and sufficient power applied, this speed would be perfectly practicable, provided that the mechanism of the driving-gear and printing apparatus were in accurate working order and made sufficiently strong to stand the wear and tear resulting from the same.



Asbestos in its Natural State: H. W. Johns.

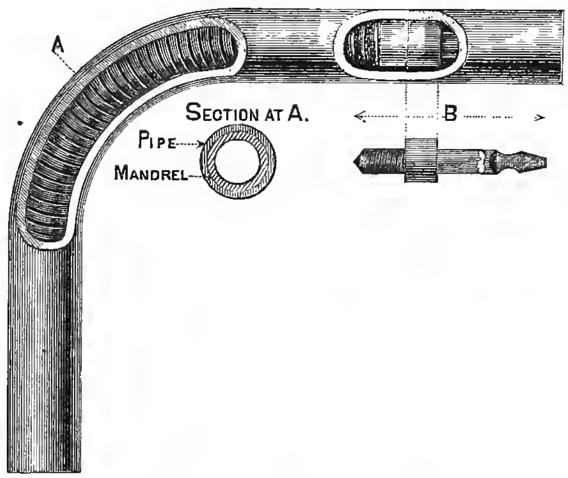
The mineral Asbestos, although familiar to the ancients and employed by them in the manufacture of a fire-proof cremation-cloth and for some other purposes, has, in modern times—until within the last few years—been classed among those substances more curious than useful. The silky, fibrous nature which it possesses, and its well-known fire-proof and non-conducting qualities and resistance to the action of acids have, however, at last attracted attention, and we are indebted to Mr. H. W. Johns, of New York for its adaptation to some very important purposes in the useful arts. We present above an engraving of an exceedingly characteristic specimen of this mineral which has been placed among the exhibits.

Asbestos exists in vast quantities in the United States and numerous other parts of the world. It is obtained from the mines either in bundles of soft, silky fibre or in hard blocks which are capable of separation into fibres. These fibres vary in length from two to forty inches, are of a greasy nature and exceedingly flexible, possessing great strength in the direction of their length, and are therefore capable of being woven into cloth as used by the ancients. These properties possessed by asbestos render it an excellent substance to incorporate into cements—as hair is put into plaster—to bind the parts together and at the same time to give body to the material, and it was this use that Mr. Johns first made of it.

The facilities for obtaining the mineral were very poor—there never having been any demand for it in the market—but as the want was created and it really existed in nature in great quantities, these facilities soon increased and with abundance of material Mr. Johns was enabled to utilize it for other and more important purposes. It was found to make an excellent roofing material. Sometimes it is applied in the form of an asbestos concrete and spread over the roof by a trowel, but more generally a peculiar roofing felt—into the composition of which asbestos largely enters—is first nailed down on the sheathing boards, and this is then covered by means of a brush with a preparation of flocculent asbestos, silica paint, etc., making an entirely water-, fire- and weather-proof surface, a good non-conductor of heat, well adapted to all climates and costing a very reasonable price.

Its non-conducting qualities render asbestos peculiarly applicable as a covering for steam-boilers, pipes, etc., and it has largely been used for this purpose. One of its most recent applications has been for steam-packing. The elevated temperature, moisture and friction to which steam-packing is subjected requires a material possessing just the qualifications existing in asbestos, and experience has shown its great adaptability to this use. As a body for paints, being mixed with linseed-oil and colors, it has succeeded remarkably well; an asbestos paper is made incombustible and very useful for filtering acids, and every day new applications are discovered for this material, so few years ago supposed to be worthless.

Mr. Morris L. Orum, of Philadelphia, exhibits a Flexible Mandrel for Bending Metal Pipe that has attracted considerable attention, being an exceedingly ingenious and novel arrangement of great value in its particular department. By the usual method of bending pipes they are first filled with melted rosin, some fusible metal as lead, or sand, so as to preserve their shape, requiring considerable trouble and care in cleaning out afterwards and making it a tedious, expensive and imperfect job at the best, requiring almost universally—unless with very small pipe—the use of the hammer and file to straighten the irregular crimps formed on the interior curve of the bend. By this method, a mandrel is used, being a strong, closely wound steel helix, formed of square or rectangular wire, and having a uniform external diameter such that it may fit easily in the pipe to be bent. A nut is fastened into one end of the mandrel into which a stem is screwed, which may be made of any length, for removing the mandrel after the work is accomplished. This is done by simply revolving the stem in the direction to wind up the helix, when its diameter is reduced, allowing it to be easily withdrawn, and the spring in the metal restores it to its original size after removal. If the mandrel is not sufficiently long for the whole bend of the pipe, it may be moved from place to place as required, or reverse bends introduced, if desired, with the greatest ease. If the proper sized mandrel is not on hand to bend a given pipe, the next size smaller may be used without any appreciable error.

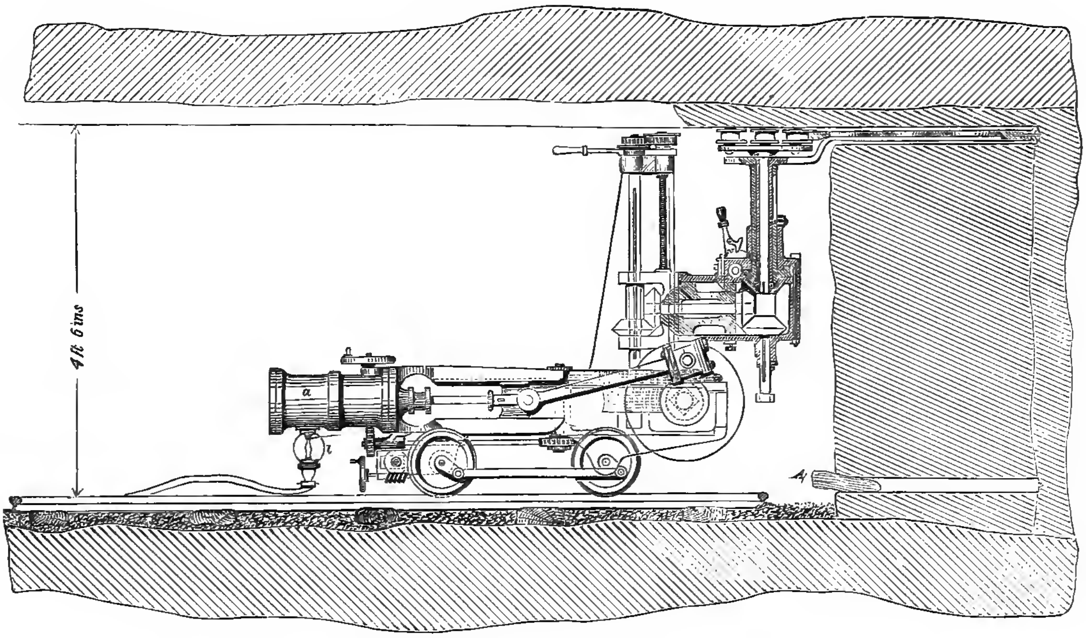


Oram's Mandrel, for Bending Pipe.

Large pipe can be bent as accurately and readily as small pipe, a matter of great difficulty by the old methods, and impossible when the pipe became quite large, requiring previous softening by heat, and resulting in elliptical, unequal and irregular shapes of cross-section that were exceedingly undesirable, the material at the outer diameter becoming very thin and weak. By this method, the pipe after bending has a practically uniform internal section without appreciable variation in diameters, a qualification that will be fully appreciated by the manufacturers of pneumatic despatch-tubes, where this requirement is so necessary.

Mr. Oram has bent ¾-inch butted zinc pipe to a curve of 1¼ inches radius, 1-inch pipe to 2 inches radius, and 2½-inch pipe to 5 inches radius. A 2-inch pipe has been bent to 4 inches radius, cold, without any difficulty. Square pipe may also be bent as readily as round, and the process seems to supply a want long felt.

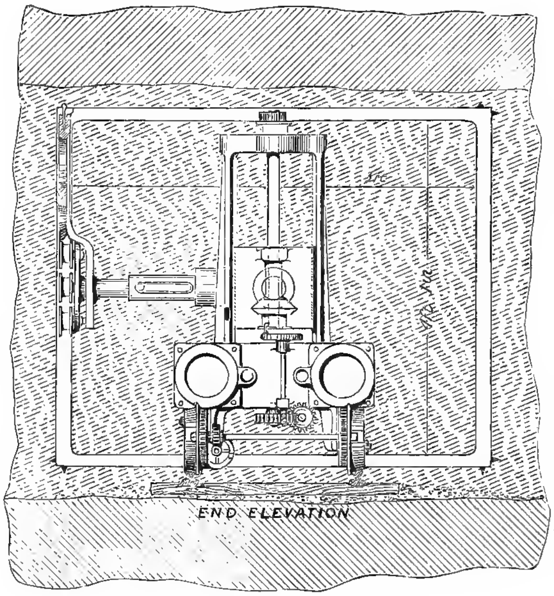
Messrs. Frederick Hurd & Co., of Wakeford, England, exhibit a Coal-Cutting Machine, which appears to present some novelties in design and to be a very

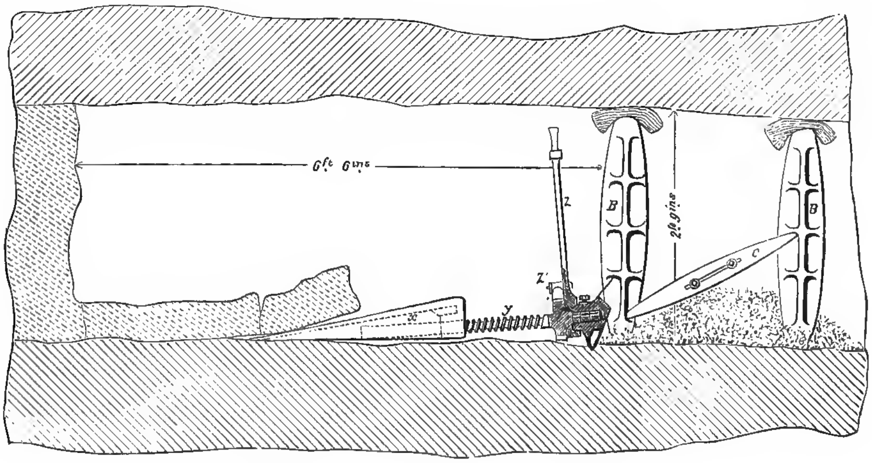


Coal Cutting Machine: F. Hurd & Co.

desirable form of apparatus for our mines, cutting gangway as well as room-work. We refer more particularly to the pattern for four feet to four and a half feet seams, smaller seams not being, as a rule, worked with profit in this country. The illustrations accompanying—presented on pages 36 and 37—will give the reader an idea of the construction and mode of action of this machine. The value and importance of reliable coal cutting machinery is increasing every day, tending to dispense with the most exhausting and dangerous part of a miner's work, to lessen by a very large amount the waste or slack always obtained in getting out coal, and to obviate the expense, trouble and unreliability of hand-labor.

The machine is provided with two cylinders of six inches diameter and twelve inches stroke, and works by the action of compressed air. This has been found the most satisfactory motive power that can be used for mining machinery, being easy of application and, at the same time, improving the ventilation and reducing liability to fire. Motion is given to the cutters by bevel gearing, and the shaft driving the cutters, by a simple arrangement, is made capable of being revolved in a vertical plane about the horizontal shaft, thus providing for cutting out all four faces of the drift, quite an advantage over the usual machines which make only the under-cut. In the cutting-wheel the periphery in which the cutters are fixed is placed eccentric to the fulcrum on which they revolve, and the pressure is resisted by anti-friction bowls, which also act as drivers, thus dispensing with guides and slides. The cutters are put in or taken



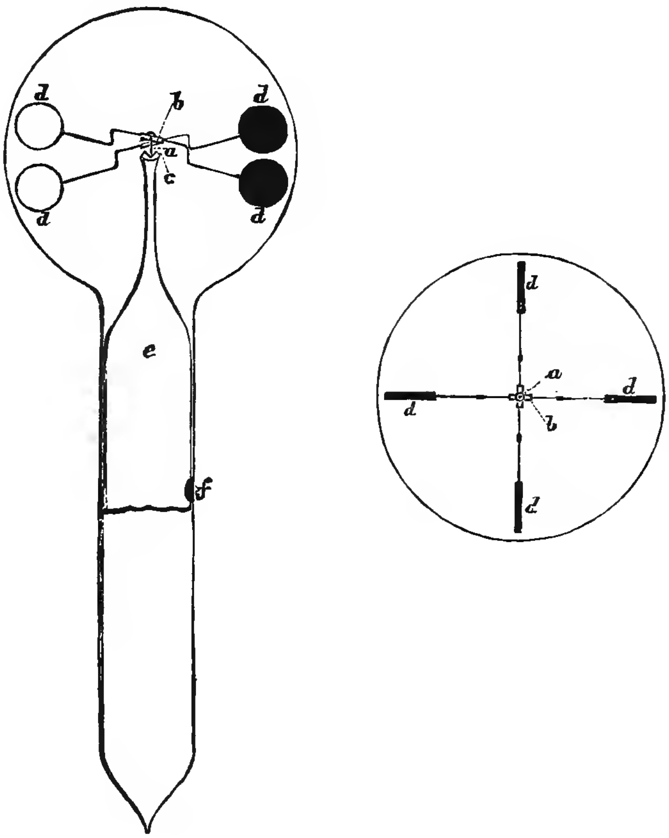


Coal Cutting Machine, Figs. 2 and 3: F. Hurd & Co.

out of cut by a swivel-nut and screw acting on the lever or radial arm in which they revolve, or by a pinion and quadrant. They are made of plain, square, Titanic steel, manufactured by S. Osborne & Co., of Sheffield, and are set sideways, above and below, allowing for the clearance of the disk, being readily adjusted radially to vary the depth of the cut according to the quality of the coal or mineral.

The leading wheels of the machine are kept in position on the rails when at work, by a bowl mounted in a differential lever, with self-acting adjustment to adapt itself to irregularities on the coal face without the possibility of getting off the rails while at work.

After removing the coal included within the cuts, a sort of wedge-shovel,



Crookes' Radiometer: Jas. J. Hicks.

as shown by Fig. 3, is used to raise up and remove the lower portion of the seam. The form of post shown in this figure is not nearly so good as the French post, where the bottom is placed in a ring containing sand, so that if the roof presses down and holds it, it can be relieved by letting some of the sand run out, being on the same principle as the method of supporting the centres for arch bridges by sand-tubes.

Mr. James J. Hicks, of London, England, exhibits a curious apparatus in the form of a Radiometer for demonstrating the mechanical action of light and the conversion of radiation into motive power, constructed according to the design of Mr. William Crookes, F.R.S., to whom is due the discovery of this force. Mr. Crookes' attention was first drawn to the matter from noticing that in weighing heavy pieces of glass apparatus in a vacuum, there appeared to be a variation in weight, corresponding to variations in temperature of the material weighed from that of the surrounding air and weights of balance. This led him to institute a series of experiments with very delicate forms of apparatus, and he discovered that there was a force depending upon the action of the light. In the case of an exceedingly fine and light arm suspended in a glass tube with balls of various materials at the ends of the arm, the whole being thoroughly exhausted from air, he found that on the approach of a heated or luminous body to one of the balls a very decided repulsion took place and an attraction if a cold body, such as ice, was used. He also ascertained that when the different rays from the spectrum were thrown on white and black surfaces there was a decided difference between the action of light and of radiant heat, dark heat having no perceptible difference of action on white or black substances, but luminous rays repelling black surfaces much more energetically than white. Acting upon these facts he designed and constructed an instrument, completely and beautifully exemplifying the principles of his discovery, which he called the "Radiometer."

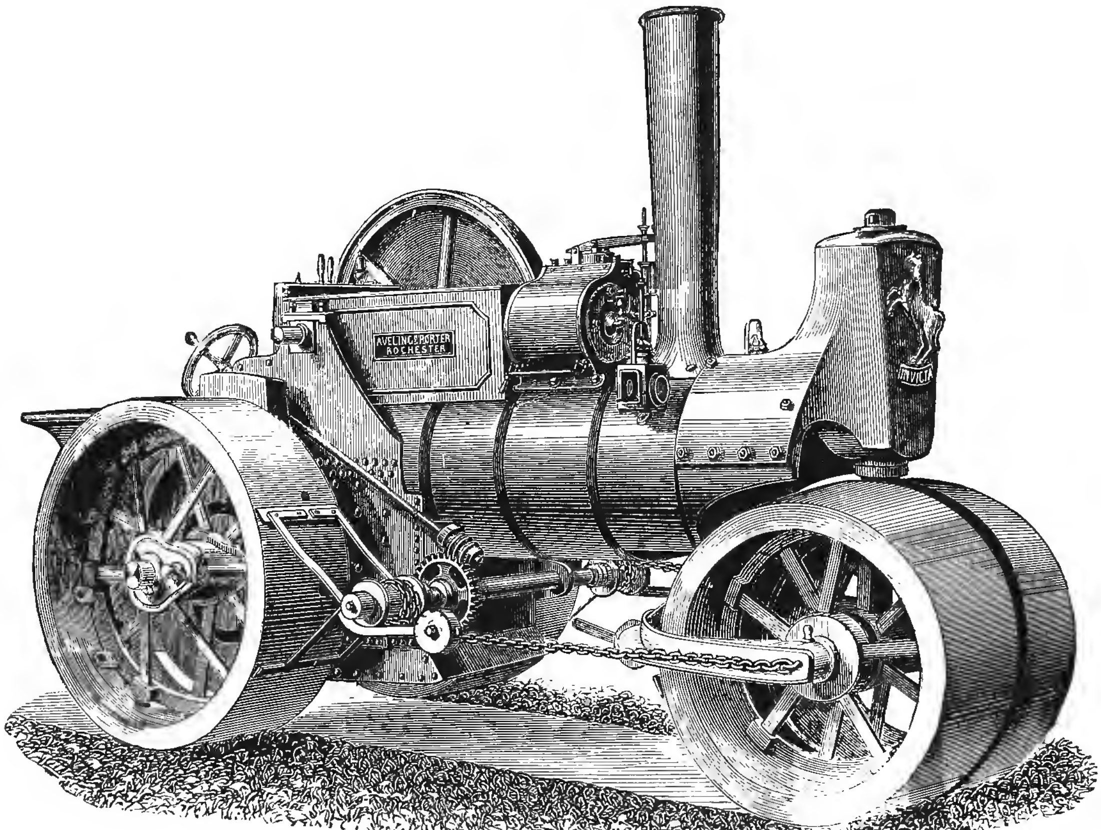
This instrument is shown on the preceding page in section and plan by Figs. 1 and 2, and consists of four arms of some light material, to the ends of which are fixed thin disks of pith with one side black and the other white, the black sides for the four disks all facing the same way. These arms cross each other at right angles and are balanced at their centre points on a hard steel point, *a*, resting on a jewel-cup, *c*, so that they may freely revolve in a horizontal plane. A thin glass globe, drawn out to a tube at the lower part so as to form a support, encloses the whole and is exhausted to the greatest attainable vacuum and hermetically sealed.

When this instrument is placed subject to the influence of light, the arms rotate with greater or less velocity directly in proportion to the intensity of the incident rays, and in the case of very intense light, like that from the sun or burning magnesium, the rapidity of rotation becomes so great that the separate disks are lost in a circle of light. Experiments made by varying the distance from the source of light show that the mechanical action is inversely proportional to the square of the distance. Dark heat produces no rotation.

This new apparatus may be applied practically to a number of uses. A standard candle may be defined as one which at a given fixed distance causes a certain number of revolutions to the apparatus per minute, and comparison can readily be made between this standard and various other kinds of light, or these various kinds may be compared among themselves. The effects of light through different media can also be ascertained and the photographer may use this instrument to great advantage in his so-called dark-room to ascertain whether the light he is using is likely to injure his sensitive preparations or not. He can also measure the intensity of the light in his operating-room, and by means of one of these instruments, instead of a watch, regulate the amount of exposure necessary for a subject with the greatest accuracy, working according to so many revolutions of the instrument independent of the time.

The discoverer has also very lately invented a torsion-balance by which he is enabled to weigh the force of radiation from a lighted body—as a candle—the principle being similar to that of Ritchie's torsion-balance, and fully confirming the previously ascertained law of inverse squares. By calculations deduced from an experiment with sunlight, it was demonstrated that the pressure of sunshine amounted to two and three-tenths tons per square mile. Mr. Crookes' discovery is one of great value, and promises to be the means of solving in future many problems, as yet unexplained, in the action of forces in our vast universe.

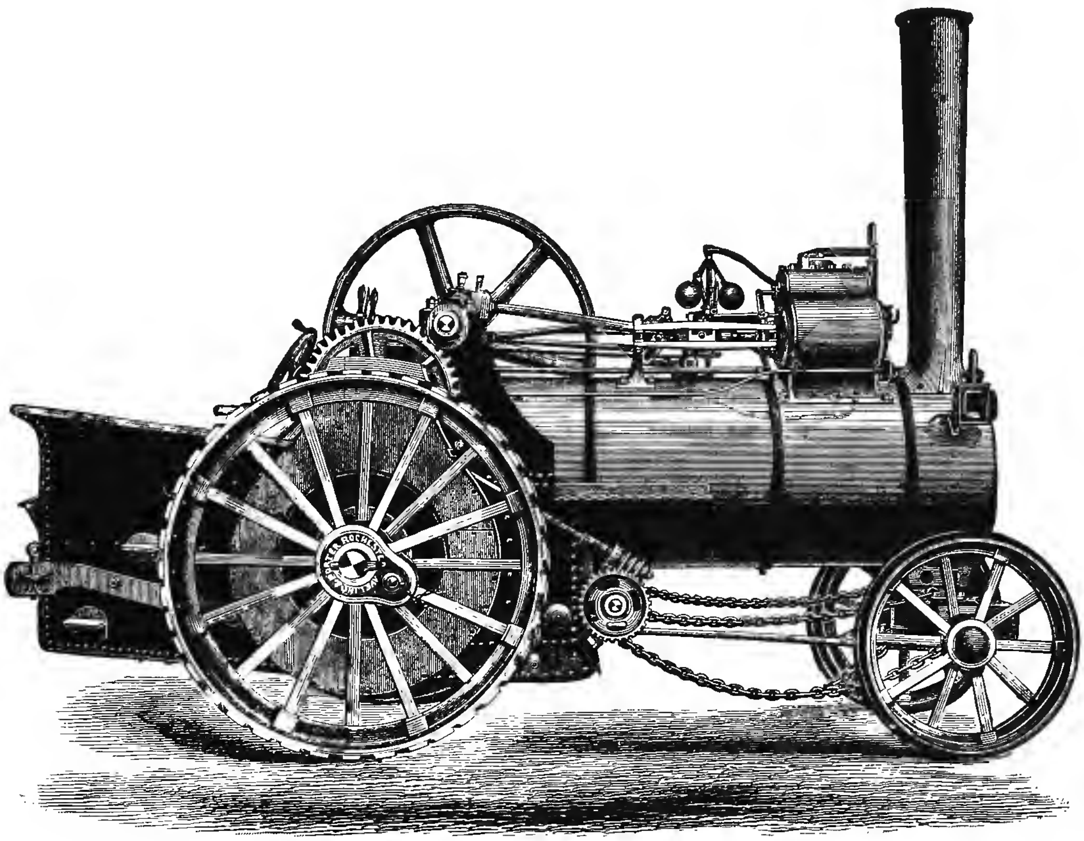
Messrs. Aveling & Porter, of Rochester, England, well known as occupying a high position in the specialty of Locomotives applicable to common roads, to agricultural purposes, to road rollers, etc., make a very creditable exhibit in the British Department of the Machinery Hall. One of their latest improvements, and an exceedingly important one in this class of machines, consists in their method of mounting the principal working parts of the locomotive, the crank-shaft, the counter-shaft and the driving axle, so as to prevent the unequal working of these parts from producing any injurious strain upon the boiler, a defect that has long been a fertile source of trouble in all engines of this kind. This is accomplished by prolonging the side plates of the fire-box upwards, as will readily be seen by the accompanying engraving, thus forming a complete arrangement for carrying the bearings of these working parts without connecting with the boiler directly. Many other improvements have been made in these machines from time to time, and they may be regarded as possessing great simplicity, strength, durability and economy of working.



Steam Road-Roller: Aveling & Porter.

In the "Road Locomotive Engine," a single cylinder is used and it is placed on the forward part of the boiler, preventing priming, dispensing with steam-pipes and resulting in considerable economy of fuel. This cylinder is surrounded by a jacket, with which it is in direct communication, and the steam is taken into it from a dome connected with the jacket. The driving-wheels are of wrought-iron, provided with compensation motion, so as to allow the turning of sharp curves without disconnecting either wheel, and sustain about 85 per cent. of the weight of the engine. The steering is done from the foot-plate.

It is stated that the working expenses vary from 2½ to 6 per cent. per ton per mile, depending upon whether the work is continuous or intermittent and the condition of the roads travelled over. Whenever circumstances render the use of the ordinary rigid tires objectionable, the wheels are fitted with the spring tires of W. Bridges, Adams, consisting of inner and outer tire-frames, having solid blocks of India-rubber between them, and connected together by a "drag-link," to prevent friction on the rubber blocks.

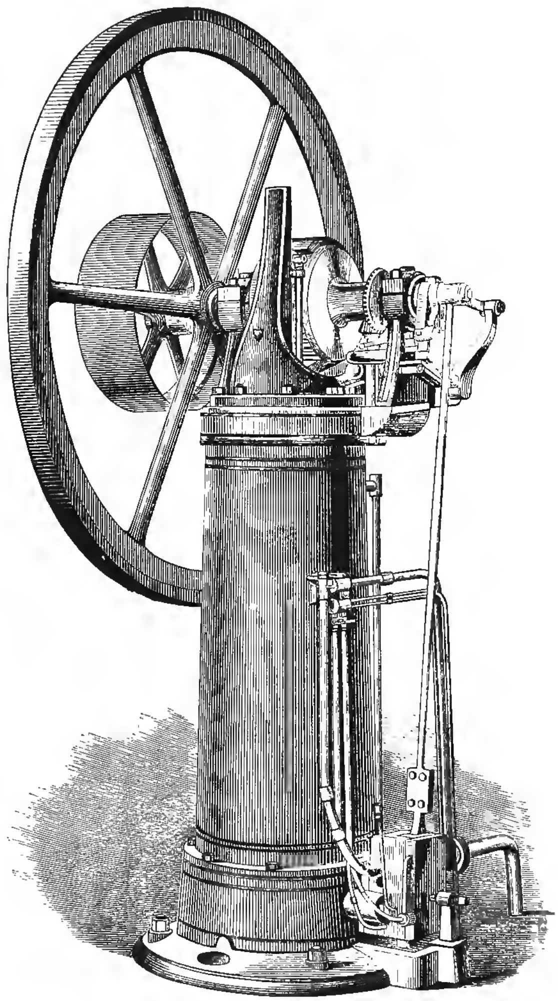


Farm Locomotive Engine: Aveling & Porter.

Cranes are attached to the front of these engines when desired, very much increasing their usefulness in dock-yards, quarries, etc., and those visiting the Exhibition Grounds during the moving and placing of the exhibits have no doubt noticed the effective work performed by one of these machines in use by the British Commission.

The general characteristics of the "Agricultural Locomotive" are very similar to those of the "Road Locomotive," and this apparatus is expressly adapted to the working of machines for steam cultivation, thrashing, sawing, pumping, or other agricultural duty.

Among the motors exhibited in the Machinery Hall, LANGEN & OTTO'S Patent ATMOSPHERIC GAS ENGINE, in the German Department, is a remarkably ingenious and exceedingly useful and effective machine, applicable with advantage in many cases in the industrial arts, more than three thousand being now in use on the Continent of Europe, working with considerable economy and effect.



Atmospheric Gas Engine: Langen & Otto.

In all gas-engines, as previously designed, the motive power has been obtained by the direct action of the force of the explosion of a mixture of gases on the surface of the piston, in a similar manner to that in which steam acts in the steam-engine. In this engine the main characteristic may be said to be in the use of a "free piston," rising without resistance upon explosion, the motive power being obtained indirectly during its descent by the pressure of the atmosphere acting upon its upper surface, owing to the partial vacuum below, following the explosion. Great advantage obtains from this arrangement in furnishing a power of longer application, less suddenly exerted and more steady in its action. In former machines the sudden, intense force necessarily given out could not be immediately made available, resulting in destructive action on the machinery of the engine and in great loss of power, which expended itself in heat, requiring a large application of water to keep the parts cool, and avoid oxidization of the lubricant and destruction of the piston. All this could be accomplished, but the consumption of water was great and the heat taken up by it was carried off without doing work, amounting to just so much power lost.

The present engine—as shown by the perspective—consists of a large vertical piston-cylinder, having on one side, near the bottom, a valve-system for the admission and ignition of the mixed gases, and at the top a fly-wheel and the necessary mechanism for utilizing the force from the piston and for working the valves below. Fig. 1 gives a cross-section at the base, showing the valve arrangement, and Fig. 2 a partly sectional detail of the mechanism at the top.

The most novel part of the design consists in the method adopted by which the piston is allowed to move freely upward, but must connect with the fly-wheel as it returns downward. The piston-rod is a rack, and gears into a toothed wheel, shown in Fig. 2, which consists of a central pulley, *a*, keyed on to the shaft of the fly-wheel and surrounded by a toothed ring, *b*, on the interior face of which three inclined surfaces are cut. Between each of these and a corresponding curved wedge, *c*, faced on the side next to the pulley with leather, a set of live rollers—made of rubber—travels freely. On the upward motion of the piston, the toothed ring is free and revolves backward upon its central pulley; but upon the return stroke, the live rollers wedge in between the ring and pulley, giving a firm hold on the shaft and allowing the piston to impart its motion to it. One might suppose that a ratchet-wheel and pawl would accomplish this result better, but it was found too sudden and rigid in its action and on trial abandoned.

To start the engine the piston is lifted up about one-eleventh of its stroke, causing a proper mixture of gas and air to be drawn in under it by the passage *x*, *x*, Fig. 1, and at the same time, by the motion of the valve, the chamber, *y*, filled with gas and air, goes first downward, igniting its contents by a flame, *w*, continually burning outside, and then upward to *x*, where it fires the charge under the piston. The resulting expansion drives the piston up very rapidly, reducing the temperature of the gaseous contents of the cylinder, consuming the heat in work, and the result is a partial vacuum under the piston which, by the pressure of the atmosphere, then makes a return stroke. The atmosphere is prevented from entering the lower part of the cylinder from the outside and destroying the vacuum; but a valve is provided that allows the products of combustion to be expelled by the piston as it reaches the bottom. The pawl, *d*, Fig. 2, in gear with the ratchet-wheel, *e*, on the main shaft gives the proper valve-motion. This pawl is controlled by an ordinary governor, worked by bevel-gearing from the fly-wheel shaft, and when the engine is running at full speed, a lever connected with this governor holds the pawl away from the rat-

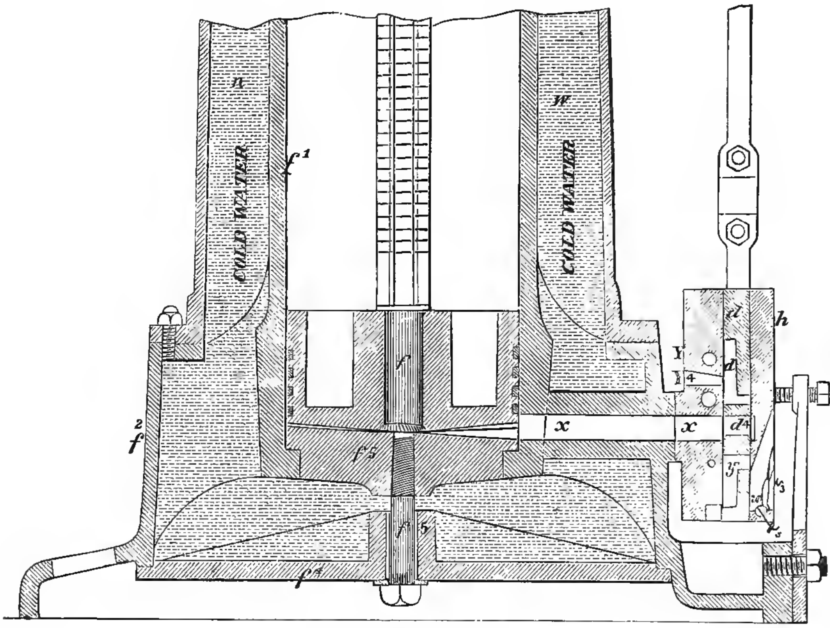


Fig. 1. Atmospheric Gas Engine (base): Langen & Otto.

chet-wheel, *e*, and no motion of the piston takes place. As soon as the speed decreases in the least, however, the action of the governor releases the pawl, which makes connection with the ratchet, and, causing one turn, operates the valve-rod, and, at the same moment, by means of the mechanism, *i*, *k*, *l*, *m*, *n*, raises the piston-rod far enough from the bottom to receive the charge of mixed gases; the explosion follows and the piston rises, repeating its operation as before. It will be seen by this that the piston does not necessarily act at every revolution of the driver, unless the full capacity of the engine is used, but only works when required to keep up the power. The driving-wheel may make even forty or more revolutions without any motion of the piston, unless the falling of the governor brings it into action. The economical effect of this is at once apparent, as the consumption of gas becomes directly proportional to the amount of work done.

The driving pressure on the return stroke varies from eleven pounds per square inch at first, to nothing, at about four-fifths of the stroke; or, say, a mean effective pressure of about seven pounds per square inch through the entire

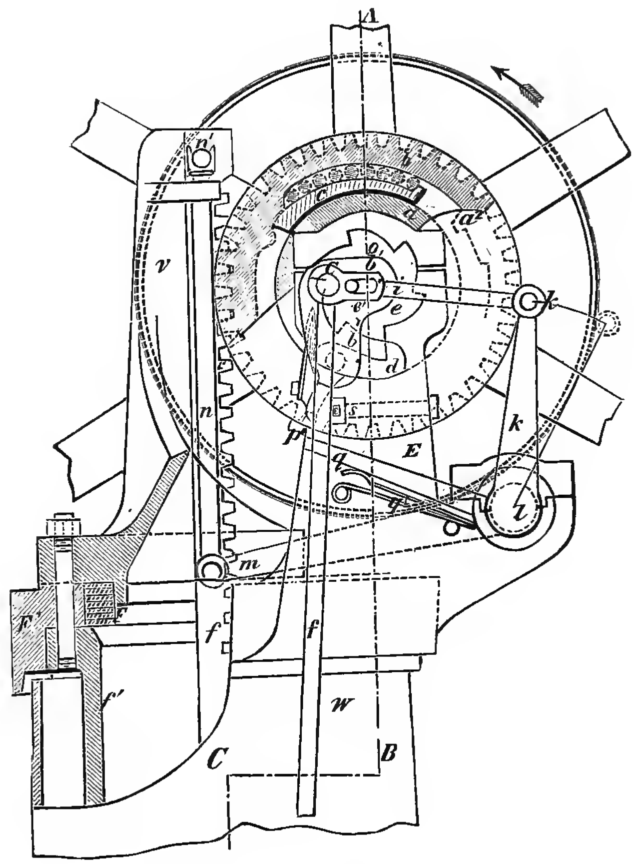
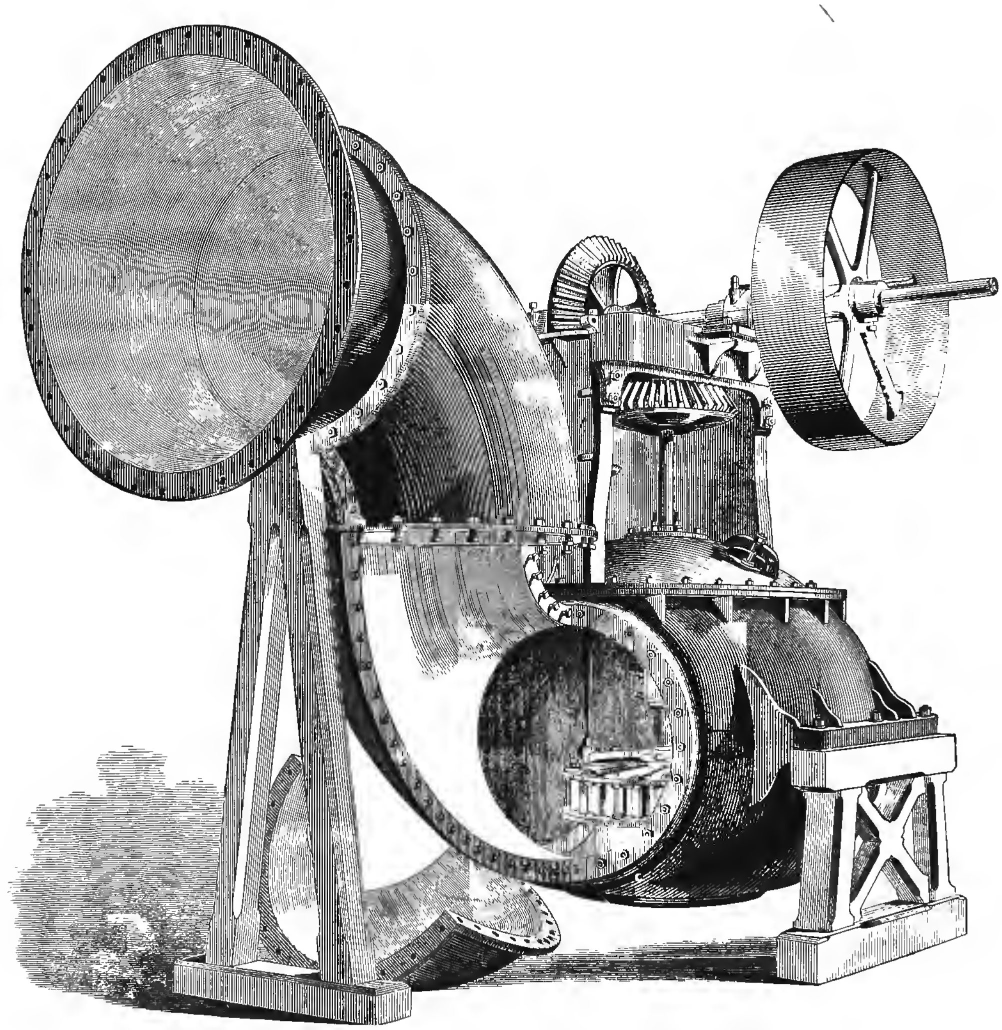


Fig. 2. Atmospheric Gas Engine (top): Langen & Otto.

movement. The parties claim a consumption of gas of 26.5 cubic feet per horse-power per hour, and about 12 per cent. effective power on the theoretical amount supplied by the fuel.

The engines make a slight noise in working,—an inherent feature in machines of this kind,—but there are undoubtedly decided advantages in economy of fuel, cleanliness, absolute safety from accident by explosion, and capability of starting at full power at a moment's notice, making these machines formidable rivals of steam-engines—in the limited sphere for which they are adapted. Messrs. SCHLEICHER BROS, of Philadelphia, represent the exhibitors of the GAS-ENGINE, and have made arrangements to manufacture it in the United States.

Messrs. POOLE & HUNT, of Baltimore Md., exhibit several sizes of "Leffel's Patent, AMERICAN DOUBLE TURBINE, WATER-WHEELS;" and we present an engra-



Double Turbine Water-Wheel: Poole & Hunt, Baltimore.

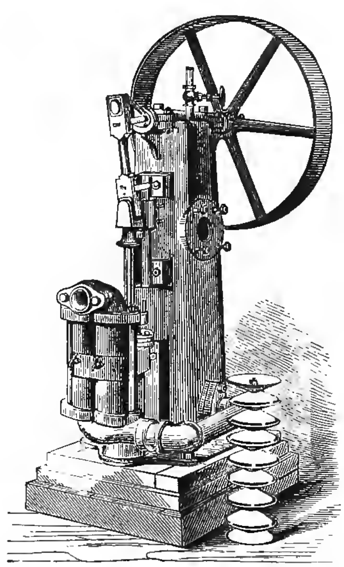
ving of one having a wheel thirty and a-half inches in diameter, the largest shown, although the manufacturers make up to a diameter of ninety-six inches.

These wheels are exceedingly popular in the United States, there being over seven thousand now in use, and the owners of the patent-right claim great advantages from the peculiarities of construction. The unsteady motion, variable speed, and irregular quantity of water always obtaining in practical manufacturing operations, necessitate requirements in the construction of water-wheels that do not always show themselves in the usual test-trials, where everything is arranged for the purpose, and it is claimed that the Leffel Double-Turbine meets just these points and possesses remarkable efficiency and durability under actual long-continued use. This Turbine belongs to that class in which the water enters at the circumference and discharges at the centre, and it has two sets of buckets on one wheel, one over the other, and each constructed upon a different principle. The upper ones curve only slightly downward and run in towards the centre of the wheel, having the faces at quite an angle to a radial line, while the lower ones curve down almost immediately and bend sideways in the direction of the circumference very considerably, before reaching the lower face. The upper buckets, therefore, receive a great side-pressure and the lower ones almost a vertical pressure. By this arrangement it is claimed that there is admitted to a wheel of any given size, the greatest possible volume of water, consistent with its economical use, and at the same time the greatest attainable area is provided for its discharge.

Movable guides around the outer circumference direct the water in to both sets of buckets, and these guides may be adjusted to any position at pleasure, even to shutting off the water entirely if desired; working by guide-rods and a segment of a toothed wheel running in a pinion regulated by a vertical rod convenient of access. The wheel is surrounded by an ample spherical cast-iron flume or penstock, seven feet six inches in diameter in the present case, furnished with a movable cap large enough to allow the passage of the entire wheel, if necessary, at any time for repairs, and also provided with man-holes. The penstock is attached at one side by a flange connection to a cast-iron supply-pipe, three feet eleven and a-half inches in diameter. The wheel is supported at the foot of its axle by a hard-wood rest, set on end, and working with excellent effect.

It is claimed for these wheels that they give a maximum discharge of water with a minimum friction, and produce an actual work of eighty-five per cent. on an average of the absolute work of the fall. The cast-iron penstock presents great difficulties of construction, and has been executed in superior style, reflecting great credit on the makers. In fact all the parts of the machine have been manufactured with great care and precision, this alone adding materially to its economy and efficiency; and the whole combination, in proportion and general mechanical arrangement, is first-class, well adapted to its intended purpose, and securing the best results, both in efficiency of action and durability under use.

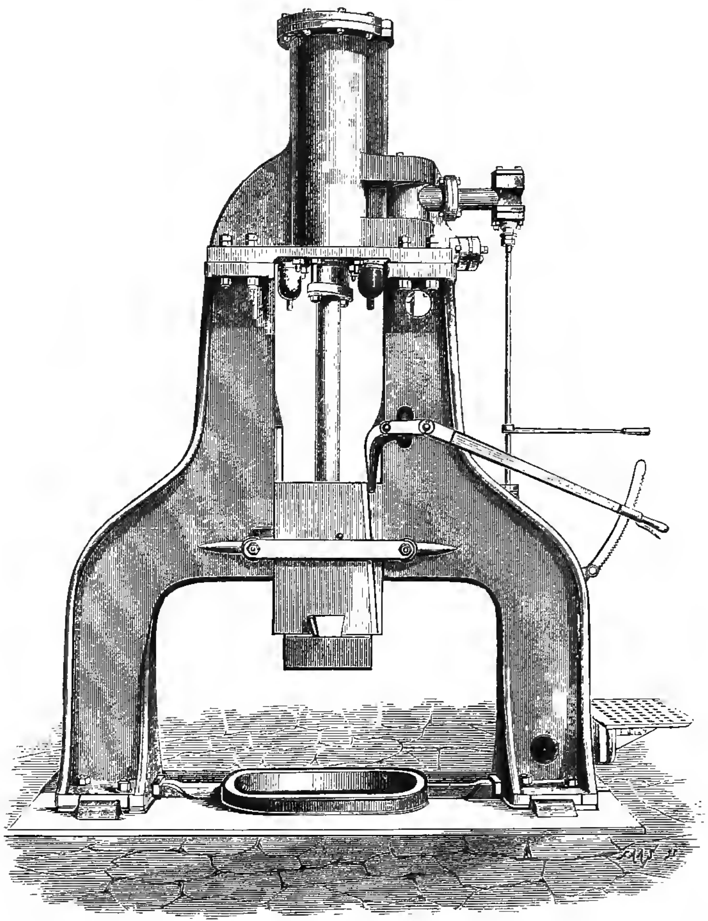
We also engrave on this page a PATENT FEED-WATER HEATER and DOUBLE-ACTING FORCE-PUMP, exhibited by MESSRS. POOLE & HUNT. In feed-water heaters as usually constructed, the exhaust steam from the engine is discharged into the water and there permitted to escape; whereas in the present example the heater is simply connected by a branch-pipe with the exhaust in such a way that a sufficient volume of the exhaust steam is attracted into the heater to raise the feed-water to a temperature of 200 degrees without in any way impeding the free escape of the exhaust, or causing back pressure in the cylinder. The supply of cold water is admitted into the heater in a small but continuous stream, and flows over and through a series of disks set inside, but shown separately in the engraving.



Feed-Water Heater and Double-Acting Force-Pump: Poole & Hunt, Baltimore.

By the arrangement here adopted the condensation, refuse grease and other matter from the cylinder does not enter the heater, and is therefore prevented from access to the boiler. In the ordinary heaters, where the steam discharges directly into the water, these impurities are carried on into the boiler, forming injurious combinations, causing foaming, etc., and raising serious objections to the use of "open heaters" as usually constructed.

MESSRS. FERRIS & MILES, of Philadelphia, exhibit a large variety of steam hammers, one of which, known as the DOUBLE FRAME STEAM HAMMER WITH PARALLEL RAM, is shown by the accompanying engravings. This hammer follows very closely in general arrangements the well-known steam hammers as introduced by James Nasmyth, of England, and consists of a steam cylinder mounted upon two frames, which form convenient guides for the hammer ram playing between them. The piston-rod connects the hammer ram with the piston, and operates it directly by the steam pressure in the cylinder. The ram in the present case is set parallel with the frames, although Messrs. Ferris & Miles, under one of their patents, frequently set the ram diagonally, for the purpose of enabling the operator to utilize the whole extent of the lower end of the ram for die surface, and for placing this surface in proper



Double Frame Steam Hammer with Parallel Ram; Ferris & Miles, Philadelphia.

direction for convenient working. To afford additional stiffness to the frames, which are box castings, flanges are placed on their exterior edges, and the ram is made rather thicker than the frames, projecting slightly on each side, so as to give a neat appearance and allow the workman to readily see every motion it makes.

The main steam valve is a cast-iron hollow cylinder with enlarged ends, which work in cylindrical seats, where are situated the steam ports. The steam supply enters the valve chamber between the valve seats, circulating freely around the valve; and the exhaust chamber, fitted with proper drain and exhaust pipes, lies below the floor of the cylinder, allowing any condensation which may occur to drain into it. The exhaust steam from above the piston passes down into this chamber through the hollow cylindrical main valve. The valve stem making its connection with the valve in this exhaust chamber, has only atmospheric pressure on it, and requires no stuffing-box. This method of connection also prevents any disturbance of the perfect balance of the valve, as would be the case if attached on the steam side, and reduces the amount of power required to work the valve, as well as the friction of the parts, to a minimum.

Motion is given to the valve automatically by means of an inclined plane on the ram, which operates a cam, rocker or bell crank, connected by a link to the valve stem, and a hand lever pivoted on to this rocker places the whole apparatus directly under the control of the operator. The mechanism is characterized by extreme simplicity, consisting of only three pieces, and yet by means of it every possible gradation of stroke can be given, continuous or intermittent, light or heavy, dead or elastic, long or short, fast or slow, with as much ease and certainty as if the enormous machine, sometimes as much as ten tons in weight, and having a stroke of eight feet, were a mere tack-hammer in the hands of the operator.

Spring buffers below the cylinder protect it from injury, and by removing these the piston packing can be examined or replaced in a short time without disconnecting any of the other parts. Stuffing-boxes are provided at the connections of steam and exhaust pipes to prevent leakage from vibration due to action of hammer.

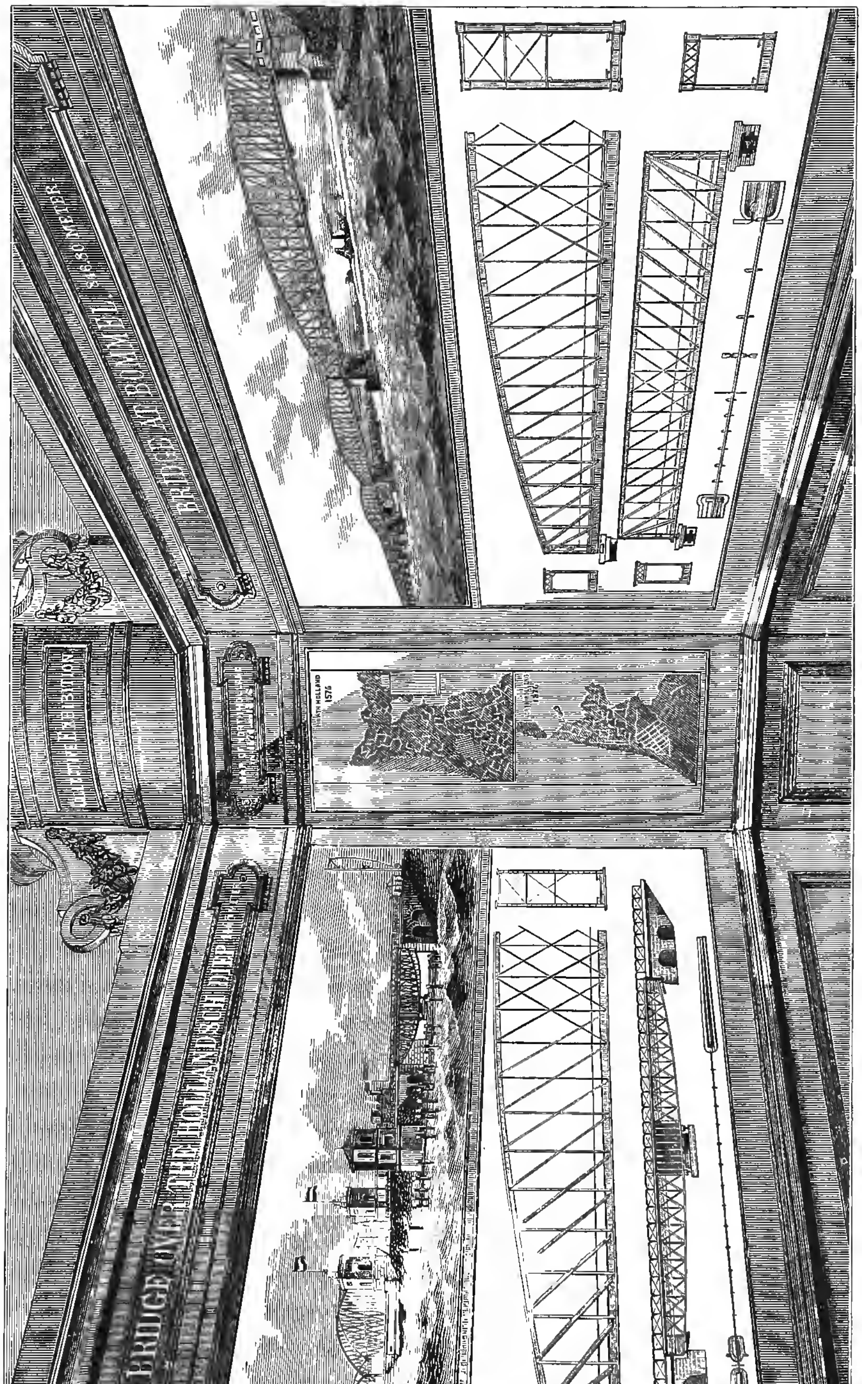
Drop-treadles, worked by the hammer-man's foot, are frequently fitted to the smaller sizes of hammers, which generally have only single frames, and they work exceedingly well, stopping and starting the hammer "on the blow," the ram always stopping "up," ready to strike again. The guides are made adjustable, so that any wear can easily be taken up and the dies kept in accurate position for stamping work into moulds. Much thought has been bestowed by the makers upon the arrangement of the anvil and foundation, so as to provide the most perfect attainable base for the machine at the least possible expense consistent with the requirements.

The provinces of the Netherlands from time immemorial have been obliged to contend with great difficulties from encroachments of the sea and from inland floods of the rivers. The waters of the North Sea, under storms in certain directions, are driven with great violence on the coast, and although in many places a natural barrier exists in the sand thrown up from the ocean, forming rows of hillocks, which give protection to the country back of them, yet at other places, and necessarily at the mouths of the rivers, this does not occur, and sea-walls or dikes of great strength have to be constructed to resist the action of the waves. On the other hand the nature of the country, consisting of vast areas of low bottom-land like that on the Mississippi, sometimes even twenty feet or more below the beds of the rivers, subjects it to great risk of overflow, especially in the spring of the year, when the upper waters, coming from more temperate climes, break up before a free passage has been opened to the sea, and accumulating, completely fill the channels of the rivers and spread over the country, carrying destruction in all directions.

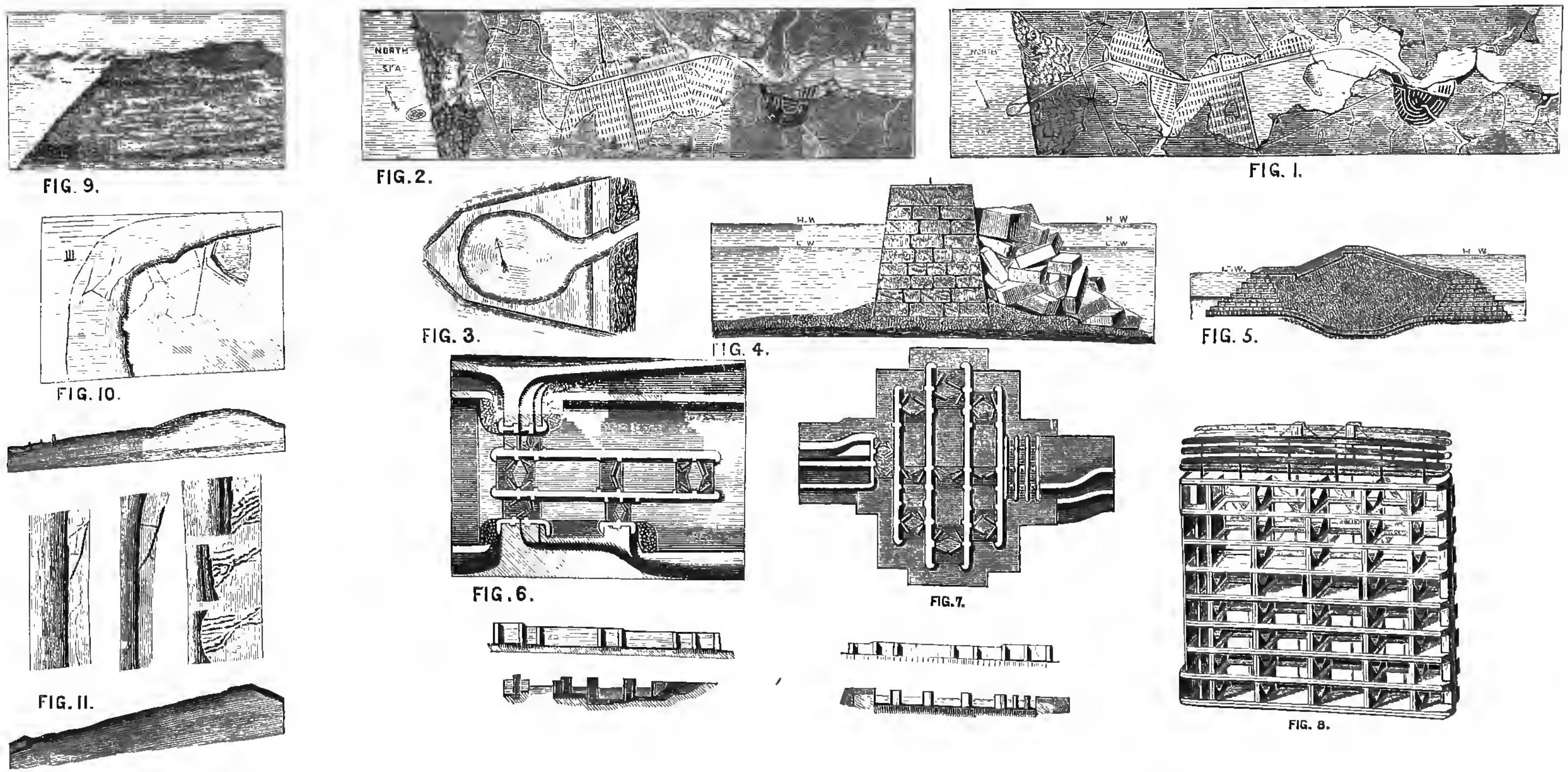
The proper protection of Holland against these encroachments demanded the mutual coöperation of all the inhabitants, and therefore became a national undertaking, and resulted, after much trouble from want of union among the different provinces, in the establishment, in 1798, of what is called the Water-staat, an organization clothed with almost absolute power, with authority to compel service from all sources if any sudden demand should occur for it, and into whose hands was intrusted the construction and maintenance of all hydrographical undertakings in the kingdom of the Netherlands.

The causes previously given, and the fact that the soil is generally composed of a soft alluvium over sand of unknown depth, and also that the great sedimentary deposits brought down by the rivers are continually acting to elevate them above their surroundings, have together resulted in a strong development of the principles of hydraulic engineering, and the actual execution of great operations in the reclamation of flooded lands, the opening of rivers to navigation, the building of sluices, locks, canals, the construction of difficult bridge foundations, etc.

In 1842 a Royal Academy for Engineers was founded at Delft, where



Bridge over the Hollandsch Diep, and Bridge at Bommel, with details: Department of the Netherlands.



Canal from Amsterdam to the North Sea.

Fig. 1. ***Plan showing state** of the work in 1872.* *Fig. 2. Plan* ***showing** completed* ***work.*** *Fig. 3.* ***Jetty at North Sea entrance.*** *Fig 4. Section* ***of*** *jetty-walls* ***at North Sea*** *entrance. Fig 5. Section of dam across the Y* ***below*** *Amsterdam. Fig. 6. North Sea locks. Fig. 7. Zuyder-Zee* ***locks.*** *Fig. 8. Lock-gate. Figs. 9, 10, 11 Exemplify the denudation and protection of the* ***sea-coast of*** *North Holland*

scientific training was provided not only for engineers intended for the Waterstaat, but also for those proposing to engage in kindred pursuits of industry and trade. In 1860 the construction of all railroads came under the charge of the Government, and the quarter century just passed has been more prolific in bringing forward engineers of distinguished ability and in the completion of grand engineering works of most important character, than any previous period in the history of the country.

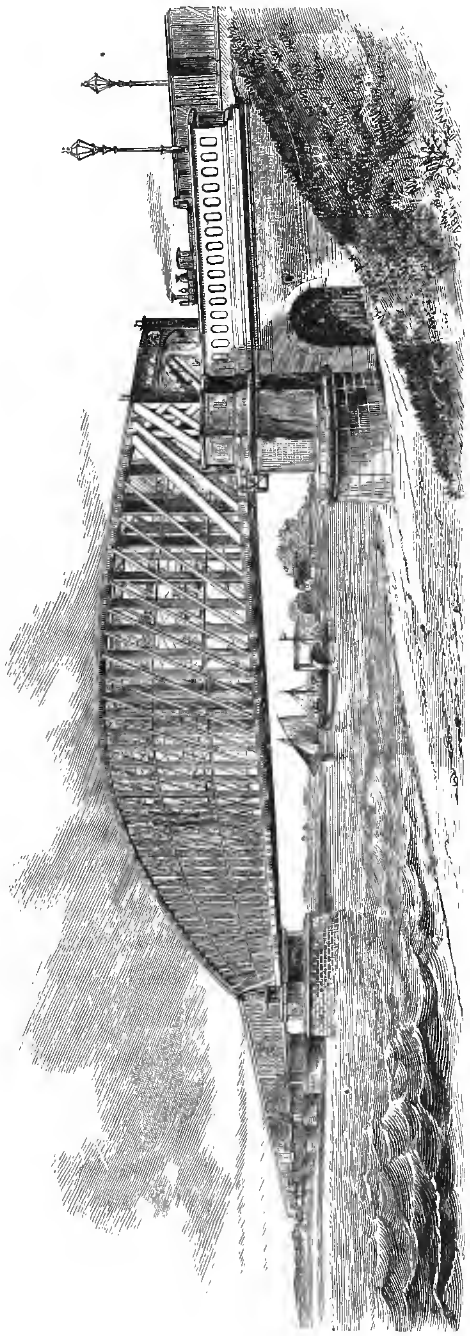
The Department of Public Works of the Netherlands makes an exceedingly handsome display at the Exhibition, illustrating, by means of maps, plans and models, its principal great works.

Among the first of these was the drainage of the lake of Haarlem, ordered on the 27th of March, 1839, and completed in 1852, at a cost of over four and a half millions of dollars. This lake had been formed by an overflow very many years before, and the present operation recovered some 42,481 acres of valuable land, by the sale of which the entire expenditure was returned. All that section of Holland surrounding and covered by the Zuyder Zee has been entirely changed from its original condition by the inroads of the ocean, which have occurred from time to time on a greater or smaller scale, and on record from the fourth century. The gradual formation of the Zuyder Zee itself has been due to this cause, the whole area having been at one time a fertile, well-cultivated country. A comparison of the two maps on exhibition, of Holland in 1576 and 1876, illustrates this very clearly. The question of the drainage of the vast area of this sea has also been taken up, and the investigations show that the work is entirely practicable and can be carried out in from eight to twelve years' time.

Another important work has been the construction of the North Sea Ship Canal from Amsterdam, saving thirty-six miles in distance, and restoring a large amount of land from the waste waters of the Wijker-Meer and the Ij. The building of the piers or jetties for the North Sea entrance was effected under great difficulties, the treacherous sands of the coast rendering unsuccessful the method first adopted, of using heavy concrete blocks as previously carried out on the English coast at Dover, and requiring considerable modifications of plan. The construction of the great embankment or dam across the Y below Amsterdam, from Schellingwoude to Paardenhock, a distance of three-fourths of a mile, rendered necessary in carrying out the project, and involving the building of a system of locks sufficiently large to pass the immense shipping business without allowing the barrier to be even *felt* as an obstruction, was one of the most important features connected with this undertaking, and it was here that the use of mattresses of fascine work, weighted with ballast stone, one of the peculiarities of dike construction in Holland, came so extensively into play.

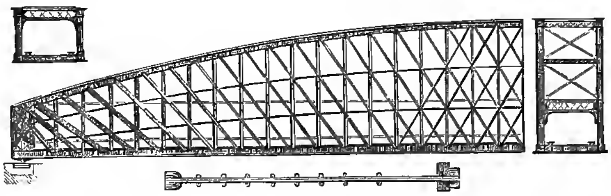
Next in order came the project for the improvement of navigation from Rotterdam to the sea, by the selection of the most favorable of the numerous channels by which the Rhine, the Meuse and the Scheldt communicate with each other and discharge into the ocean, and by the introduction of lateral dikes, contracting the width where too great, or widening it where too narrow, so improve it as to allow the most effective action of the tides in removing deposits; also the formation of a new outlet to the sea by a cut through the Hoek van Holland and the building of jetties into the sea for the proper protection of its entrance from storms. The whole of this work involved great practical difficulties, and required engineering skill of the very highest order. It has been carried out with the greatest success, and rests, it is to be hoped, an enduring monument to those by whom it was undertaken.

The particular feature in the construction of the jetties has been in the use of the fascine mattress, a thing not before attempted in the open sea, although very extensively used in dams and dikes obstructing or confining inland waters. The mattresses are made on the sea-shore between high and low water, so that they can be floated off to their final locations by the tide. Fascines are made from willow branches, osiers, etc., which are grown for the purpose as a regular business on the low lands of the estuaries of the rivers, the crop being cut every third or fourth year. The largest sticks are used for cask hoops, and the smaller ones tied up into bundles, each bundle being made to contain at least three sticks, from ten to eleven and a half feet long, and two of six and a half to eight feet, the twigs and smaller branches remaining attached, and more being added if necessary to make up the standard size. The whole is bound together with two osiers, making a bundle about seventeen inches in circumference at the thick end, and fourteen at the other. Long ropes, called "wiepen," are made up with a series of fascines, each bundle bending well into the next, all firmly tied together, and making a rope of seventeen inches circumference. To build the mattress a series of these "wiepen" are first laid parallel to each other, at distances apart of about three feet, and on top of these, at right angles to them, a second series, the same distances apart. These are then tied together at each crossing-point with two twigs, except those on the exterior lines and the alternate ones on the interior, which are fastened with tarred rope from old ships' cordage. The ropes are twisted upon small stakes, so that the ends may be used for tying upper wiepen to be mentioned hereafter.



Bridge at Kuilenburg: Department of the Netherlands.

A continuous layer of bundles of twigs is now laid upon the lower lines of wiepen, at right angles to them, covering the whole of the open spaces, the top ends of the twigs being upward, and the different bundles lapping partly over each other. A second layer is then placed over the whole at right angles to the first, and on top of this a third layer of the same kind, rectangular to the second. Wiepen are then placed at right angles in both directions directly over the lower wiepen, the small stakes at the corners fixing the locations of the cross points, and they are tied at the alternate crossings with the ends of the tarred ropes used for tying the lower wiepen, the whole being firmly pressed and held together. The intermediate crossings are tied with twigs, as in the case of the lower wiepen, and the small stakes at the alternate corners are pulled out. The upper surface of the mattress is finally provided with divisions or cells to contain the ballast or broken stone necessary for sinking the mattress and holding it in position in the work. These are formed by driving stakes into the upper lines of wiepen, and weaving basket-work in between them with willow twigs up to a height of seven to nine inches, the stakes being then driven down well into the mattress, leaving the ends about six inches above the willow-work. At the third and fourth crossings of the wiepen from the corners, and also at distances of about fifty feet from each other over the surface of the mattress, a large stake is driven with some six or seven others in a sloping direction from the centre one, these being used to fasten the cables by which the mattress is conveyed to its destination and held in place while being sunk. Iron rings are



Details of Bridge at Kuilenburg.

also provided, fixed to cross points of the wiepen, so as to attach vessels by lines when the mattress is placed in position. The mattress is now towed to its position, and anchored as far as may be necessary, dependent upon the velocity of the sea; and small vessels of ten to fifteen tons are secured all around, filled with good supplies of stone. The pockets of the mattress are gradually loaded from the centre outward, and then more rapidly as it begins to sink, care being taken to let it settle evenly. At the proper time all ropes are let go simultaneously, the stone being thrown out as rapidly as possible, and the mattress finally sinks to the bottom. The ballasting proceeds until about three and a half to seven hundredweight of stone per square yard are deposited over the whole surface.

The work is built up in this manner, one layer of mattresses over the other, until the required height is reached. The head of the southern jetty has a width at the top of eighty-two and a half feet, the centre being three and three-tenths feet above mean low-water line. At the height of ten feet above that level is a platform of timber, supported on rows of square piles driven down through the whole construction, the outside rows being inclined and bolted at the tops to the adjoining rows. The platform has a width of about twenty-five feet, and carries a line of railroad track. The sides of the jetty are filled with large blocks of basalt stone set to a slope of one to one on the south side, and one and one-fourth to one on the north, the lower mattresses projecting from twenty-seven to thirty-three feet beyond the body of the work. The head is protected by two ranks of piles, bolted together at the top, and two other ranks of shorter piles are driven in the stone-work as a protection around the outside of the whole.

The Utrecht Boxtel line of State railways in the Netherlands crosses three large rivers, the Lek, the Waal and the Maas, within a distance of ten miles, the bridges at these points being known by the respective names of the Kuilenburg, the Bommel and the Crèvecœur viaducts. The great lengths of these bridges, the nature of the streams that they cross, and the local circumstances necessitated engineering skill of a high class. The conditions of the foundations were such as to require piling. The piles varied from twenty-three to fifty three feet in length, being driven in some cases by the ordinary pile-driving engine, and in others by a steam ram. After the piles were cut off to a level below water, the space between them was filled with beton or concrete, projecting from three to five and a half feet beyond the footings of the masonry above, and varying from eleven to twenty-one feet in thickness. The tops of the piles were completely floored over, and masonry built up, well bonded on to the floors to prevent sliding by longitudinal and cross walings of oak, and the faces of piers and ice-breakers were finished in Belgian ashlar. The footings of the piers were thoroughly protected by a close row of long piles to each, and heavy rip-rapping of rough stone.

The superstructure of the Kuilenburg bridge was built by the well-known Dutch firm of HARCORT & CO., under the superintendence of MR. N. T. MICHAËLIS, Engineer-in-chief. It consists of nine spans, entirely of wrought-iron construction, there being one span of 492 feet clear opening, one of 262 feet 6 inches, and seven of 187 feet each, making, with the widths of piers, a total length between the faces of abutments of 2181 feet. The bridge consists of two open trusses, built of riveted plates and angles, the upper and lower flanges being formed in the shape of double T's, side by side, the inclined ties of thin rectangular bars, except toward the centres of spans, where they require stiffening for compression under variable load, and the vertical struts of I-shape, some of the largest being strengthened by the introduction of two series of channel-bars between the verticals. The trusses are placed so as to give a clear width of roadway of 27 feet, and height of 16 feet 5 inches, the structure being a *through* bridge. Cross-girders 2 feet 11¼ inches deep connect the main trusses, and the whole is well stiffened by a thorough system of lateral and diagonal bracing. The span of 492 feet has a parabolic upper member, the depth of truss in centre being 35.6 feet, and at the ends 26.24 feet. The other spans have rectangular trusses of the same depth as the ends of the parabolic truss.

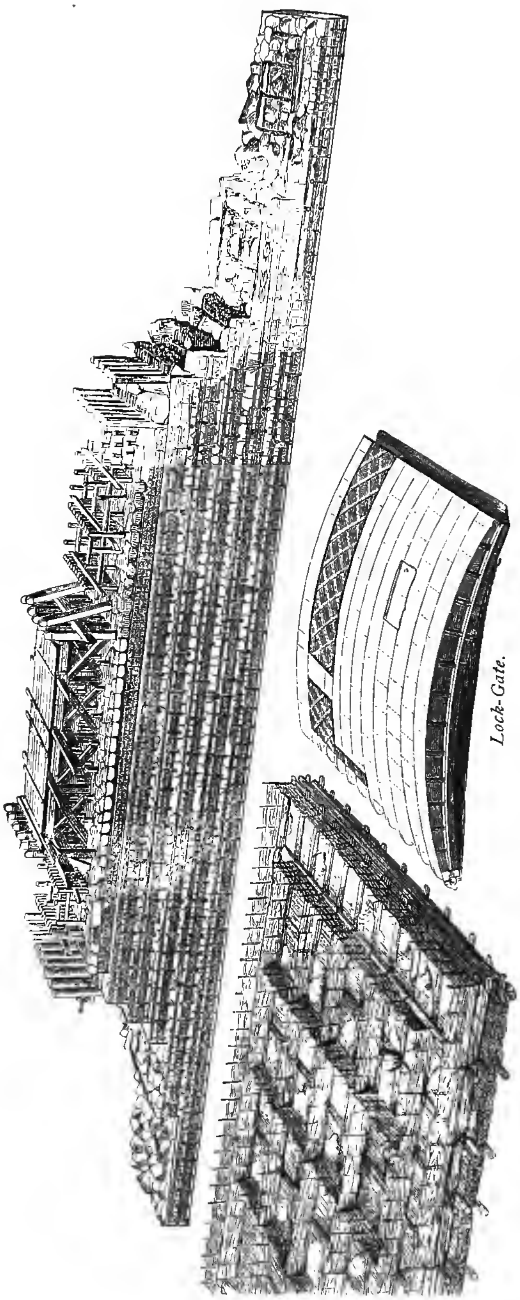
All holes for riveting were drilled, no punching being allowed in the work. The bridge is built for double track, there being only a single track placed on at present. Two foot-paths are provided for the service of administration. The total weight of material in the structure is as follows:—

Wrought iron, ...	$4394\frac{6}{10}$	tons.
Bessemer steel, ...	$610\frac{5}{10}$	"
Cast iron, ...	30	"
Lead, ...	$3\frac{2}{10}$	"

There were also 8000 cubic feet of oak, 9500 cubic feet of fir timber used, and 350 tons of plates placed between the rails to form the floor of the bridge. The total cost for masonry and superstructure was $1,187,100.

The Bommel bridge consists of eight land openings of 187 feet each, and three openings of 393 feet, making a total length between abutments of 2839 feet 7½ inches. The Crèvecœur bridge has ten openings of 187 feet, and one of 328 feet, making a total span of 2346 feet. The superstructure of these two bridges is of the same character as that at Kuilenburg, except that the masonry is made for two separate single-track bridges, only one being erected at present, and an additional line of superstructure must be put up when double track becomes necessary. Curved upper members are used in the longer spans of both bridges. The weights of material at Bommel are—

Wrought iron, ...	$3468\frac{2}{10}$	tons.
Bessemer steel, ...	$227\frac{1}{10}$	"
Lead, ...	$2\frac{3}{10}$	"



Lock-Gate.

Details of Jetty at North Sea—Entrance of Water-way to Rotterdam: Department of the Netherlands.

the total cost being $1,358,125 for masonry and superstructure.

The Crèvecœur bridge contained—

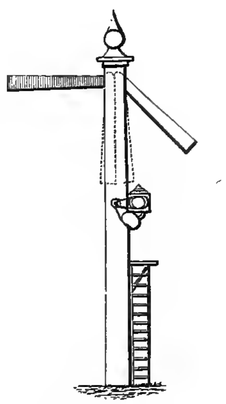
Wrought iron, . .	$2106\frac{8}{10}$	tons.
Bessemer steel, .	$84\frac{9}{10}$	"
Lead, ...	$\frac{5}{10}$	"

and cost $465,000.

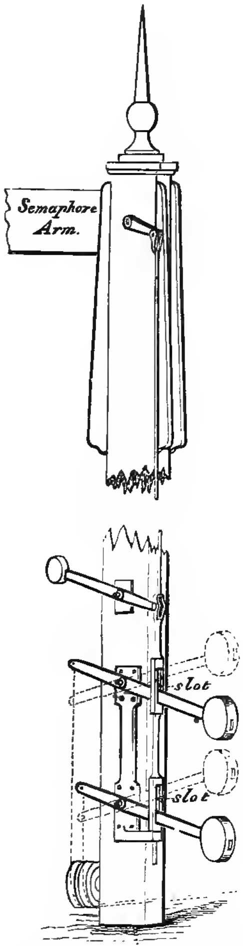
The whole of the iron and steel work in these bridges received six coats of best lead-oil paint after being cleaned in a bath of muriatic acid. The limiting strains for tension and compression were taken at 6½ and 4½ tons per square inch respectively.

Among the other noteworthy exhibits may be mentioned the bridge over the Hollandsch Diep, the steel bridge at Dordrecht, the swing bridge across the North Holland Canal, etc., and a handsome model of the Blanken lock-gates, used at a number of places in Holland. They are arranged by means of communicating ducts between the chambers of the locks and a recess into which the gates open, that the gates may be opened and closed simply by regulating the passage of the water through these ducts

During the early years of railway management, when traffic was light and the number of trains few, a very simple system of signals was quite sufficient for the proper regulation of these trains. Hand signals, with flags by day and lamps by night—different colors being employed, red generally for danger, blue or green for caution, and white for safety—answered all purposes. As business developed, however, and as the turnouts and crossings at stations increased in complication, it became evident that something better than these primitive methods must be adopted. Stationary signals were then introduced; elevated at some height above the level of the rails, so as to be seen from a considerable distance, and they were placed at safety or danger as required to correspond with the clearing or blocking of the line. That known as the Semaphore signal, consisting of a vertical post with a movable arm attached near the top by a pivot, and capable of hanging vertically or of being moved out at right angles to the post, was the form of signal most universally adopted, proving so superior to all other kinds as to rapidly replace them. When the arm was thrown out at right angles to the post, it signified danger; when hanging vertically, it denoted safety; and when inclined at an angle of forty-five degrees, it expressed caution. The movable arm was counterweighted, so that in case of derangement of the apparatus or breakage of connections, it always flew out to "Danger," stopping all traffic, and at the worst only causing delay. As the system of tracks became still more complicated, arms were introduced on both sides of the post, and occasionally two or more tiers of arms, one above the other, the arms on one side always referring to trains in one direc-



Saxby & Farmer's System of Railway Signals. Fig. 1.



Saxby & Farmer's System of Railway Signals. Fig. 2.

tion, and those on the other side to trains in the other direction. The arms were painted red on the side next to the approaching trains they were intended to govern, and white on the other side, so as to appear less prominent and avoid confusion. Lamps were attached to the post for night use, the movement of red or green glass over the white glass indicating the desired signals. Where several arms were in use it became necessary to number them or mark them with symbols so as to distinguish them apart and signify to which set of tracks each signal belonged.

The Semaphore signal was found eminently satisfactory, continuing in use to the present day, but the method of operating it was quite inefficient. By errors of the signal-men, signals were sometimes given for wrong tracks, or switches were opened before the danger signal was turned on, or sometimes the danger signal changed to safety before the switches were set right, resulting often in cases of serious accident. The obvious remedy for this was to make the movement of the signal automatic with the movement of the switch, or, better still, to make the movement of the danger signals obligatory before the track could be blocked, or the clearing of the track obligatory before the safety signals could be set. The solution of this problem, step by step, has resulted in a system of apparatus so complete as to leave little if anything to be desired.

MESSRS. SAXBY & FARMER, of LONDON and BRUSSELS, have been early and strongly identified with this system, taking out patents in England as long ago as 1856, and in this country in 1868. They are represented by an exceedingly handsome and complete working model at the Exhibition, and we cannot explain better the latest and most novel improvements in this direction than by a description of their apparatus.

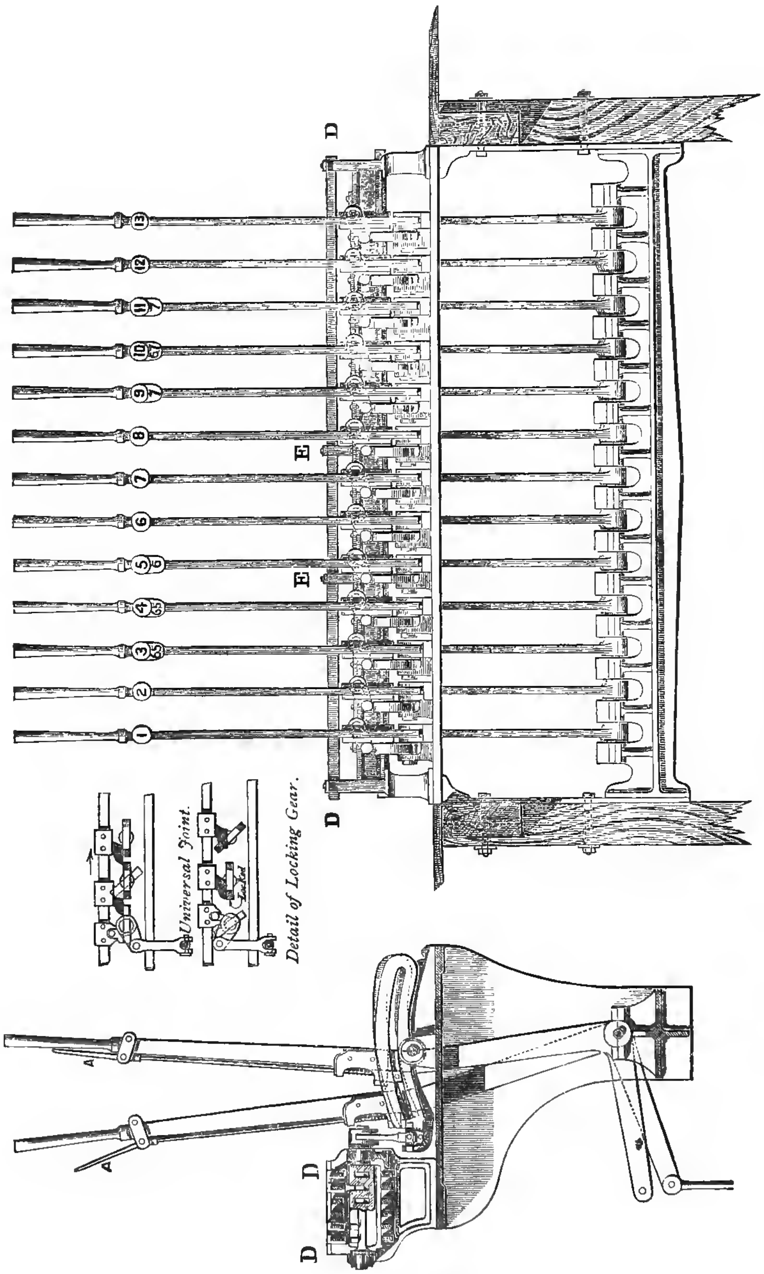
On the preceding page we present an engraving, Fig. 1, showing the Semaphore signal, and also one of the Semaphore with slotted rod, Fig. 2. It is exceedingly desirable in certain cases that two signal-men should control one signal, so that the consent of both should be necessary to its use. This is arranged in a simple manner by means of two slots on the signal-rod, in which pivoted levers move up and down, each being operated by a separate signal-man. It is evident that both levers must be moved the same way before any change can be effected in the signal, and that such change must be in concordance with the intentions of both operators. This principle, which is capable of almost unlimited extension, and allows any number of slots, in which a pointed lever or pin may work, was the germ of the system introduced by Mr. Saxby, in 1856, in his invention of combined interlocking signals, by which it was rendered mechanically impossible to make the position of the switches contradictory to the position of the signals, or to allow irreconcilable signals to be given, no matter how complicated the system of tracks or switches.

Messrs. Saxby & Farmer claim, with their system of apparatus, perfect safety in working switches, signaling junctions, stations, &c.; great facility and rapidity in manœuvring trains; and great economy of working, one signal-man being able to operate all but the very largest stations.

In arranging a Saxby & Farmer apparatus at any particular station or junction, a convenient site is selected, on which is erected a signal-tower, or building with a second story, having large windows, and well overlooking the arrangement of tracks. In this is placed a set of levers, arranged in a cast-iron frame side by side, and by which the whole system of signals and switches is operated. Some work the switches and others the signals, the former by rod connections, and the latter usually by wire rope.

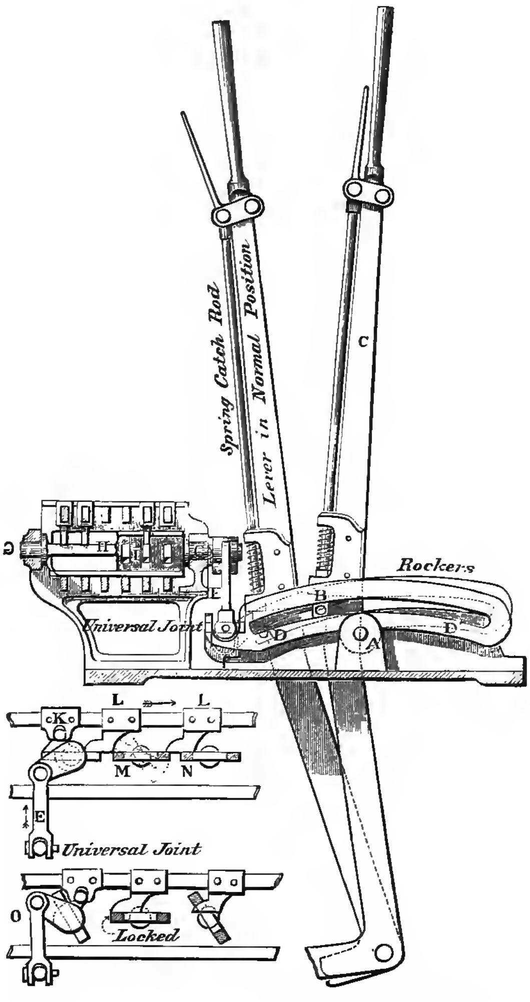
Fig. 3 shows this arrangement of levers for some particular station, the name generally given to it being the "Locking Apparatus," for the reason that the levers are so interlocked that the switches must be properly set and locked in the right direction before it is possible to move the signal-lever corresponding, and the signals themselves are so interlocked, so as to protect the path of a signaled train, throughout its whole length, from all crossing lines. It will be noticed that each lever is numbered, and that some have one or more secondary numbers under the principal number. These numbers are to guide the operator, and the secondary numbers specify the levers which control the principal lever, and which must be moved before any movement of the principal can be made. For instance, suppose lever No. 11, having under it secondary No. 7, operates a certain switch. Before it is possible to use it, lever No. 7 must be moved, acting on the danger signal, and covering the opening of this switch by No. 11. It is evident that with this system it is impossible to make a mistake causing any further inconvenience to an approaching train than possible delay.

In describing the method by which this locking is accomplished, we will refer to Fig. 4, and we would state that an important advantage belongs to



Saxby & Farmer's System of Railway Signals. Fig. 3.

this apparatus in the fact that the interlocking gear is actuated solely by the movement of the spring catch-rod in front of the lever and attached to it. This spring catch-rod carries a stud, upon which is a small block, B, which travels in the curved slot of the rocker, D, a segmental plate, movable on the centre, A. When the lever is thrown forward or backward to its full position, the spring catch fits into a notch in the fixed quadrant on which it moves. When it is in its forward or normal position, to the front of the frame, with the spring catch-rod down, the left-hand end of the rocker is depressed, and the right-hand end raised, as shown by the dotted lines. When the spring catch-rod is raised, the rocker moves into the position shown by full lines, and keeps this position until the spring catch falls into the notch at the rear of the frame, when it assumes a third position, elevated on the left and depressed on the right. A jaw at the left-hand end of the rocker carries a universal jointed vertical link, E, giving motion to a small crank at the end of a spindle, the bearings of which are shown at G, G, there being a spindle for each lever. These spindles lie directly under a series of horizontal rectangular bars, shown at D, D, in Fig. 3, called locking-bars, which slide to and fro in the guides E, E, and to these bars are attached locks L, L, Fig. 4.



Saxby & Farmer's System of Railway Signals. Fig. 4.

The spindles are flat in their central portion, as shown at M and N, Fig. 4, and when they stand in their normal position they are horizontal, and the locking-bars and locks are free to move forward and back over them. When turned up, however, out of the horizontal, as shown at I, and in dotted lines at M, they catch on the locks and stop their movement and that of the bars to which they are attached. Some of the spindles are required to work locking-bars, and are provided with a short vertical crank, the stud of which works between two horns on the locking-bar, as shown at K, giving a horizontal motion to the bar at any movement of the spindle.

It will be seen that the locks and crank attachments may be fixed at any locations desired on the locking-bars, by means of set screws or a similar arrangement, some being made to allow free movement of one spindle, as at M, while at the same time another spindle, as at N, is locked.

Whenever the spring catch of any lever is raised, its rocker is lifted and the corresponding spindle turned. If the spindle is locked it will be impossible to move the spring catch. A very small movement of the spring catch, if the spindle is free, will cant it up sufficiently to lock the locking-bar upon which it works and prevent any movement of it by other levers.

The spindle can occupy three positions, as shown at M: first, the horizontal, when the lever is in its normal position; second, slightly inclined, as shown by dotted lines, when the lever is being moved; and third, a more inclined position, also shown dotted, when the lever has been pulled to its full open position and the spring catch released.

The third position is a very important one, some of the locks not being released until this position is attained. Thus the spindle N is not released until that at O is in the third position, and the lock over it has moved sufficiently to be able to enter a hole in it. The spindle then by its new position prevents a return movement of the lock or any change of the spindle O until brought back to the horizontal again, corresponding to the lowering of the spring catch into the forward notch of the quadrant.

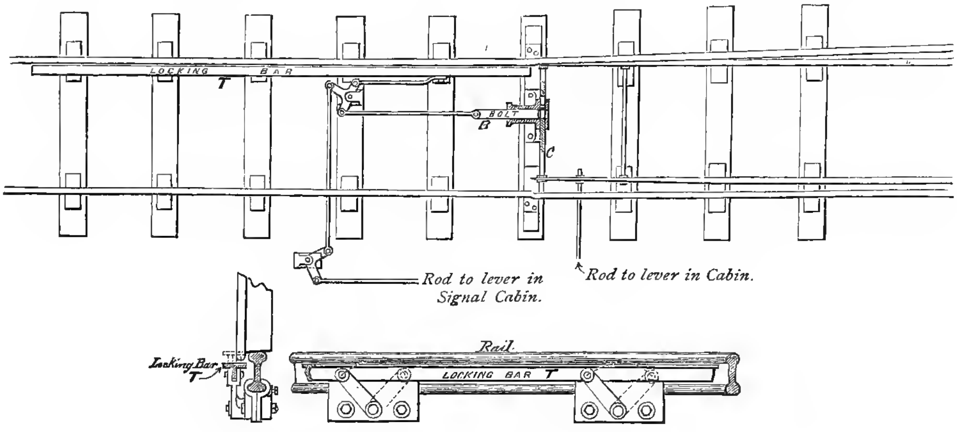
By this interlocking apparatus it is possible to absolutely prevent any signal-man from even commencing to make a movement of either switches or signals until all switches or signals which have any relation to the movement intended to be made have been effectually locked in their proper positions, a matter of the utmost importance.

By the system here explained it may readily be understood that any combination or arrangement of interlocking different levers may be made as desired, that changes can be made to accommodate alterations to tracks or switches by merely moving the positions of the locks, and also that extensions of the apparatus can be economically effected to suit extensions of business without throwing away the portion already in use.

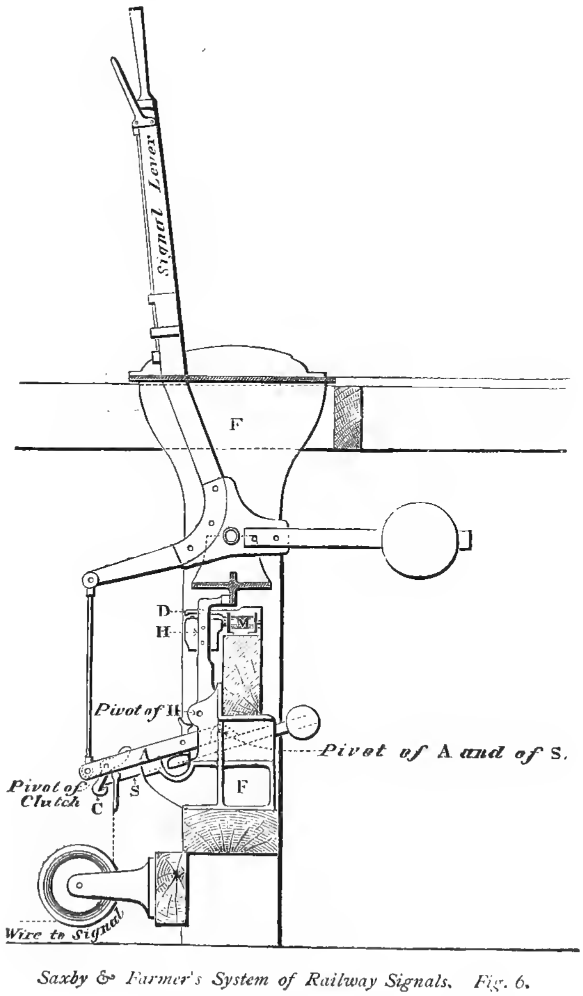
Messrs. Saxby & Farmer also provide a "Patent Facing Point Lock," which insures that the switches shall be properly closed and locked before a train can be signaled over them, and also prevents the possibility of the switchman moving the switches while the train is passing. This apparatus, shown by Fig. 5, is worked by a lever in the "locking apparatus," and the interlocking of the levers forces the switchman to use this lock before giving the signal. A cross-rod connects the two switch-rails near their movable ends, and in this are two holes, so that the switch may be locked for either position. A taper bolt shoots into one or the other of these holes, bringing the apparatus up home, and keeping it snug and tight. If the switches are not properly closed, the bolt will not enter the hole, and the facing switch lock lever in the apparatus will not work, and will consequently prevent the safety signal being given.

In order to prevent any danger of a signal-man carelessly moving the switch-rails while a train is passing over them, a switch-locking bar is provided, consisting of a bar at least as long as the greatest distance between any two pairs of wheels of a car, placed on the inner side of one of the fixed rails immediately adjoining the switch-rail, and connected with the system by which the lock-bolt just described is worked. It is hinged on short links lying in a vertical plane, so that it cannot be moved lengthwise without at the same time being raised. When the lock-bolt is at either end of its stroke, the bar is at its lowest level, and just allows the flanges of the wheels to pass over its length. When an attempt is made to move the lock-bolt for either of its extreme positions, the switch-man is unable to do so without raising the bar, which cannot be done so long as the cars are passing over it.

We have before mentioned the great advantages resulting from the use of slotted signal-rods, rendering it impossible for disagreement to take place between signal-men who by mechanical means jointly control a signal, although they may be a considerable distance apart. Messrs. Saxby & Farmer exhibit in this connection Farmer & Tyer's patent "Electric Slot Apparatus," by means of which the same result can be accomplished for an unlimited distance between the signal-men. This may be applied to their ordinary locking apparatus without



Saxby & Farmer's System of Railway Signals. Fig. 5.



Saxby & Farmer's System of Railway Signals. Fig. 6.

difficulty, and carries out, by means of an electric current, all the advantages of the mechanical slot. Fig. 6 represents one of the signal levers of the locking apparatus to which this arrangement has been attached. A is a lever consisting of a pair of wrought-iron plates placed side by side, with a space of about three inches between them. This lever is worked by a connecting-rod from the signal lever, and the clutch, C, pivoted to it, connects it with the lever, S, acting on the same pivot as A, and working the signal. H is a hammer, so pivoted that a small upward movement of A will raise H to the nearly vertical position in which it is shown. M is an electro-magnet, and D a detent. When the lever, S, is free, and not held by the clutch, C, the signal always flies to "Danger."

The electro-magnet, M, when under the action of an electric current, holds the hammer, H, in place, being further assisted by the detent, D, also under its influence. If the current be broken, the hammer, H, falls on to the clutch, C, releasing the bar, S, and placing the signal at danger. When the current is broken, therefore, it is impossible for the signal-man at the lever to move the signal from danger, no matter how often he moves the lever back and forth, and by putting the control of the current around the electro-magnet, M, under the charge of the other signal-man, he can control the signal as he desires.

This invention gives each signal-man on a block system, in addition to the usual block telegraph instruments, the actual mechanical control over the signals at the next station, controlling the coming train even before it enters his section of road. Messrs. Saxby & Farmer also show an admirable arrangement of gates for level crossings, so arranged that danger-signals are displayed whenever the gates are shut across the railway, and cannot be lowered until the gates are opened again and shut across the public roadway. The gates are connected to a lever similar to a switch-lever, and by a rack and pinion movement all gates are shut and opened simultaneously, the lever being made to interlock with the signals.

There are two general methods employed for the reduction of the metal copper from its ores—one the old system of repeated fusions, or the smelting process, always used in the case of rich ores, and the other designated the wet process, by which the material containing the metal is subjected to the action of a solvent which dissolves the copper out, leaving the other ingredients behind as a residue. This wet process has been very extensively used in the extraction of copper from lean or poor ores, which could not be profitably worked by the old method. Rich ores are easily smelted, and the proportion of fuel used compared with the metal obtained is small; but as the percentage of copper decreases, the difficulty of separation increases, and the amount of fuel required becomes greater, making the operation too expensive for practical use. With the wet process, however, only one furnace operation is generally required, and but little fuel. To reduce a ton of copper from a five per cent. ore by the smelting process would consume about fifteen tons of coal, while only three tons would be necessary in obtaining the same amount by the wet process. There are, however, expenses in the latter method which do not obtain in the former, the principal one being the precipitant necessary to throw down the copper from its solution. The amount of this varies directly with the amount of copper obtained; and while its use as compared with the consumption of fuel by the other process makes the wet method the most economical for a low-grade ore, it does not do so for a rich ore. The manner of procedure must therefore vary with the kind of ore available.

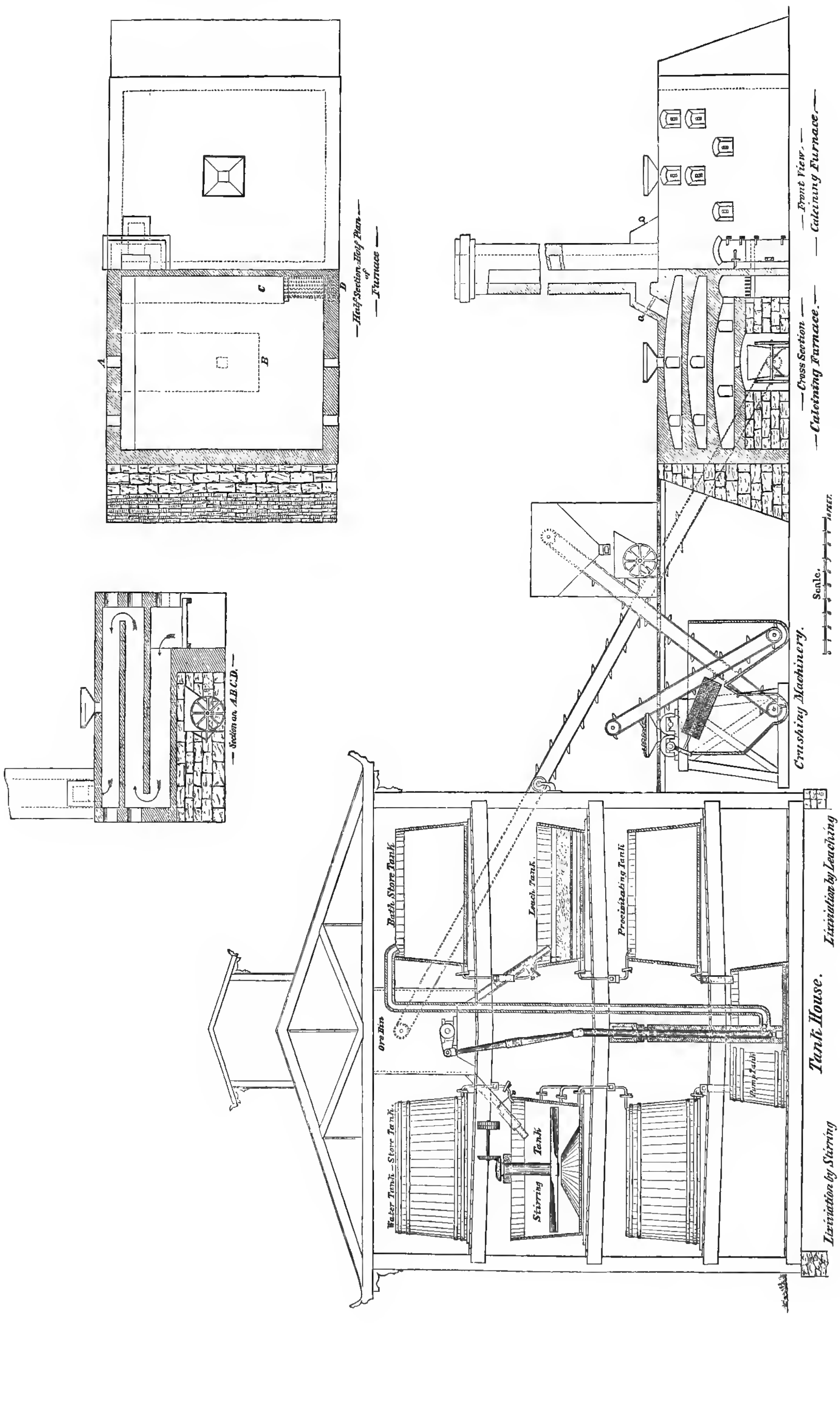
The precipitant usually employed in the wet process is metallic iron, depositing the copper in a pure state, and it depends on the form in which the copper exists in solution how much iron is required. With the proto-salts one ton of copper will require nearly a ton of iron, the atomic weight of the latter being a little less than the former, while with the sub-salts less than half a ton will be necessary.

In England copper is reduced from some six hundred thousand tons of Spanish pyrites annually, most of the sulphur having been first extracted for the manufacture of sulphuric acid by roasting the already partially roasted ore with salt. By this means the copper is converted into proto-chloride, becoming soluble in water; and to render the process still more certain, the water is acidulated with muriatic acid, which at the English extraction-works is almost a waste product The solution is then brought into contact with metallic iron, which precipitates the copper, and the liquid, containing chloride of iron, is thrown away. At some works in England and on the Continent, where acid is a waste product and carbonates of copper are available, the copper is extracted simply by acids. Both these methods are exceedingly effective, but are applicable only where salt and acids are very cheap, which is nowhere the case in this country.

In order to utilize a secondary product of sulphuric acid manufacture, Mr. Monnier patented in the United States, some years ago, a process which consisted in sulphatizing, and thus rendering soluble in water, the copper in sulphuretted ore, by roasting with sulphate of soda, and he obtained, when his method was worked with skill, very satisfactory results. The limited supply of the reagent, however, and its cost elsewhere than at the chemical works, interfered with the general adoption of the process.

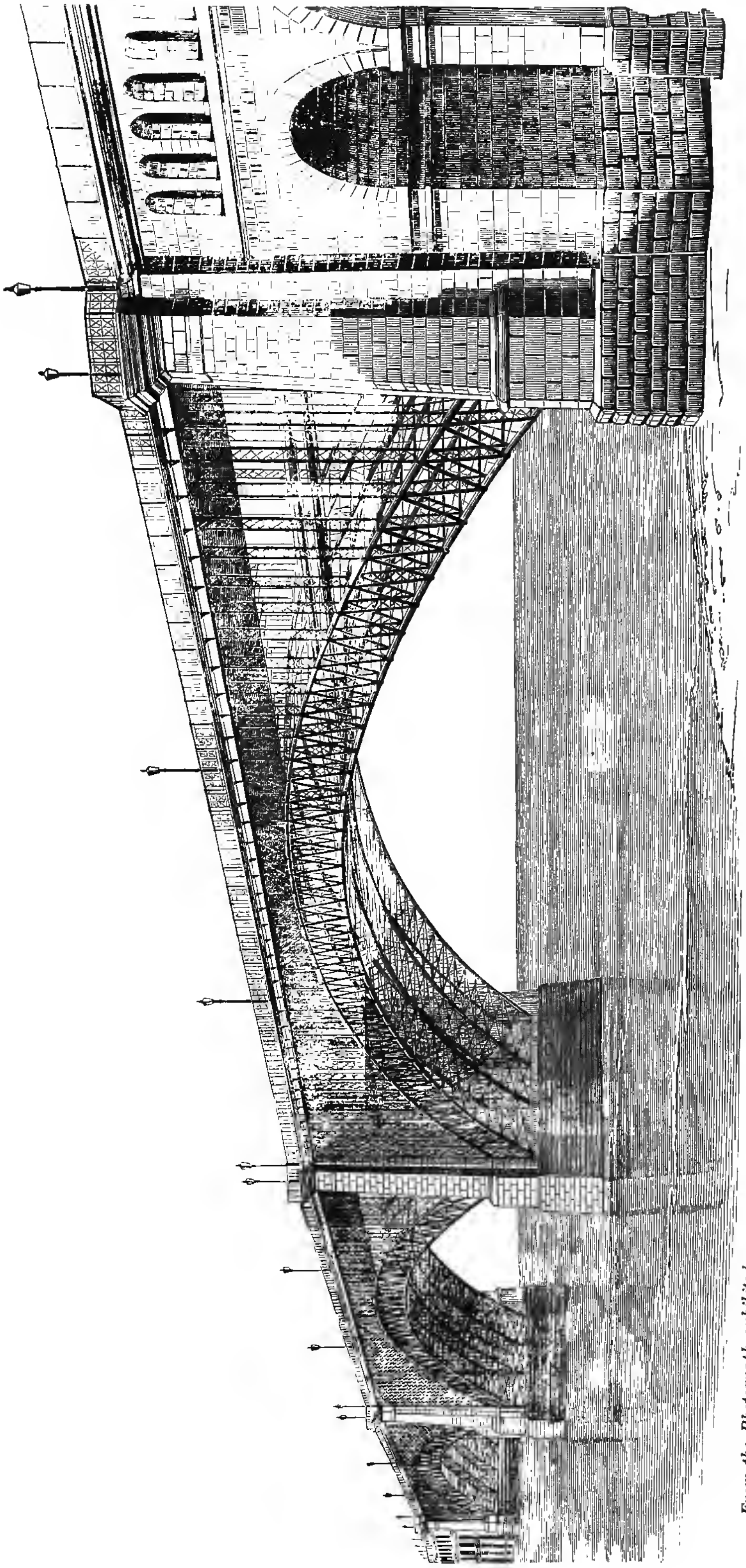
Copper is very generally distributed, almost every one of the United States claiming copper-mines, but the ores are seldom abundant enough in one place to justify the erection of works at the mines, or sufficiently rich to bear transportation to a market. Displays are contributed to the Exhibition from quite a number of localities, both of ores and furnace products. The CHEMICAL COPPER COMPANY, of PHŒNIXVILLE, PENNSYLVANIA, exhibits in the Government Building a series of specimens illustrative of a wet method called the HUNT & DOUGLAS PROCESS, showing the ores treated, the different steps of the method employed, and the marketable products obtained. In the exhibit of the American Society of Civil Engineers, in the west gallery of the Main Exhibition Building, is shown a drawing of the works, from which we have taken our engraving. MESSRS. HUNT & DOUGLAS claim, as the chief merit of their process, the use, as an efficient solvent, of the waste liquors containing chloride of iron which are run off as worthless after the precipitation of the copper in the salt and acid methods. They find that a solution of chloride of iron, when used in connection with a strong brine, dissolves readily the copper from either, naturally or artificially, oxidized ores. They therefore make such a solution by dissolving, in the proper proportions, sulphate of iron (copperas) and salt, or in any other convenient way, and in this solution, heated to about 150° Fahr., they digest the ore, which if massive must first be ground to such fineness that its copper contents will be exposed. If the ore is already oxidized by nature, and consists of a native carbonate or oxide, or a silicate like chrysocolla, it will yield up its copper to the solvent without other treatment; but if the copper be combined with sulphur, it must first be roasted to drive off the sulphur and oxidize the metal.

Ores that are very slimy and form mud on settling must be agitated with the chloride of iron solution in vats provided with a stirring apparatus, as



From the Drawings exhibited.

The Hunt & Douglas Process for the Reduction of Copper from its Ores.



From the Photograph exhibited.

Illinois and St. Louis Bridge: Keystone Bridge Co.

shown in the engraving, while if the ores be coarse and gritty, they may be laid a foot or more in depth on the false bottom of a leach-tub, and the solvent solution be allowed to filter slowly through them. This method by filtration is slower but quite as thorough as by agitation. The chloride of iron in passing through the ore reacts with the oxide of copper, and there results an insoluble peroxide of iron and a mixture of soluble chloride and dichloride of copper which flows into the precipitating tanks, where it comes into contact with metallic iron, and the copper is thrown down in crystalline metallic grains. The liquor becomes recharged with chloride of iron, and ready therefore to be pumped back into a storage tank and heated so that it may be used over again and passed through the ore to dissolve a fresh charge of copper. The solvent is thus constantly regenerated, and the same liquor circulates indefinitely, alternately charged with chloride of copper and with chloride of iron. The only reagents used are a little salt, which must be added from time to time to supply inevitable loss, and the iron consumed in precipitation. This item, however, is less than in the ordinary methods, as about two-thirds of the copper is dissolved as a dichloride (that which is kept in solution by the brine), and therefore only from sixty to seventy-five parts of iron are consumed in yielding one hundred parts of copper.

MESSRS. HUNT & DOUGLAS do not claim that the neutral solution as used will dissolve the copper as thoroughly as acids would; but if the ore be suitable and at all skillfully treated, the residue from a four per cent. ore will not retain over one-half per cent. of copper.

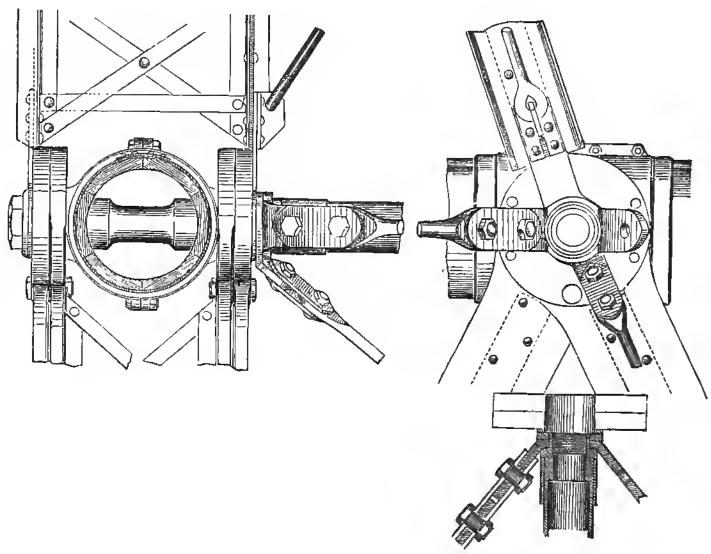
In the exhibits of the CHEMICAL COPPER COMPANY may be seen some remarkably perfect and large crystals of metallic copper obtained by slow precipitation, and ingots made from the cement by a single fusion. This method of reduction is also employed at the Ore Knob Copper Mine in North Carolina, and for the extraction of silver and copper at the Stewart Works, Georgetown, Colorado.

The KEYSTONE BRIDGE COMPANY, of PITTSBURGH and PHILADELPHIA, exhibit in the Main Building a beautiful model, on a scale of one twenty-fourth the full size, of the swing-bridge which it has recently erected over the Raritan Bay, New Jersey, for the New York and Long Branch Railroad Company. The bridge was designed by J. H. Linville, C. E., the President and Engineer of the KEYSTONE COMPANY, and is four hundred and seventy-two feet in total length, being the longest pivot-span ever built in the United States, and believed to be the longest in the world. It is what is denominated a through bridge for a single track, and consists of two trusses, forty feet high at the centre, and thirty feet at the extremities, calculated for a maximum live load of two thousand five hundred pounds per lineal foot, and a constant dead load of four thousand five hundred pounds per lineal foot, the parts being proportioned so as to resist the stresses due to the dead weight of the bridge when open, as well as the dead and live load when closed, and operating as two spans of ordinary bridge. The upper and lower chords are consequently calculated for both tension and compression. The whole construction of the bridge is in wrought iron, the posts being hollow and readily accessible for painting on the interior surface. The structure is supported on the rotating pier by a central drum, the load being transferred either to a central anti-friction cone-bearing pivot or to a series of thirty bearing-wheels under the drum, two feet in diameter, twelve inches face, and traversing between steel-faced tracks. By means of centre suspension bolts in the drum, the weight may be adjusted either partly or entirely on the central pivot or on the bearing-wheels, as found to be most desirable.

The lower chords of the bridge are parted at the centre, so that by means of wedges the ends of the trusses may be adjusted to any required elevation. Before swinging the bridge open, the entire structure is lifted about four inches by four hydraulic rams placed in transverse girders of the central drum under the four central posts of the trusses, and operated by a double engine having two cylinders of eight inches diameter and ten inches stroke, the same engine being also employed to turn the bridge. The turning-gear is brought into action by a friction-clutch, there being two pinions which are made to act equally on opposite parts of the rack by an equalizing attachment in a large mitre-wheel placed between the shafts that drive them.

Automatic locks fasten the bridge at both ends when it is rotated into the line of track, and it is then lowered on to solid bearings on the drum and at the extremities by simply turning a valve, the projecting rails of the track fitting into the same shoes that receive the rails of the permanent spans. About one-half of the dead weight of the structure is made to bear upon the solid adjustable supports of the rest piers, the bridge by this arrangement being rendered firm and steady under the load of passing trains, the trusses acting as two independent spans. Therefore when one arm is loaded no effect takes place in the other arm, and no provision is required for holding this arm down, or otherwise providing as necessary in the case of continuous girder swing-bridges. The bridge has been designed as a cantilever under dead load when swung, and as two independent spans under dead and live load when closed, this being considered by the engineer as the most satisfactory plan; and by means of a slotted link connection at the centres of upper chords, the continuity may easily be destroyed when the bridge acts as two spans. The operation of lifting the bridge by the rams as previously mentioned, before swinging, renders the practical execution of this principle entirely feasible. The weight of the entire structure above the drum is six hundred tons, and the engine, turning-gear and hydraulic machinery operate the whole with ease.

The Keystone Bridge Company in this connection also make an exhibit illustrating the method adopted for forming and uniting the steel tubes used in the arches of the great bridge over the Mississippi River at St. Louis, and the

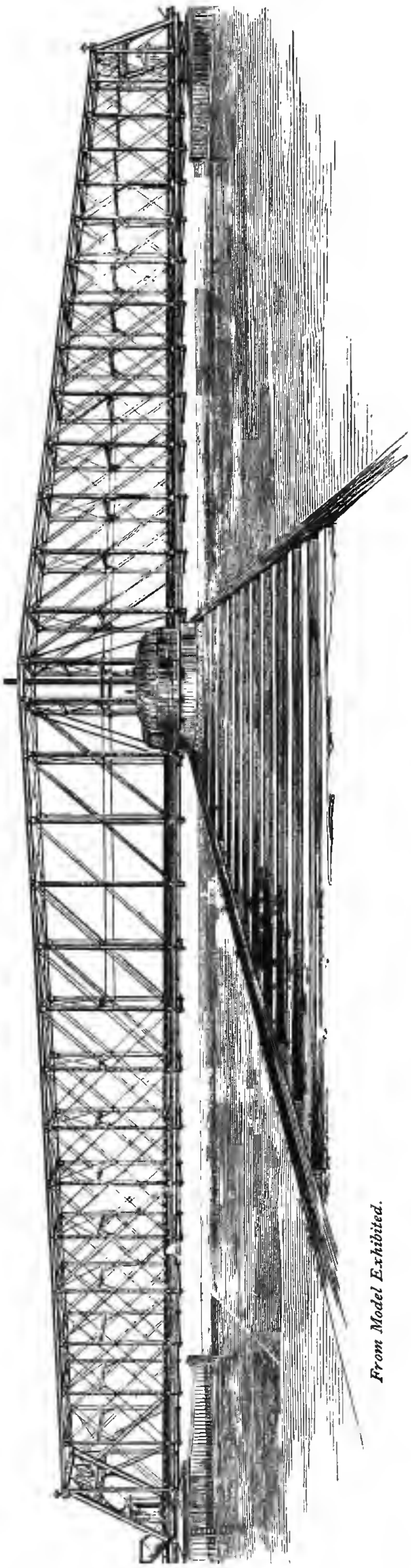


From the Models exhibited.

Details of the Illinois and St. Louis Bridge: Keystone Bridge Co.

accompanying engraving will serve to explain more clearly our description of the same. This bridge, the largest arched bridge in the world, with its spans of five hundred and twenty and five hundred and fifteen feet, was designed by Captain James B. Eads as Chief Engineer, and the superstructure was manufactured from his designs and erected by the Keystone Bridge Company. The tubes of the arches are composed of six rolled cast-steel staves forced into a cylindrical envelope of steel, the lengths of sections between the joints being about twelve feet, and the depth of the arched rib between the centres of two concentric tubes about the same. The two lines of tubes are braced together, and the ends of contiguous sections are united by couplings made in two parts with projections turned on the inner surface to fit into corresponding grooves on the ends of the tubes. The connecting-pin for lateral struts, diagonals and lateral bracing between the several arches is tapered and driven tightly into the joint, the whole connection being made water-tight.

We present an engraving of the bridge which will give the reader an excellent idea of its general design and magnitude. The arches were built outward simultaneously from the abutments and from each side of the piers, being supported by means of direct guys, composed of two lines of main cables of forty-two square inches section, passing over towers to



Swing-bridge over the Raritan Bay: Keystone Bridge Co.

From Model Exhibited.

anchorages on the shore, and by guys balanced over towers on the piers. The towers stood on hydraulic rams, which were caused by automatic gauges to rise and fall, to compensate for changes of temperature in the arches and cables.

The KEYSTONE BRIDGE COMPANY also make a handsome display of photographs of large span bridges constructed by them, the Parkersburg and Bellaire bridges of three hundred and forty-eight feet span, the Newport and Cincinnati bridge of four hundred and twenty feet, etc., etc., and a fine perspective of the High River bridge of the Cincinnati Southern Railway over the Ohio, with spans up to five hundred and twenty feet.

Among the various articles shown in the Machinery Hall, the SPOOL-WINDING MACHINE exhibited by the CLARK THREAD COMPANY, of NEWARK, NEW JERSEY, and PAISLEY, SCOTLAND, merits particular attention, as an automatic apparatus of considerable beauty from a mechanical point of view, and one in which the combinations and details necessary to carry out the requirements have been designed with great skill, and evince that study and forethought on the part of the inventor which never fail to show themselves in the results.

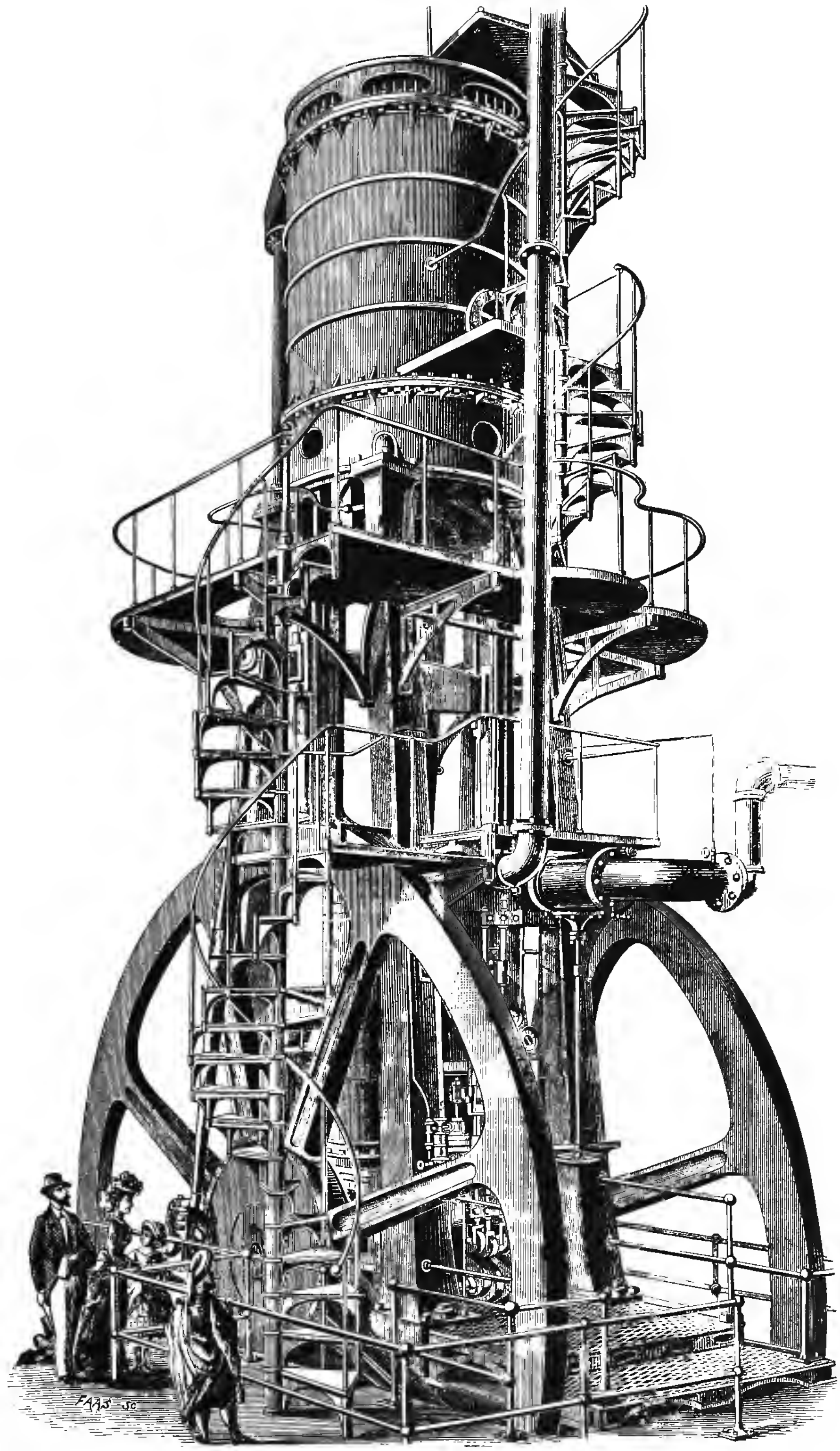
Our engraving gives a front view of the machine, which may be considered as composed of two parts, the portion on the left, really consisting of eight little duplicate machines arranged in a row, and that on the right, which forms a single piece of apparatus and operates the whole. Each of these little machines winds a spool of thread, and hence eight spools may be wound at a time. Back of these may be seen a trough, which is to contain empty spools, and back of this again, in the rear of the apparatus, is a shelf which is intended to hold the bobbins of thread roughly wound as they come from the mill. From these bobbins, threads are taken up and passed through a tension apparatus above them, which keeps them at the proper stretch for winding, and then carried on, each to its little machine. The machines are held rigidly together by longitudinal rods so as to oblige them to work firmly as one piece, and there are three longitudinal shafts or rods passing through the whole set from the machinery at the right-hand end; the upper one, which we will call the guide-rod, moving back and forth and giving side motion to the thread; the main shaft below and behind, with cog-wheel attachments at each machine for revolving the spools; and a rod in front, which carries a steel finger for moving the thread as will be explained presently. The spools are held horizontally and longitudinally in position just back of the front finger-rod by clamping-pins like axles, which pass into the holes at the ends and revolve with the spools very rapidly. Just back of each spool is a swinging curved hopper, its upper end reaching almost to the spool-trough previously mentioned, and its lower end open and curving up just under the position of the revolving spool. In front is a small receiving-trough to each machine for wound spools. All that the attendant has to do is to keep the hoppers filled with empty spools, remove the full spools from the lower troughs as they accumulate, and see that the thread is regularly supplied by the bobbins behind, adding new ones when the thread winds off of those attached. The machine otherwise is entirely self-acting.

A piece of highly-tempered steel called a thread-guide, in the front edge of which is a groove the size of the thread to be wound, is fastened on the upper sliding or guide-rod at each machine. The thread passes down from the tension apparatus over this guide to the spool. As the spool revolves, the longitudinal motion of the guide-rod back and forth moves the thread to and fro over the spool, which winds it up layer by layer; and all those who have noticed the beautiful regularity with which a spool is wound, each layer of thread, one over the other, and each thread in the same layer next to its brother, close up, but no lapping, no confusion, will bear witness to the nicety requisite in machinery which shall accomplish this end.

There is a measuring-gauge attached to the machine. Just as two hundred yards are wound, the spool ceases to revolve; a little chisel moves up and nicks its edge; the sliding-rod in front with its steel finger moves longitudinally and draws the thread over; a hook passes up and pulls it down tightly into the nick; another chisel cuts it off, and the spool drops down into the receptacle provided for it in front. The swinging hopper then flies up with an empty spool in its curved lower end, which is taken up by the axle-clamp and starts into revolution. At the same time the thread, the cut end of which has been held down by the apparatus for the purpose, is pulled over and started on the new spool, and the operation proceeds as before.

It will be noticed that the part of a spool on which the thread is wound always has a variable length, increasing as the winding proceeds outward from the centre. Provision must therefore be made to give this variable motion to the guide-rod carrying the thread-guides. This is effected in its feed at the right end by giving a variable motion to the stops changing its direction. There are attached to this guide-rod two segmental nuts which are made to come alternately into contact with a revolving shaft having reverse screws contiguous to each other, one screw working in each half nut, causing the nuts to travel first in one direction and then in the other. These nuts connect with an arm with a forked end, which works on a fulcrum and operates over a pair of stops or jaws, pressing on to them and moving above them for one motion, and below them for the other, two heavy springs operating to

Spool-winding Machine: The Clark Thread Co., Newark, N. J.



Blast Engine: I. P. Morris Co., Philadelphia.

produce the pressure and change the motion, alternately forcing it down and up, the alternate action of the nuts changing each time in accordance with this motion. By means of a cam and an arrangement of toggle-joint the pair of jaws opens gradually as the thread winds, keeping at a certain distance to correspond to each particular layer, thereby regulating exactly the sliding movement of the guide-rod. When the winding is finished and ready for another spool, the jaws are suddenly closed to their smallest dimensions and the operation is repeated.

We have endeavored thus to bring the main points of this interesting machine before the reader, our limited space not allowing us to pass on to further details, but we believe we have sufficiently explained its peculiar features to make its operations intelligible.

Prominent among the exhibits in the Machinery Hall, just west of the Corliss Engine, and towering almost to the roof, may be seen the BLAST ENGINE of the I. P. MORRIS COMPANY, of PHILADELPHIA. This engine has been designed to meet the wants of American Furnace Managers, certain requirements having been laid down as a standard which the firm have endeavored to follow as closely as possible. These requirements are, "completeness without sacrifice of accessibility to the moving parts, self-adjustment of parts liable to irregularities of wear, and steadiness of the whole structure and preservation of alignment by being self-contained." The first engines of this class—a pair having steam cylinders forty inches in diameter, and blast fifty-eight inches, with a stroke of four feet six inches, and producing a blast pressure of twenty-five pounds—were built about eight years ago for Bessemer steel production. Since that time twenty-four, including the present engine, have been built and put into successful operation, showing that the efforts of the builders towards perfection of design have not been without their reward.

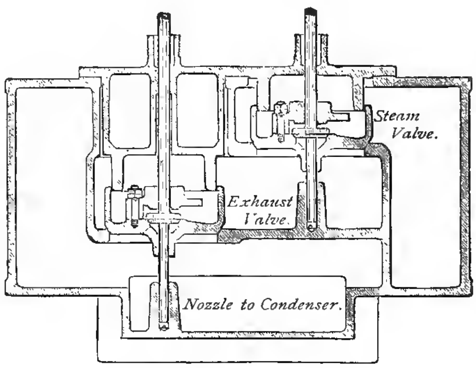
The firm construct engines on this plan with blast cylinders varying from seventy-five inches in diameter and six feet stroke to one hundred and eight inches in diameter and nine feet stroke, and nearly all of them are provided with condensing apparatus sufficient for initial steam pressure of forty pounds per square inch, admitted during three-fourths of the stroke, and producing a vacuum of twenty-four and one-half to twenty-six inches. All parts are proportioned to the work of supplying steadily a blast of forty pounds pressure if required; and although this is beyond the ordinary working of anthracite coal-burning furnaces, it has been exceeded in one case, a pressure of thirteen and one-half pounds having been blown for a considerable time by one of these engines without causing it any injury.

The engines are fitted with the Wanich equilibrium valve, designed by Mr. A. Wanich, foreman of the machine-shop of the Company. The essential feature of this valve consists in the use of a ring cast on the back of the main valve, extending upward and bored out so as to envelope and slide freely upon the outside of another ring cast on the steam-chest bonnet above, extending downward and turned off evenly on the outer circumference. These rings are of course concentric, and the annular space between them is quite small, very much less than the aggregate area of the holes for the passage of steam below the pilot-valve, consequently any steam passing this annular opening when the pilot is raised, goes freely through into the cylinder, exerting no appreciable pressure on the back of the main valve, and permitting it to rise easily. This has been confirmed by connecting an ordinary steam-gauge with the space enclosed by the rings, showing the pressure, when the pilot was seated, to be say thirty-five pounds, and dropping suddenly almost to zero when the pilot was raised, until the main valve opened, when it rose again to thirty-five pounds. This valve has been in use for about four years with highly satisfactory results, saving steam and proving easily manageable.

The blast-valves are of selected thick sole-leather, backed with plate-iron, and the blast-piston is fitted for either metal, wood or bag-packing. The steam-piston is provided with metal double rings held out by springs. The valves are lifted by cams operating directly against rollers fitted into the bottom ends of the lifting-rods, and these cams are adjustable but not variable, giving facilities for experimenting so as to determine the best distribution of steam without interference with each other. The cam-shaft is driven by spur-gears fitted to the main shaft. The rim of the fly-wheels on the side in line with the crank-pin is cored out, so that the excess of weight on the other side will counterbalance the weights of piston-rods, cross-heads, etc. The shaft is of wrought-iron, and the cross-head swivels in the yoke connecting the two piston-rods, so that it may accommodate itself to any irregularities of wear in the main shaft or crank-pins.

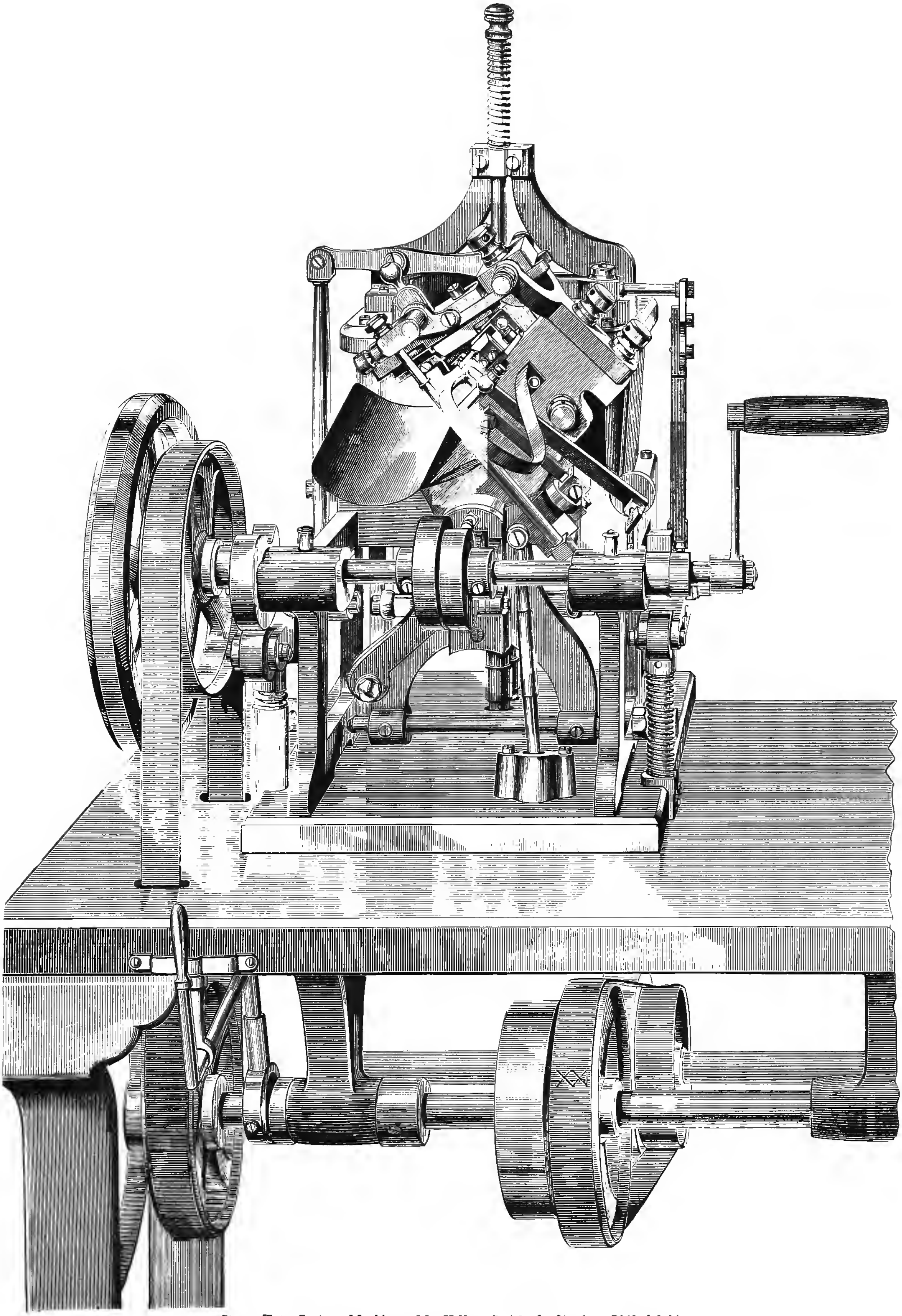
This particular engine has a height of thirty-six and one-half feet, weighs two hundred and fourteen thousand seven hundred and ninety-four pounds, and exerts seven hundred and fifty horse-power, delivering ten thousand cubic feet of air per minute. The bed-plate upon which the whole construction rests is eight feet wide and thirteen feet long, weighs seventeen thousand pounds, and is laid on a foundation of hard brick or good stone at least ten feet in depth and well anchored to it so as to insure stability. The steam-cylinder is fifty inches in diameter, and the blast-cylinder ninety inches, the stroke being seven feet. The fly-wheels weigh forty thousand pounds each.

The height of the engine is principally due to the length of stroke, and this has been done so that a given quantity of air can be supplied by a less number of revolutions and with fewer beats of the blast-valves than is generally adopted in other engines. The direct loss in delivery due to piston clearance and space in the passage being a quantity depending on the diameter of the blast-cylinder, then if we take a fixed diameter of cylinder, it is clear that the percentage of loss of useful effect will diminish as the stroke increases.



The Wanich Equilibrium Valve.

The engine is provided with a condensing apparatus situated just back of the main working parts, and in the entire construction everything has been carried out with a view to proper economy both in first construction and in future use. The firm claim for this style of blowing-engine, as compared with others, a reduced cost, not only of the engine itself, but also of the foundations required in setting it up, and the buildings necessary to cover and protect it when placed in working condition. Great advantage also results from the direct action of the engine, the power being transmitted directly from the piston-cylinder to the blast-cylinder without the action of a beam, as in many engines of this kind. The I. P. Morris Company have for many years been engaged in the manufacture of heavy machinery for iron blast-furnaces, and their exhibit does them great credit.



Steam Type-Casting Machine: MacKellar, Smiths & Jordan, Philadelphia.

Great advances have been made in the methods of casting type for printing purposes from the time of the wooden blocks and rude types of Laurentius of Haarlem to the improved hand-moulds of Archibald Binny of Philadelphia at the beginning of the present century. By the latter as many as six thousand types per day were produced. The hand-moulds were supplanted in 1845 by the complex and effective American type-casting machines, which have wrought an important revolution in the business.

Among the large type-foundries in the United States, that of MacKellar, Smiths & Jordan, of Philadelphia, occupies the first position, and is well represented by an extensive display in Machinery Hall. This firm exhibits a number of modern type-casting machines, which may be operated by hand or power. These machines are constructed upon the same principle (whether operated by hand- or steam-power), and their average production is about one hundred per minute for the ordinary sizes of printing-type, being far beyond the amount of product of the earlier methods. The advantage in using power is that it enables one man to attend to two machines. Our illustration on page 85 shows a machine with steam attachment.

Type-metal is an amalgam of lead, antimony, copper and tin in such proportions as to produce a material hard but not brittle, ductile yet tough, flowing freely yet hardening quickly. Each letter is first cut in reverse shape on the end of a short strip of steel, the greatest care being taken to insure accuracy of proportion and harmony of appearance in the letters of the entire alphabet. The least variation is inadmissible, as it would destroy the harmonious effect of the types when composed or formed into columns or pages. The steel strips when finished are termed punches; and after criticism and approval, each punch is placed in a stamping-machine, and a deep impression made of it in one side of an oblong piece of copper near its end. These pieces of copper are called matrices. They are dressed and fitted up with delicate skill, so that the types cast from them shall be of uniform height and accurate range. They are then ready for use in the casting-machine.

The machine casts but one type at each revolution. It consists of a furnace, on the top of which is a small reservoir of metal kept in a fluid state. In this reservoir is a pump, the plunger of which operates in a cylinder in the bottom, and projects at each stroke a small quantity of the molten metal out from a small hole in a spout or nipple in the front face. The mould in which the stem or body of the type is formed is of steel and is movable, being set in place in front of the reservoir and worked by the action of the same machinery which operates the pump. The copper matrix, containing any special letter stamped into it with the punch, rests with its face against the bottom opening of the mould, being held in position by a curved steel spring shown in the engraving. The method of operation is as follows: The initial movement of the machine brings the upper opening in the mould opposite to the matrix exactly against the hole in the nipple. A simultaneous action of the pump projects a stream of the liquid metal into the mould with considerable force, at the same time stopping the opening in the nipple by a small plug from behind to prevent the further escape of metal. The next movement draws the mould away from the nipple and opens it, throwing back the matrix, extricating the type and dropping it by a slide into a box below. This operation is repeated over and over again as rapidly as the crank or wheel of the machine is turned, and a type is cast each time. On the rapidity of the motion depends the quantity produced. Such is the modern type-casting machine—turning out one hundred types per minute, or sixty thousand per working-day of ten hours, every one of which is a mite contributed to the spreading of knowledge over the world for good or for evil.

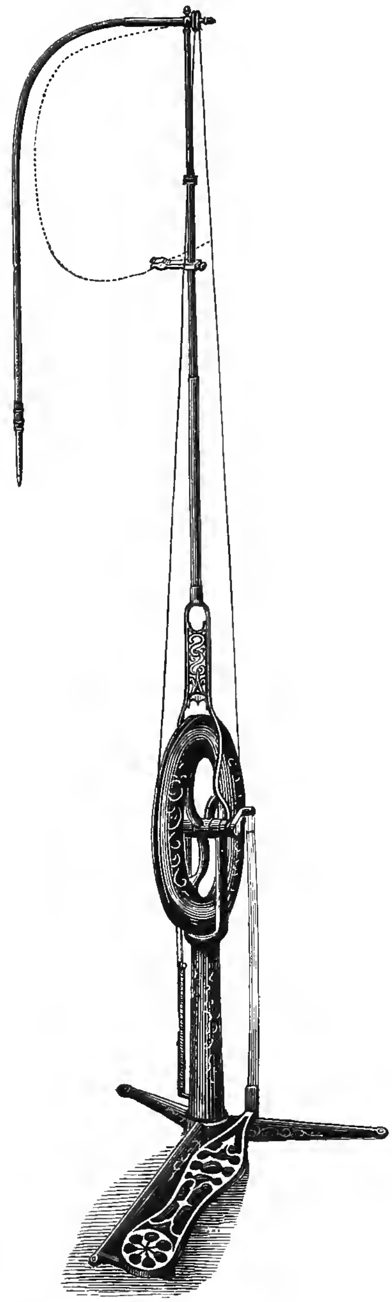
The type as thus formed is passed to boys, who break off the jets or waste ends; then to the dressing-room, where the rough edges are rubbed off on the faces of large circular stones; and finally, they are set up in lines, slipped into a long stick, screwed tight, and the bottom of the type is neatly grooved by a planing-tool. The letters are afterward closely inspected with a magnifying-glass, and all imperfect ones rejected.

The exhibit of this firm is exceedingly well arranged, evincing great taste and a considerate regard for the interests of visitors, by showing them not only the modern type-machines themselves, but the various adjuncts of their establishment, as well as the tools used by this house in the last century. The exceptional excellence of their type is proved by the handsome appearance of our book, which is printed from them. Cases are also displayed containing type—the smallest not thicker than a pin—ancient and modern, plain and highly ornamented, and exquisite borders, crochet and music type, and numerous other essential matters for printers' use. These are all shown in their two magnificent Specimen Books, also on exhibition, which are printed in the highest style of typography: the matter of the lines displaying the types being original and exceedingly quaint, these remarkable volumes have no counterpart in the world. This foundry is the oldest in America, having been established in 1796 by Binny & Ronaldson, and claims to be the most complete in the world.

In the profession of Dental Surgery great progress has been made of late years in the introduction of machinery for the use of the practitioner. The manufacture of instruments, apparatus, furniture, artificial teeth, and dentists' materials generally, has been largely increased and developed, and one may now obtain at the dental depots, ready for use, all of the latest and most improved appliances required in this department of business.

Prominent among these establishments is that of S. S. WHITE, of PHILADELPHIA, represented by an exceedingly elaborate display in the Main Exhibition Building. We desire particularly to draw attention to the DENTAL ENGINE, exhibited by this house, as an exemplification of the modern application of machinery, and well illustrated by the accompanying engravings. By means of this engine all the operations of drilling, filing, polishing, etc., are accomplished with great saving of labor and time to the operator and of pain to the patient, affording better-shaped cavities than by the old methods, and giving great facilities for finishing the fillings and cleaning the teeth. It combines great steadiness of motion with ease and quietness of working, possessing at the same time elegance of construction and simplicity of action. It is operated by foot-power.

Fig. 1 gives a general view of the apparatus. The base is divided into three feet well spread out and making a firm support. To one of these feet, lengthened for the purpose, is attached the foot-pedal, which connects by a flat steel spring, called a pitman, with a steel crank, moving a driving-wheel, which is supported by a post rising from the centre of the base and forked so as to provide bearings for its axle-shaft. Above the driving-wheel is an upright rod, the lower portion formed into a yoke passing over the upper part of the wheel and hinging on to the journal-bosses of the axle-shaft, thus making what may be termed a rocking-arm. Its primary statical condition is assured in an upright position by a prolongation beyond the axle-shaft of that arm of the yoke on the opposite side of the crank and the attachment of a spiral spring with its lower end fastened near the base of the apparatus. A screwed



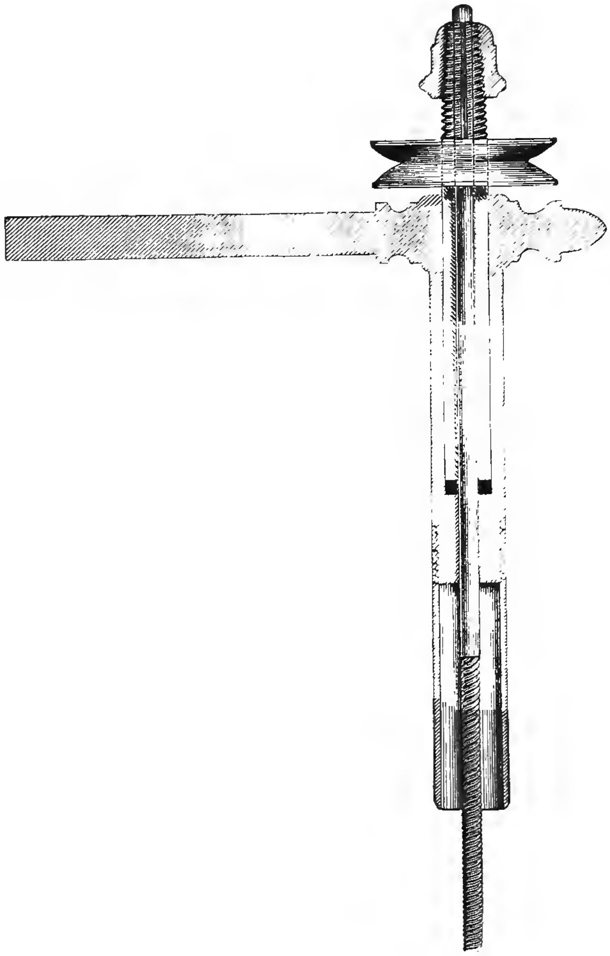


Fig. 2.

Fig. 1. *Dental Engine: S. S. White.*

extension-joint and jam-nut are provided in the vertical rocking-arm, by which it may be lengthened and the driving-cord tightened if necessary. To the top of the rocking-arm is fixed a right-angled head-piece shown in detail by Fig. 2, the horizontal part of which is drilled to receive a stem, upon which is fastened a pulley by a squeeze-nut on a conical screw. This pulley is driven by a cord passing around the driving-wheel, and revolves the stem, the other end of which connects with the rotating shaft of a flexible arm. The head-piece is pivoted and has free horizontal motion, and the arm is flexible at nearly every point in its length of twenty-six inches, being a rotating spiral within a fixed spiral sheath. The hand-piece is fastened to the end of the flexible arm, and the tool fits in to a tool-holder or chuck, being held by a simple yet perfectly satisfactory arrangement, revolving with the chuck without any vibration, and easily removed in a moment if a change of tool is required.

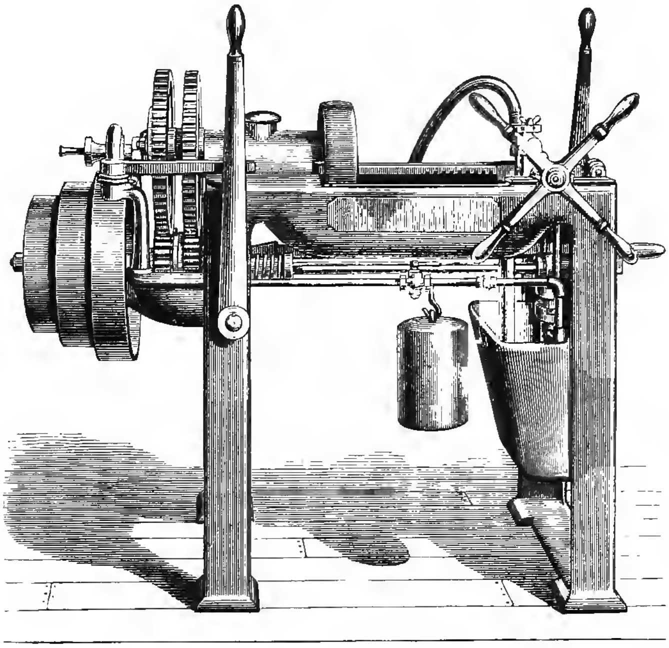
A large variety of tools is provided for this machine, such as excavating-burrs, drills, burnishers, finishing-burrs, corundum points, boxwood disks, wood-polishing points, etc., and a right-angle attachment is also furnished, which can be fixed to the hand-piece and is of great advantage in certain operations.

By means of an extension-treadle the operator can produce motion from either side of the patient's chair without moving the machine. An air-injector apparatus is also provided, consisting of a rubber bulb or bellows, which is compressed automatically by a simple mechanism connected with and working by the driven pulley. The air is forced from the bulb through a connecting rubber tube to a fixed nozzle at the hand-piece, from which it is thrown into the cavity of the tooth under operation, keeping it clear of burr-dust and cuttings and also keeping the bit cool.

The spring pitman which connects the foot-pedal with the crank is one of the novelties of the machine, giving the crank, when on the "down centre," an upward or live motion, and allowing the performer to operate with perfect ease. It is set at such an angle as always to keep the crank off the dead centre, being adjusted to throw it above its centre and allow greater length of turn in starting from rest.

The pivoted rocking-arm with its return spring always recovering the perpendicular when let free, constitutes another important novelty, affording the operator greatly increased freedom of motion and practically nullifying the tremor which always obtains in rigid machines, and communicates itself to the tool even with the greatest care, raising a fatal objection to their use. The flexible working-arm is also a special feature, bending, curving and yielding to every motion, and allowing the operator a freedom of touch which he could not possibly have with a rigid arm.

For many years no uniform standard existed for screw-threads for ordinary bolt and nut use in the United States. The form of thread as adopted by English engineers and known as the Whitworth standard, while possessing some advantages had many objectionable features. From results of investiga-

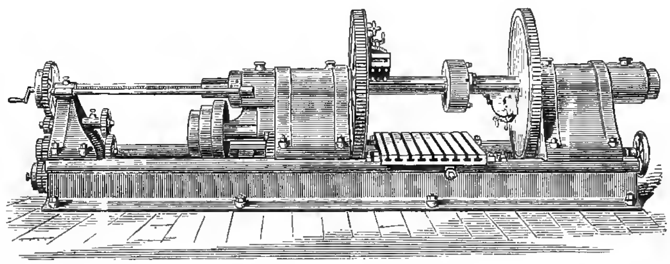


Bolt and Nut-screwing Machine: William Sellers & Co., Philadelphia.

tions of Mr. William Sellers, of Philadelphia, presented by him before the Franklin Institute in 1864, that corporation recommended a system of forms and proportions for screw-threads, bolt-heads and nuts for general adoption by American engineers, and urged the same upon the officers of the General Government, requesting their influence towards its selection as an American standard. In 1868 this system was fully indorsed and accepted by the Navy Department of the United States, and afterwards adopted by other departments, at the same time meeting with such general favor throughout the country as to have become in reality the standard of the nation. We show here an engraving of one of Messrs. William Sellers & Co.'s Patent Bolt and Nut-screwing

MACHINES, constructed according to this standard and exhibited in Machinery Hall. It represents their ¾-inch size, cutting screws from ¼ to ¾-inch, other sizes being made up to four inches. On this machine one man has cut three thousand ¾-inch set screws in a day of ten hours, threaded up close to the head, and two inches long on the part threaded, only one set of dies being used and without heating.

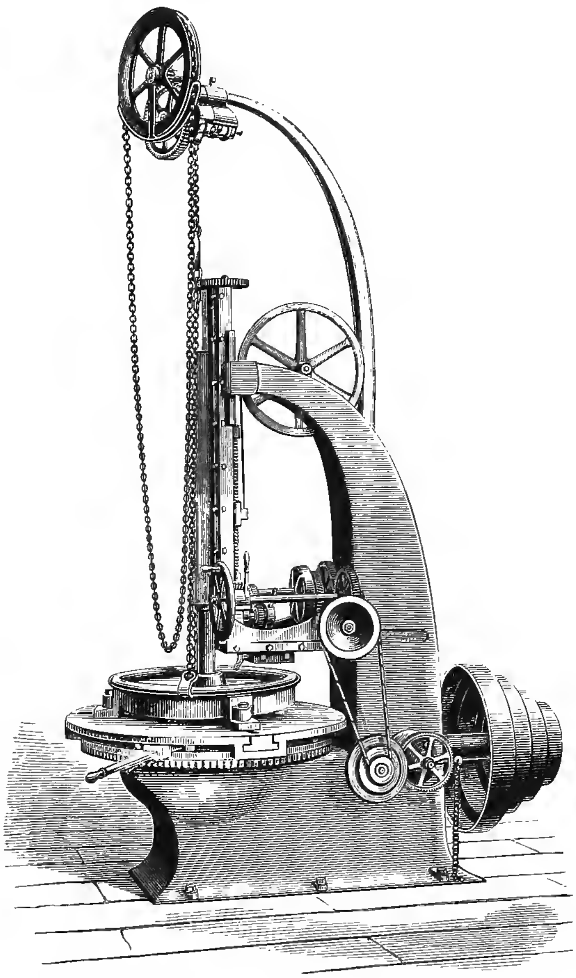
A number of important advantages are claimed for these machines over others in use. The dies revolve and the bolt is stationary, thus enabling the workman to put in a fresh bolt without stopping the machine. The motion of the dies is always in one direction, and the bolt is cut at one operation; the



Cylinder Boring and Facing Machine: William Sellers & Co., Philadelphia.

dies open under cut while revolving and remove all trace of the chip made by the cutting tools. They never run backward, the cutting edge therefore lasting much longer. An index on the back of the large driving-wheel is set to numbers given on a card accompanying, and when so set the bolt will fit a nut of corresponding size with the tap sent with the machine. By moving this index one way or the other the bolt may be cut larger or smaller to suit special requirements, and any necessary adjustment may also be made to compensate for wear of the dies. The dies can be changed without taking off any of the die-holding apparatus, and in less time than in a common hand-screwing stock. The bolt-holder always chucks the bolts in the centre of the dies, thereby insuring correct work. A self-acting oil-feeder supplies oil to the back of the dies, thoroughly lubricating the work, preventing heating, and washing out the chips from the die-box. An automatic self-opening attachment is also provided, opening the dies at a given length of thread and insuring uniformity.

Messrs. William Sellers & Co., in classifying their drilling and boring machines, designate all those in which the cutters revolve and the work remains stationary as Drill Presses, while those in which the work revolves and the cutters are stationary they call Boring Machines. Some of their drill presses, however, in the common acceptation of the term, would be called boring machines, such being generally those in which the size of the hole to be made requires the use of independent cutters inserted in a boring-bar.



Car-wheel Boring Mill: William Sellers & Co., Philadelphia.

Among the horizontal drills exhibited by them is a Cylinder Boring and Facing Machine, represented in the accompanying cut, designed to bore locomotive cylinders, and which may be classed as among "the most notable of modern special tools." It has a 6-inch boring-bar driven at both ends of the cylinder, independent slide-rests for facing off both ends, and six changes of boring feed, with quick hand feed. The bar may be taken entirely out of the cylinder by hand or by power, so as to allow shifting of the work. The cutter-heads bore from ten to twenty-two inches. The machine possesses great rapidity of work, and will take one of the largest freight or express passenger-engine cylinders, boring, facing up flanges, and counter-boring for clearance of pistons at end of stroke, in three and a half hours, the quickest time ever previously made on the same work before the construction of this machine being nine hours, and generally on ordinary boring machines thirteen hours. This rapidity is largely effected by an improvement, by which one cut with a fine feed may be made to take out the greater quantity of the metal, and the machine be then readily and quickly shifted to an exceedingly coarse feed for the finishing cut, resulting in a saving of time, with less wear of cutters and more accurate work, especially with deep holes, than if done in the old way.

Among the boring machines of this same firm we would draw attention to a Car-wheel Boring Mill, shown by the engraving on page 93, and designed for car-wheels up to 36-inch, or general work up to 48-inch diameter. It is provided with a horizontal face-plate and universal chuck for all sizes up to thirty-six inches in diameter, and is arranged with power-feed and quick hand traverse in either direction, thus allowing of rapid work as in the machine previously described and insuring uniformity of hole. The boring-bar is forced down from above into the wheel being bored, and its bearing may be adjusted vertically. The machine possesses quite an advantage in allowing the faces of hubs of locomotive truck-wheels to be turned off, at the same time that they are bored, by an adjustable hub-facing attachment, the slide of which is independent of the boring machinery. A patent safety-crane attachment, as shown in the figure, is made whenever desired. The capacity of this machine is fifty car-wheels per day of ten hours.

Messrs. William Sellers & Co. also exhibit a number of punching and shearing machines of excellent design, and we would mention especially a heavy Plate Shearing Machine for trimming the edges of long plates or for cutting plates of five feet in width or under, off to length. This machine was designed to meet the requirements of modern ship-building or bridge construction. It is provided with a bed for holding the plate and clamping it if necessary, and will shear plates one inch thick with exceeding exactness. The upper blade is guided vertically, and is driven downwards by a pitman as wide as the blade is long, receiving its motion from a long rocking shaft above it, which is operated by an arm or lever in the rear of the machine and not seen in the engraving. This arm has a segmental rack working into the teeth of a spiral pinion driven by a bevel-wheel and pinion, and open and crossed belt similar to the method adopted by this firm for their planing-machines. The driving arrangement is exceedingly efficient, and an automatic adjustment is provided to the belt-shift motion gauging the length of stroke. The blade after making the down stroke immediately ascends again at double its descending speed, and stops up ready for the next cut. It is at all times under the control of the operator, and can be made to cut to any fixed point in its length, and then stopped or raised, the hand-rod in front, operated from either side, being used for shifting the belts and starting or stopping. Curved blades can be placed in the vertical slide if desired, and the bed-plate connected with

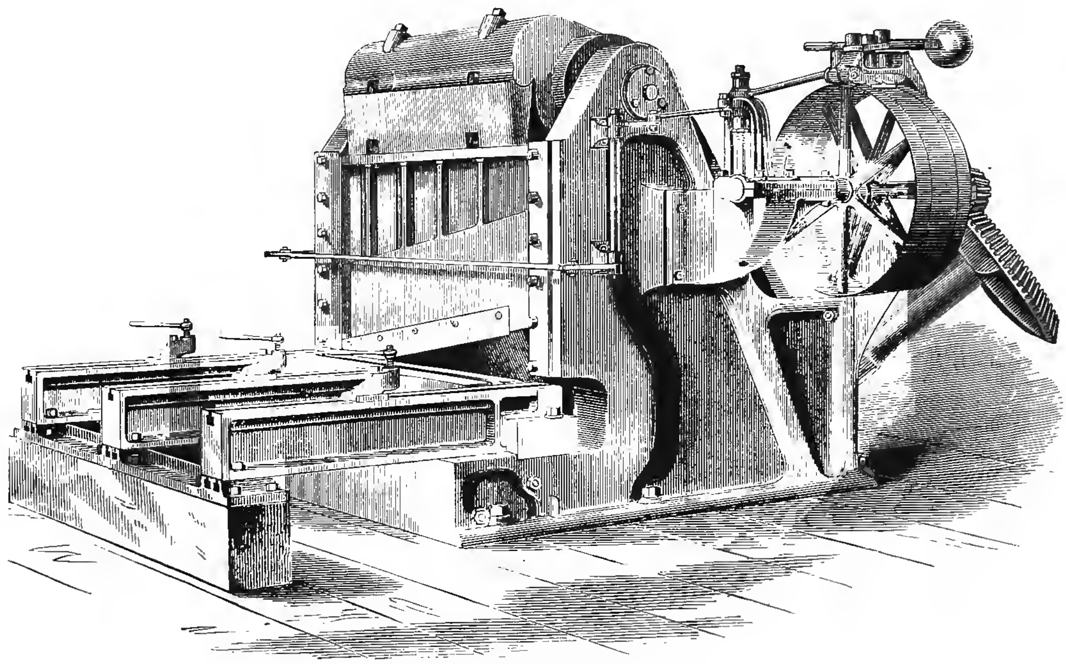
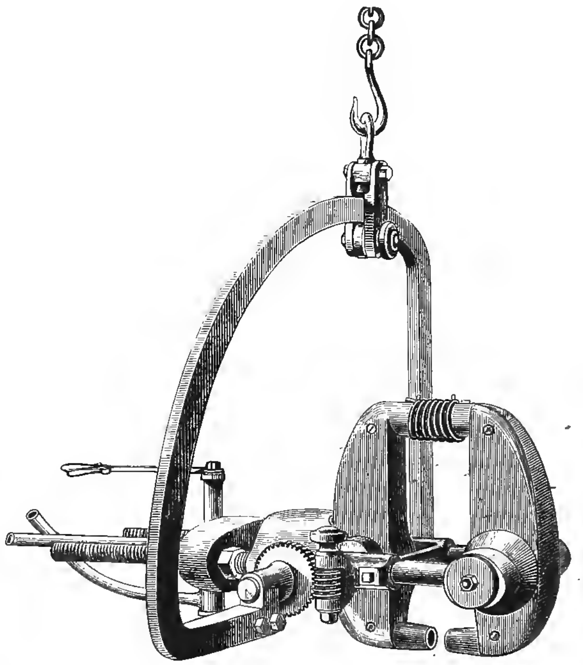


Plate Shearing Machine: William Sellers & Co., Philadelphia.

the lower blade may readily be removed to receive a curved bed-plate, with shear-plate bent to correspond with the curve of the upper blade.

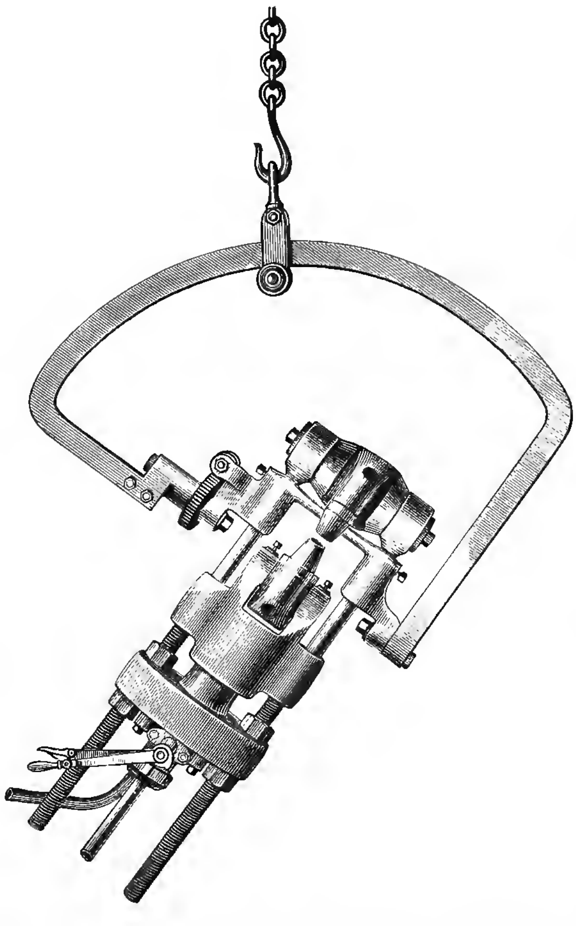
The subject of riveting by power has for some time attracted the attention of mechanical engineers, and steam-riveting machines have been used with considerable success. There are objections, however, to the use of steam which have been most effectually met by the application of hydraulic power, and we are indebted to Mr. Ralph H. Tweddell, of Sunderland, Great Britain, for the invention of a hydraulic riveting machine combining the advantages and avoiding the difficulties of previous systems. Messrs. William Sellers & Co. as assignees and sole manufacturers in the United States for Mr. Tweddell's patent, exhibit one of their make of these machines, possessing many improvements of their own, and arranged with convenient overhead carriage and hoisting machinery to facilitate its use. The essential point of this invention consists in the use of an accumulator, from which a continuous regular pressure may be obtained as wanted. The adjustable accumulator is arranged with weights suspended below the main casting, and easily released, if required, to adjust the pressure to the kind of work being done, each weight representing two hundred and fifty pounds per square inch on the ram of the riveting machine, and the maximum pressure obtainable being two thousand pounds per square inch. A double-acting pump is connected with it, operated by crank motion, and taking its water from a reservoir in the upright column to which it is attached. The pump is arranged so that when once started for work it is never stopped while the machine is in use. By an improved relief-valve, as soon as the accumulator is full, the direction of the water coming into it from the pump is changed back into the same reservoir from which it was taken, and it continues so to flow until wanted in the accumulator, when the action of the valve directs it back again. The pump is maintained in motion ready for immediate action, and yet relieved from strain when not required for work, avoiding all risk of delay at starting or of loss of water and entrance of air in the chamber while standing.



Portable Riveting Machine. William Sellers & Co., Philadelphia.

The portable riveter is suspended from a hoisting machine and overhead-carriage, having both longitudinal and transverse motion. The water under pressure is carried by jointed or flexible pipes from the accumulator to the machine, and passes into a compressing cylinder in which a piston works.

Two levers or jaws of the machine contain dies in the short ends, the long ends being connected by a spiral spring, and one or the other of these levers is attached to and moved by the piston, the dies driving the rivet. The action of the water pressure on the piston is controlled by a valve opened and shut by the operator. When the valve is opened, the piston moves the die to which it is attached until the rivet is headed, acting without blow and with a force positively defined by the pressure on the accumulator. The pressure is continuous and uniform, and may be maintained as long or short a time as desired, entirely independent of the action of the pump. One man can raise and lower the riveter, adjust it to the rivets and operate it. Our three engravings show the machine in three positions, corresponding to work in which the seams are vertical, oblique or horizontal. The rivets are supplied by boys, ahead of the operator, and on straight beam-work ten to sixteen rivets can be driven per minute.



Portable Riveting Machine: William Sellers & Co., Philadelphia.

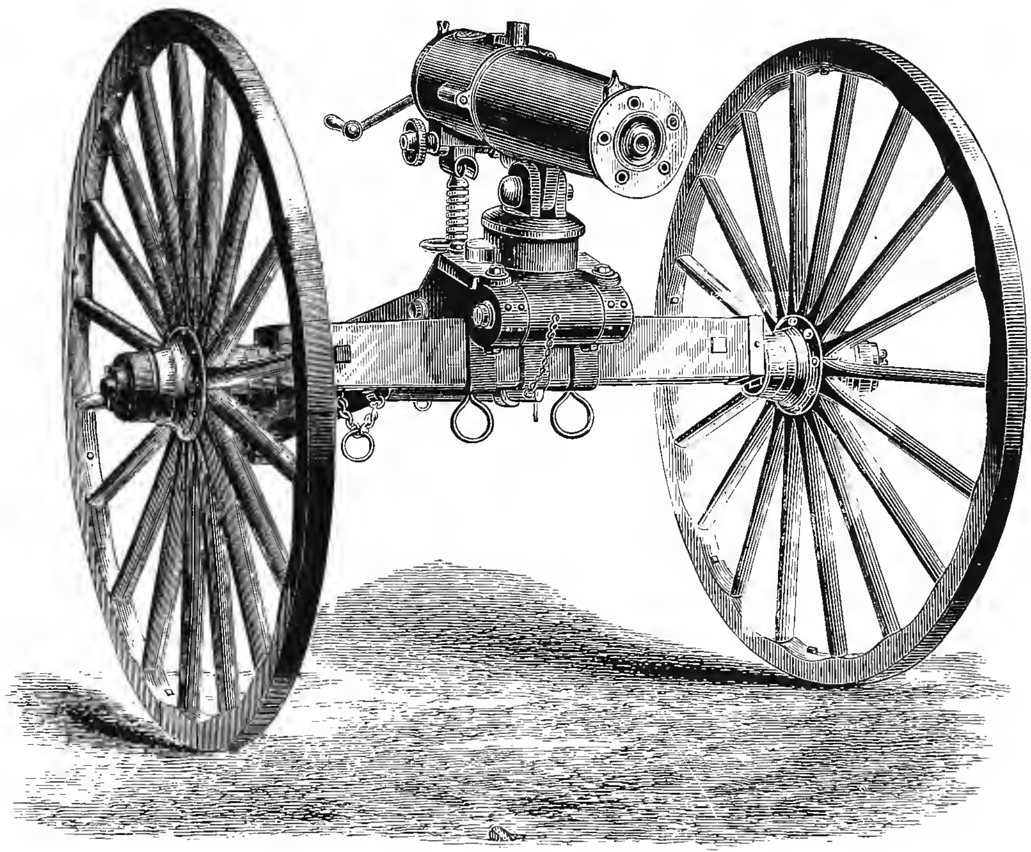
The Gatling Gun Company, of Hartford, Connecticut, exhibits in the Main Building a number of specimens of its famous Gatling Gun, invented by an American, Richard Jordan Gatling, in 1861–62, and after extensive trials, adopted into the service of our own Government as well as by most of the civilized nations of the world.

There are two styles of gun on exhibition, the original type as first constructed and a new design but recently brought forward, which possesses many advantages in arrangement of details over the old gun. Descriptions of the original type have been published and are accessible to the reader. It is of the new gun that we propose to speak.

The gun, as illustrated by the accompanying engraving, consists of five parallel breech-loading rifle barrels, open from end to end, and grouped about a central shaft to which they are rigidly connected by forward and rear disks or plates. The breech of each barrel is chambered to receive a flanged centre-fire metallic-cased cartridge. The shaft extends back some distance in the rear and immediately behind the barrels a cylinder of metal, called a carrier-block, is fastened to it, having on its exterior surface five semi-cylindrical grooves, cut parallel to its axis and forming trough-like extensions to the barrel chambers. These are to take and guide the cartridges into the barrels, and also to receive and discharge the empty cases after they are fired. A prolongation of this cylinder back forms another cylinder, called the lock-cylinder, which carries, in prolongations from the cartridge grooves, five long breech-plugs or locks. A breech-casing, rigidly connected with the gun-carriage by a screw by which the gun may be elevated or depressed, covers the lock-cylinder, and through the centre of the back plate of this breech-casing the rear end of the shaft is journaled. A cylindrical envelope covers the group of gun-barrels from muzzle to breech, and it is attached to the gun-carriage on the lower side by a vertical joint. The front end of the shaft with the front barrel-plate revolves within the end of this cylindrical envelope. A hand-crank is attached directly to the rear end, by which the shaft with its group of barrels, the carrier-block and the lock-cylinder, all rigidly connected with it, may be freely revolved. On the inner face of the breech-casing is arranged a truncated, wedge-shaped, projecting, annular or spiral cam, inclined back both ways from a flat portion, the apex of the truncated wedge pointing towards the barrels, and against this cam the rear ends of the breech-plugs or locks bear, being held in place by a lug from each, working in a groove at the base of the cam. Each lock has in it a firing-pin operated by a spiral main-spring. The firing-pin projects at each end beyond the lock, the front end being a point, and the rear end being finished with a knob which at a certain stage in the revolution of the shaft is drawn back by a groove in which it works, and then suddenly released, causing the front to enter the cartridge and explode it. The breech-casing extends over the carrier-block, covering it, except a portion from near the bottom upwards on the left side, where it is open, so that discharged cartridge-cases as withdrawn from the barrels may drop out on the ground. In the top of this casing is an opening, placed in the correct position and of the proper size, for a single cartridge to fall through into one of the channels of the carrier-block when it revolves underneath. The upper part of this opening is formed into a hopper, to which can be attached a cartridge or feed-case, holding a number of cartridges, lying in single file, one above the other. The cam in the rear of the locks is so arranged that each lock, when it gets in position behind the cartridge-hopper, is drawn back to its full extent so as to admit a cartridge in front. The action is as follows: Turning the crank, the shaft and its appurtenances rapidly revolve. Cartridge after cartridge from the feed-case drops into its respective receptacle in the carrier-block as it comes under the hopper. As each one passes on in revolution, the lock behind it, being pushed by the inclined cam, follows it up, thrusting it into its barrel, and, just before the shaft has reached half a revolution, drives it home and closes the breech. At this moment the firing-pin, which has been drawn back, is released and fires the cartridge, the reaction being resisted by the lock. The lock still revolving onward now begins to withdraw, and a hooked extractor attached to it, which had previously caught over the flange of the cartridge, draws the shell out, dropping it on the ground. By the time a complete revolution is accomplished, the lock is back again all ready for a fresh cartridge in front. The gun thus fires each barrel only once in a revolution, as many shots being fired in one turn as there are barrels. The working is very simple. One man turns the crank, and another supplies the feed-cases, one after another, as rapidly as exhausted, and the operation proceeds indefinitely.

The gun is mounted on wheels in the same way as ordinary field-pieces, or it may be placed on a tripod. In addition to the screw before mentioned for elevating or depressing the breech, there is also an adjustable arrangement at the rear, by which a limited angular movement in a horizontal plane may be given to the gun if desired. This operates very prettily by the centrifugal force from the turning of the handle, making one movement back and forth for each turn, the handle moving in an ellipse instead of a circle.

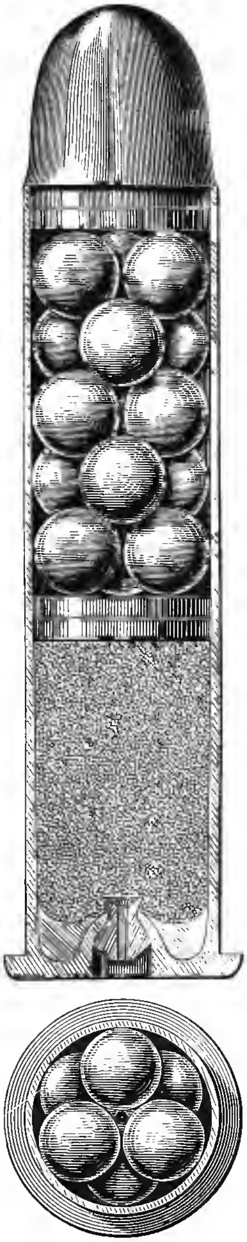
The details of construction in the new gun have been very much modified from those in the old type, resulting in great simplicity of assemblage and more substantial design, greatly increasing its endurance. The gun is very easily taken to pieces for cleaning or repairs by merely removing the nut at the rear, when the crank can be taken off, and part after part removed, the whole coming to pieces. By this nut, also, which is a set nut, an adjustment



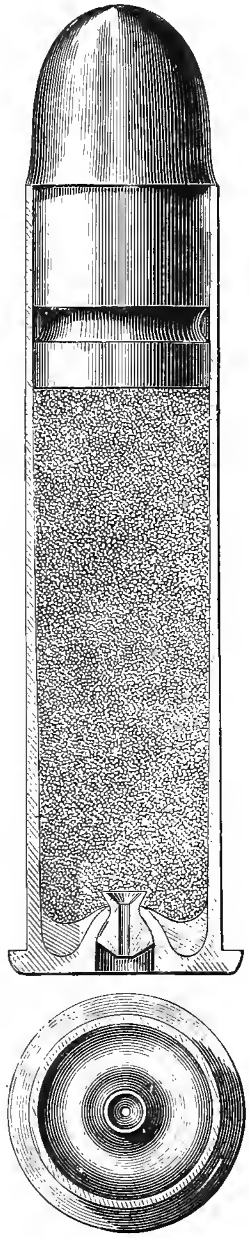
Gatling Gun: Gatling Gun Company, Hartford, Connecticut.

can be made at a moment's notice, in the length of the spaces for the cartridges, to accommodate the breech-chamber to cartridges from different manufacturing establishments, which often differ considerably in thickness of head. In the old type of gun this adjustment was a matter of considerable trouble, and had to be made at the front end. A great improvement has been effected in the new gun in the ejecting of the locks. By opening an aperture in the back plate of the breech-casing, they can easily be drawn out with the finger.

If one gets out of order, it can be taken out and the firing proceed without it, there being however one shot less for each turn, and one cartridge falls to the ground undischarged.



Cartridge.

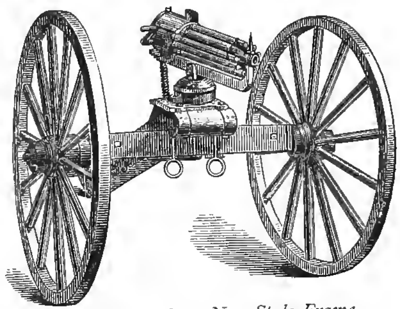


Cartridge.

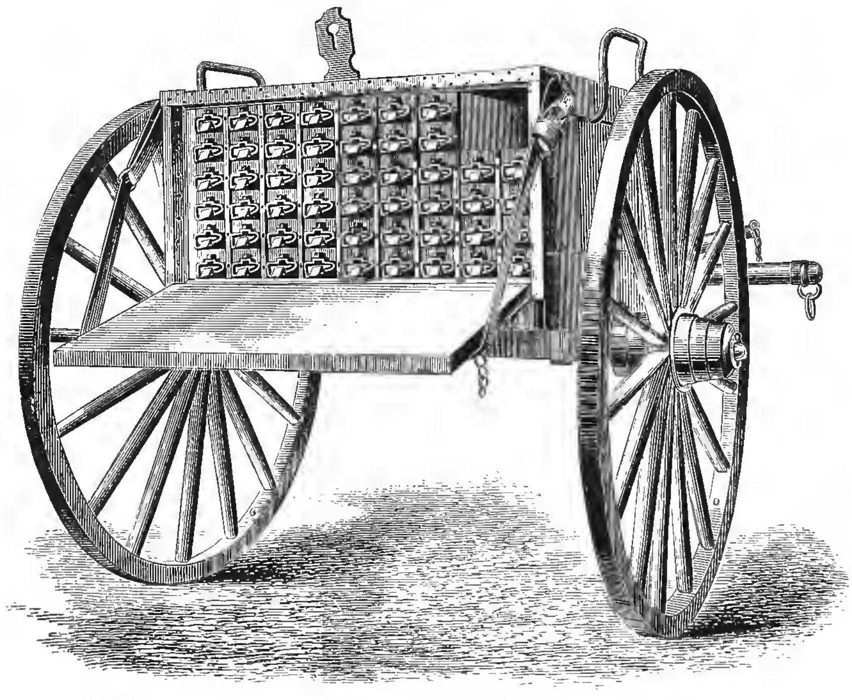
The arrangement of direct-acting crank from the rear, and the placing of the hopper exactly on top of the gun, at the same time improving its shape, so that cartridges may fall quickly by gravity without the necessity of forcing, has greatly increased the rapidity of firing, the new gun being capable of firing up to twelve hundred shots per minute, whereas the army reports claim only about four hundred and fifty shots per minute with the old gun. The new type of gun is very light, weighing only ninety-seven pounds, and it can easily be carried on mules or horses over rough country and operated at short notice.

Guns are made of 0.42, 0.43, 0.45, 0.50, and 0.55-inch calibre, and the larger calibres have an effective range of over two miles. The gun is reported by a Board of the War Department as "capable of maintaining uninterruptedly for hours a most destructive fire at all distances, from fifty yards up, being beyond all question well adapted to the purposes of flank defence at both long and short ranges."

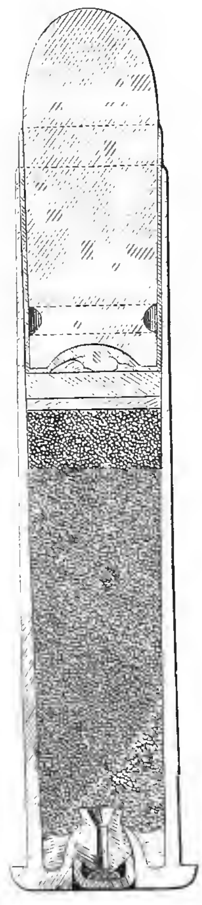
The Miltimore Car Axle Company of New York, exhibits a patent Compound Car Axle, the invention of Mr. George W. Miltimore, which it is claimed fully meets the difficulties experienced from the sliding of wheels on the rails, whether caused by curves, irregularities in the track or differences in



Gatling Gun, New Style Frame.



Limber Carriage · Gatling Gun Company, Hartford, Connecticut



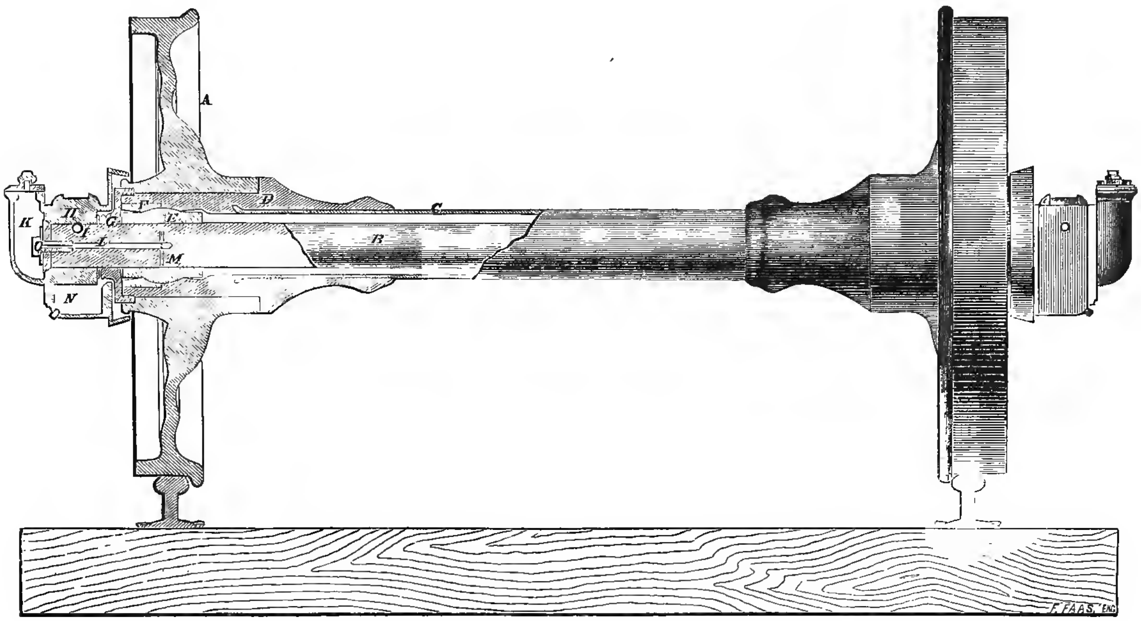
Cartridge.

the circumference of wheels, and inseparable from the use of the ordinary rigid axle. The improvement commences with a radical change from the ordinary arrangement, in that the axle is kept stationary while the wheels revolve, thus eradicating at once all tendency to torsional stress. The axle, which may be either of steel or cold-rolled shafting, is of the same size throughout, and passes at each end into a cast-iron pedestal-block, in which it is firmly secured and rendered immovable by a horizontal steel bolt passing through both axle and block. The axle is encased in a loose revolving sleeve of wrought-iron pipe, having cast-iron ends, on which seats are formed for the wheels, which are loosely mounted, each wheel being held to gauge on the inside by a shoulder in the casting, and on the outside by a cast-iron nut screwed to the end of the sleeve and fitting against the hub. Oscillating cylindrical boxes of brass fit in between the sleeves and the axle, forming the only points of contact, the bearing surface being on the under side. These boxes are made with a curved bearing on the outside to allow them to adjust themselves freely to the spring of the axle, and thus insure a perfect bearing on the interior for the whole length of the box, and avoid wearing at the ends. A box-ring fits closely to the outer half of the curve, and the sleeve-casting is turned to fit the inner half, sufficient room being left at the ends for oscillation.

The action of the device is as follows: When drawn forward, the wheels in moving, although loose on the sleeve-bearings, carry the sleeve round with them, the friction being much greater than on the axle-bearings; and on a straight track with wheels of the same diameter there is no motion whatever on these outer bearings. When, however, owing to the slighest curve, or an irregularity of track or other cause, one wheel is required to move faster than the other, instead of sliding one wheel, as is the case with the ordinary arrangement, either wheel is perfectly free to accelerate or retard its motion independent of the other, according to the space over which it has to move. No tensional strain can be thrown on the sleeve, for if a wheel should be forced slightly out of the perpendicular, as when the flange strikes the outer rail of a curve and thereby cramps the hub on the wheel-seat, it at once turns the sleeve with itself and gains the necessary increase in motion at the opposite hub where there is no cramp.

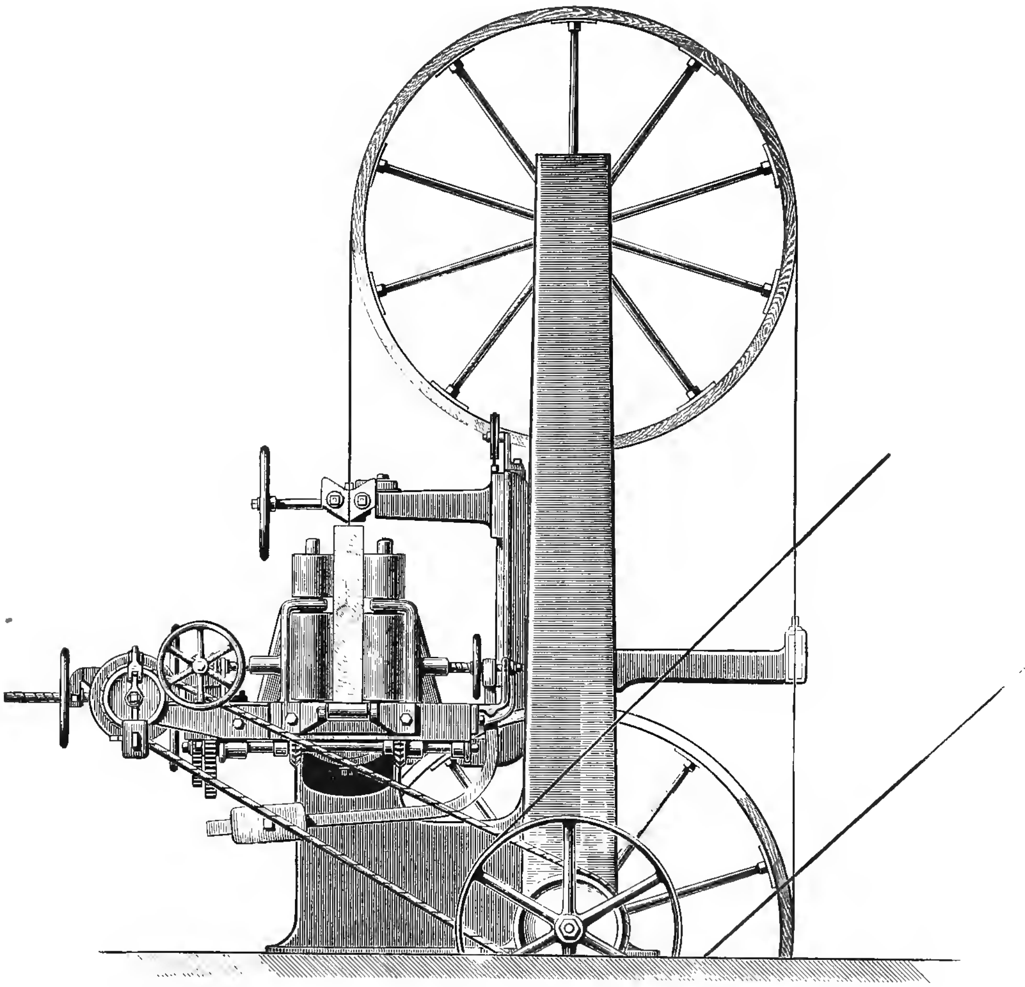
It is claimed that the following advantages are gained by the use of this axle: A reduction in power required to haul the train, consequently a saving of fuel; increased durability to wheels and axles; saving of wear on road-bed; increased comfort and safety to passengers; great economy in lubrication; freedom from hot boxes; less expense for repairs; and ability to use wheels of larger diameter. The results of practical experiments which have been made on the Vermont Central and other railroads for considerable lengths of time would seem to justify these claims, and there are at present seven cars equipped with these axles in daily service on the West End Passenger Railway in the Exhibition grounds, operating with great success. Trucks with these wheels have been running on the Vermont Central and on the Chicago, Dubuque and Minnesota Railroad for a considerable time, and the results give a durability of at the very least double that of the rigid wheels. The Miltimore wheels, after a service of sixty thousand miles on roads of heavy curvature, show exceedingly light flange wear, evincing an equivalent saving of wear on the rail. It is stated that axles now in service, running fifteen months at a rate of one hundred and fifteen miles per day, have consumed but one pint of oil per month, and when grease is used the saving is still greater. In addition to this the use of cotton-waste is entirely dispensed with. A great advantage exists in the facility with which a wheel may be changed and a new one substituted should the breaking of a flange or any other cause require it. Two men with a jack can easily remove a wheel and replace it in a short time without disturbing the car. The removal of the torsional strain from the axle affords greatly increased safety to the train and also allows the use of larger wheels, resulting in a smooth, even motion to the car and saving in power to draw the train. A fast passenger-train of five cars with forty-inch wheels has been running on the Vermont Central Railroad from one hundred and fifty to two hundred miles per day for eighteen months with great success. The wheels being triply cushioned, the hammering so destructive in the case of the ordinary axle is very much reduced. Even if an axle should break, the sleeve acts as a protection, and it would be almost impossible for the wheels to get out of place. If all that is claimed for this axle continues to bear the test of practical use, it is destined to effect an entire revolution in railway equipment.

Messrs. Richards, London & Kelley, of Philadelphia, and London, England, make a fine exhibit of machinery for working in wood, from which we select one of their Band Sawing Machines, the front and side elevations of which are shown by the engravings on pages 106 and 108. The machine is very substantially constructed, the frame being of cast iron in one piece, with a rectangular cored section; The wheels are sixty inches in diameter, made of wrought iron covered on the circumference with wood faced with leather or gum, and are warranted to stand the tension of blades up to three inches in width, and resist safely any centrifugal strain. A vertical adjustment of sixteen inches is provided to the top wheel, which is carried on a steel shaft two and a half inches in diameter, with bearings on both sides of the wheel, and saws may be used up to thirty-two feet in length and three inches in width. The supports of the shaft rest on springs, which equalize the tension on the blades, allowing them to expand and contract freely.



Patent Compound Car Axle: George W. Miltimore.

The machine has feed-rolls adapted to take timber of twenty-four inches in width and ten inches in thickness, or to cut from one side of a plank five inches thick. The method of imparting motion to the feed-rolls is novel and very superior, being accomplished as follows: A revolving plate with its axis at right angles to the feed-shaft comes into rolling contact with the circumference of a wheel on the feed-shaft, which slides on a spline of the shaft, and may be moved to and fro each way from the centre of the revolving-plate. The action of the revolving-plate causes this wheel to turn with greater or less rapidity, depending upon its distance from the centre, and its movement operates the feed, the speed of which is regulated accordingly. The feed will be either forward or backward, depending on which side of the centre of the revolving-plate the wheel is placed, and the direction can be changed at a moment's notice. The power being frictional makes it a safeguard against breakage, and at the same time it is sufficiently tractive for all practical purposes. Attempts have been made previously to use feeding appliances of this kind in moulding



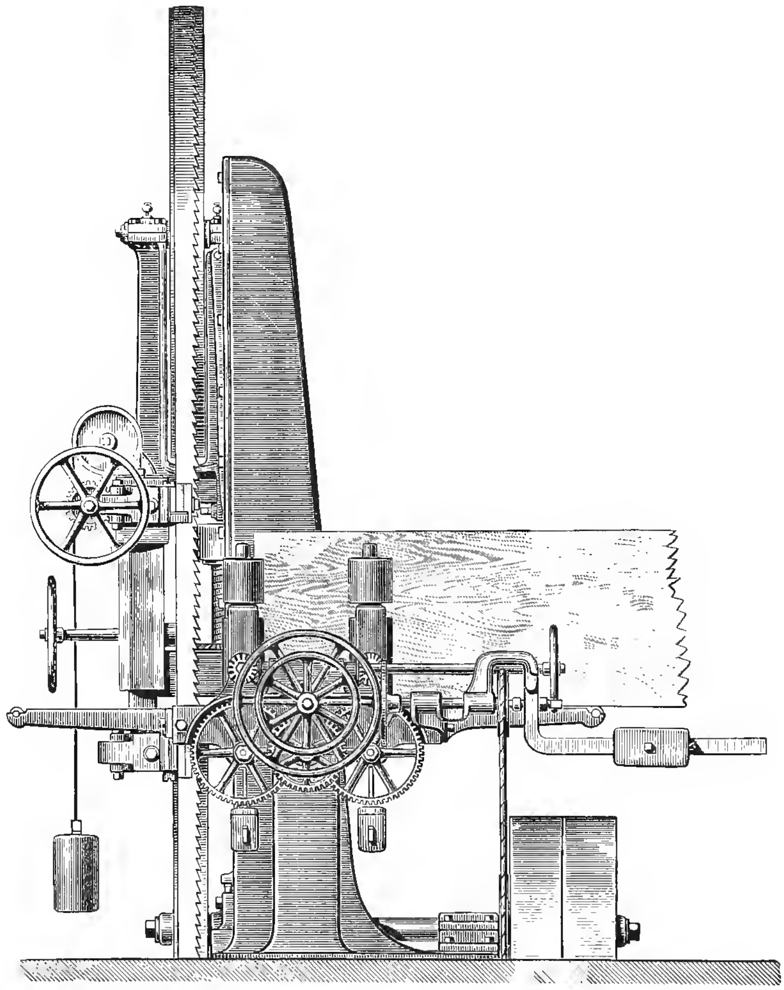
Band Sawing Machine: Richards, London & Kelley, Philadelphia.

and other machines, but the conditions were for some strange reason always reversed and the result was a failure. The arrangement here adopted seems to accomplish all that is wanted, and the rate of feed may be increased from zero to forty feet per minute or the reverse, the feed being started or stopped at pleasure, and made either forward or backward.

The saws used are those of M. M. Perin & Co., of Paris, France. Band saws were invented nearly seventy years ago, William Newberry, of the city of London, England, having in 1808 constructed and patented a band sawing machine, which, judging from the illustrations preserved of it, appears to have been a very good machine, possessing nearly all the capabilities of those of the present time. The pivotal table, the parallel gauge, the feeding rolls, and radius link were all provided, the great material difference being the inconvenient manner of removing and replacing the blades. Circular saws were hardly in use at that time, and the opportunity would seem to have been exceedingly good for competition against the reciprocating saws of the day. Little or no use was made of the invention, however, and it lay dormant until within the last twenty years, when the subject again came forward, and saws of this kind were first exhibited as a novelty at the Paris Exhibition of 1855. The cause of this is believed to have been due to the difficulty experienced in the manufacture and joining of the blades, which could not be made to stand the flexion and strain to which they were submitted in working, and it was not until M. Perin, of Paris, undertook the manufacture of blades some twenty-five years ago, and by perseverance triumphed over every difficulty, that the success of the band saw was achieved.

The blade is the principal part of the machine and the only part from which difficulties arise in its operation. France has had the monopoly of the manufacture of saw-blades, and will probably keep it for a long time, unless some of our American firms come forward and spend the money and time on experiment, and bestow that care and attention on the work which have produced their results in France, trusting not to any present remuneration, but rather to what may come in future years. The impetus given to the manufacture by the efforts of M. Perin, the special knowledge requisite, much of it kept secret; the tedious hammering process required, necessitating skilled labor, which may be obtained at so much less cost in France than elsewhere, and many other reasons have all combined to give her the supremacy.

There are various causes for the breaking of saws, such as crystallization, extreme or irregular tension, heat generated by friction on the guides, or careless use. It is well known to all those interested in such matters that a certain temper is requisite in deflecting steel springs, and that if this temper is obtained they will last for years or for a life-time. When one remembers, then, how difficult it is to obtain this temper, even with short springs like those in gun-locks, it is easy to conceive the almost insuperable difficulties in the way of obtaining this temper with bands of steel twenty to thirty feet in length; and the least variation in this temper for even an inch in the length of the saw



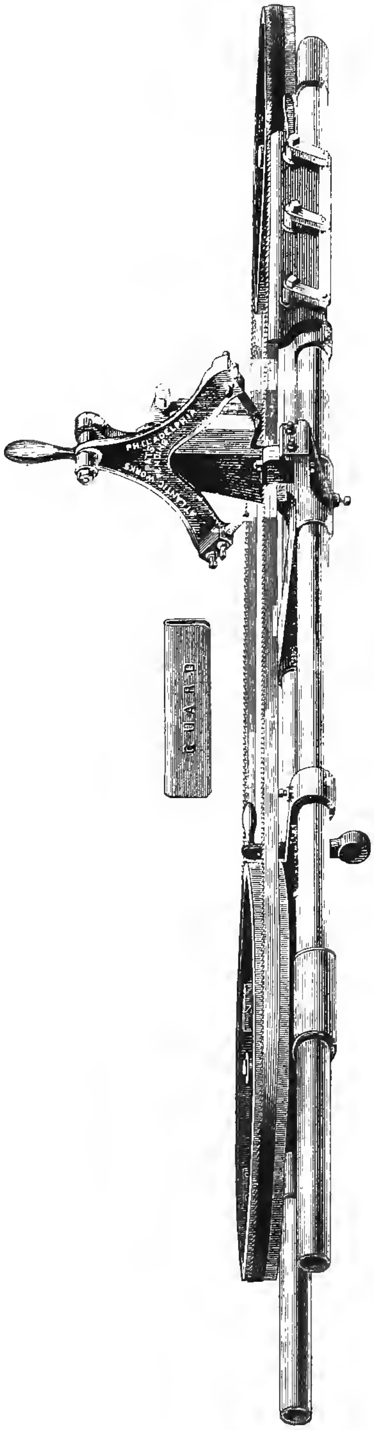
Band Sawing Machine: Richards, London & Kelley, Philadelphia.

destroys the value of the blade. In addition to this, as if to increase still further the difficulties already quite sufficient, there appears to be no reliable method for ascertaining in a finished blade if the quality and uniformity of the temper are correct. The buyer must depend on the good faith of the manufacturer, the value of the saw depending not on its appearance, but on the care with which it has been made and the perfection of the processes used;

and the blade should be completely finished ready for use by one firm, so that what may leave the hands of one party in good condition may not be spoiled by the bad work of another.

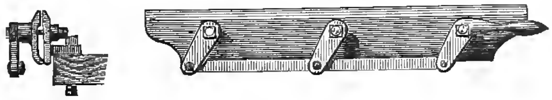
Thousands of Band Saw Machines are now in use, and occupying the high position that they do in reference to economy of both labor and material, they may well be classed among the prominent machines of the day.

In connection with the subject of band saws we would draw attention to an exceedingly effective "Band Saw Setting Machine" on exhibition and manufactured by the same firm under the patent of Mr L. O. Orton, the inventor. This machine is intended to accomplish two objects; to furnish a method of rapidly and accurately setting saw teeth and to do so by impact or blows just as would be done by a hand hammer, thus giving a permanent set to the teeth without liability to change as when set by springing or bending. The illustration accompanying shows the machine and its method of working, the saw being held in a filing frame, such as usually employed, to which is attached the setting device which is to all intents and purposes really a hammer in the hands of the operator. The frame is formed of two rails or bars connected by cross rails on which are wheels, which receive and stretch the saw blade in position. The setting mechanism consists of a pivoted swinging frame carrying two dies or hammers so arranged that when



Band Saw Setting Machine and Filing Frame: Richards, London & Kelley.

the operator by means of a handle on top swings the frame back and forth, they will strike right and left, giving alternate blows against two die-blocks placed on opposite sides of the saw teeth, the saw blade passing through a groove, and the alternate teeth coming under the hammer. By a simple mechanism a hook or pawl engages with the saw teeth and at each movement of the swinging frame draws the saw forward the distance of two teeth so that

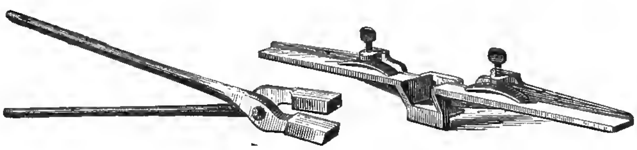


Filing Vise.

the teeth are brought automatically into the proper positions to be struck, one pair after another. An adjustment is provided to regulate this movement of the saw in a moment to any pitch of teeth. Where large saws are under operation or where the teeth are far apart two pawls are used, one for each single swing, but with ordinary saws one pawl is sufficient and is preferred.

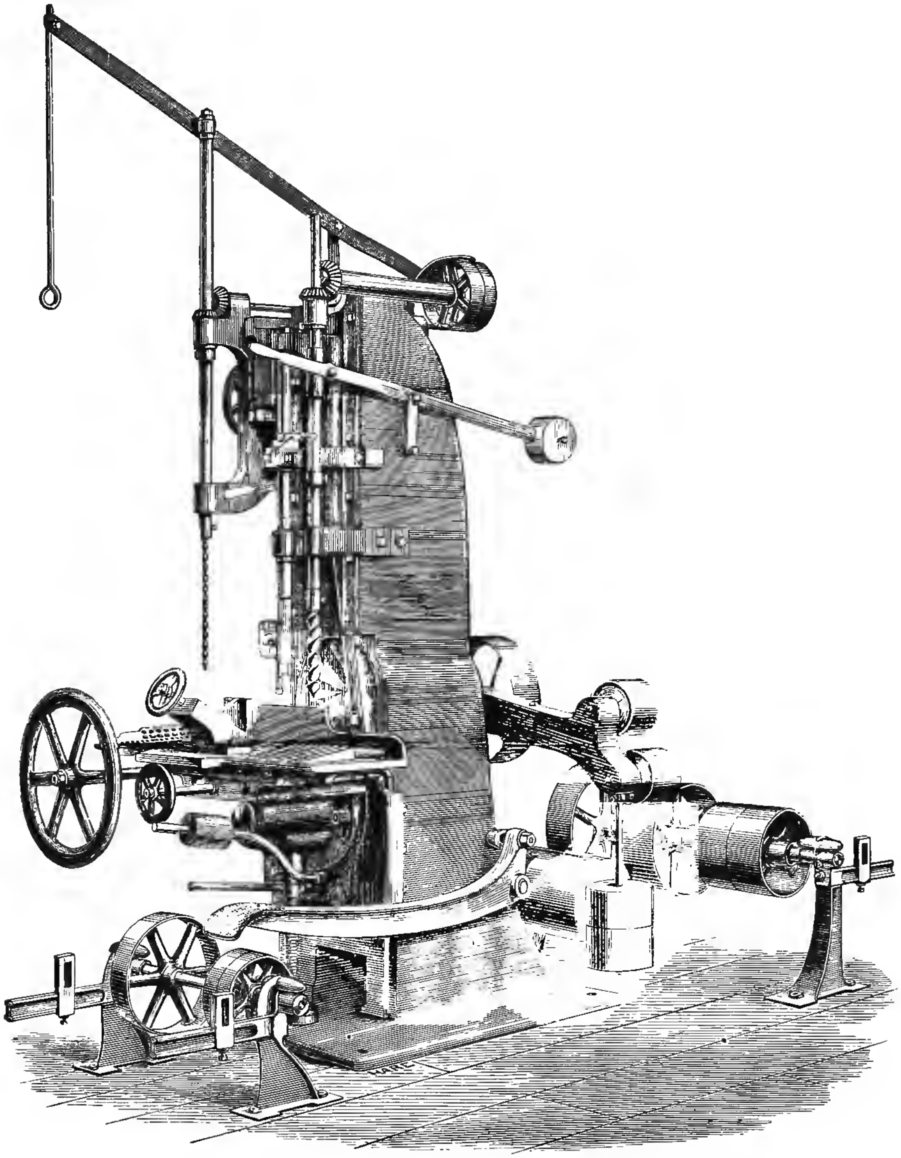
Band Saw File.

The whole of the setting mechanism attached to the frame may slide to any part, or be secured if desired and used independently. The degree of force of the blows and the time in which they are given are in direct control of the operator, the action on the teeth being the same in effect, but more perfect than can be attained by a hammer in the ordinary way.



Soldering Tongs. Scarfing Frame.

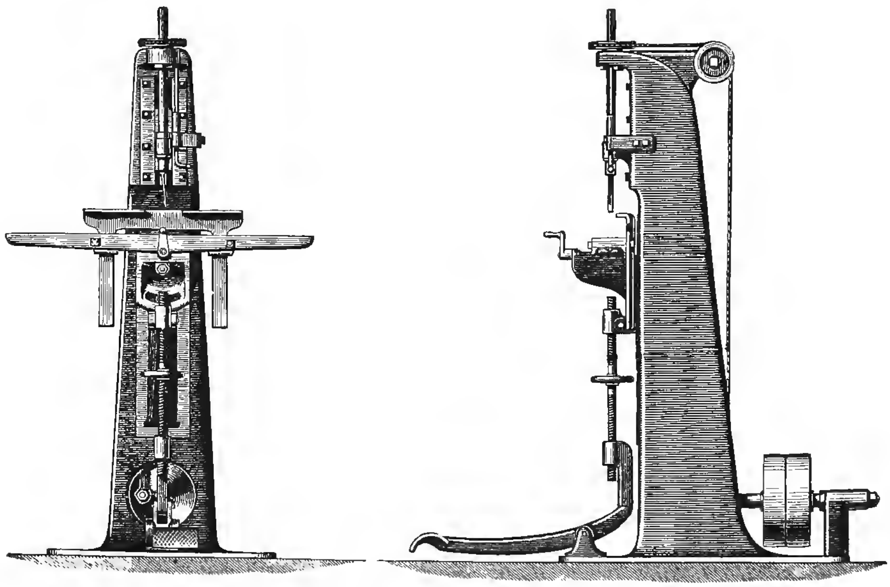
A filing vise is also attached to the frame, although it may be used independently, and is arranged with an improved clamping device consisting of two volute faces, one formed solid with the vise and the other with a handle, there being in this case with a long vise, three of these with the handles connected by links, and all actuated by one movement. By turning the handle right or left the jaws of the vise are instantly closed or released. A band saw file with round corners is recommended and used, giving a circular form to the bottom of the spaces between the teeth and preventing fracture. A scarfing frame and tongs for soldering the two ends of a saw-blade together are also exhibited. The ends of the saw are first scarfed or tapered for a length of one to two teeth, depending on the pitch, care being taken to make the scarfing



Reciprocating Mortising Machine: Richards, London & Kelley.

true and level. The silver solder of the jewelers is generally used, rolled into thin strips so that a piece of the size of the lap can be cut off and laid between. The joints are cleansed with acid, the solder placed between and the whole then clasped with the tongs which must be at a full red heat. The tongs are removed as soon as the solder runs, and a wet sponge applied to restore the temper, the joint being afterwards filed up into proper shape.

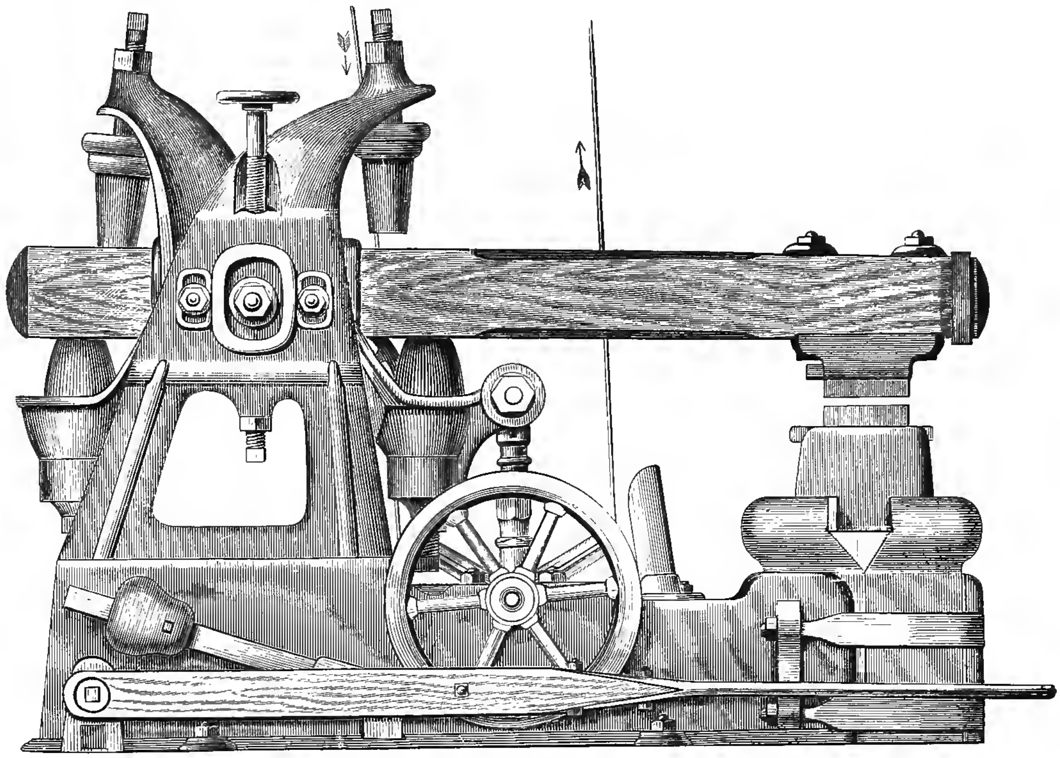
Messrs Richards London & Kelley, also exhibit a strong heavy "RECIPROCATING MORTISING MACHINE," arranged for railway car and other similar work which is deserving of notice. Motion in machinery may be divided into two classes, rotary and reciprocating, a few exceptional cases combining both motions. There are various difficulties arising in the employment of reciprocating motion that render its use objectionable wherever it can be avoided. These difficulties obtain especially in wood-working machinery on account of the speed at which it is necessary to work. In consequence rotary motion is



Elevations of Reciprocating Mortising Machine: Richards, London & Kelley.

every day coming more into use, and new applications being made of it. In England and France mortising is done almost entirely by rotary machines or by hand, but in this country reciprocating machines have been extensively used. The great variety of designs from different makers give evidence of the imperfections encountered and the efforts constantly made to overcome them. The machine which we illustrate belongs to that class in which the reciprocating parts are all brought down towards the timber operated on, the chisel having a continuous motion with a uniform range and a positive eccentric. Chisels of any width are received, and there are two boring spindles, one fixed and the other to traverse twelve inches. The feed movement is actuated by a treadle and may be locked to prevent jarring the foot of the operator. All joints are compensating and operated without noise. The distinctive feature of the machine consists in its being direct acting, and having the crank shaft not on top but near the bottom in the base of the column, the machine standing upon a foundation without top-bracing. The crank shaft, chisel bar and boring spindles are of steel.

We also give an illustration of another mortising machine exhibited by this same firm belonging to that modification in which the wood is moved up

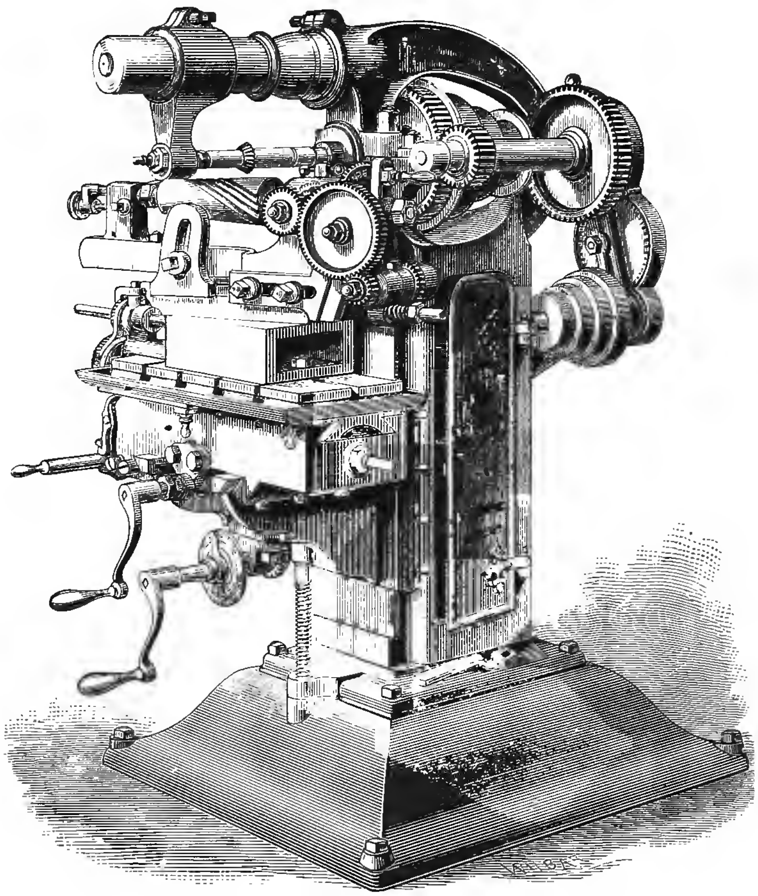


Rubber-Cushioned Helve Hammer: Bradley Manufacturing Co.

or fed to the chisel, the operating parts consisting of a crank shaft, a plain chisel bar and connection. It is well adapted for joiner and cabinet work, carriage work and general purposes, and is capable of being driven at a high rate of speed—four hundred to five hundred revolutions per minute, like the previous machine requiring no top bracing, the crank shaft being placed in the base near to the foundation, avoiding vibration and jar. The table is raised by a foot treadle to feed the lumber to the chisel which has a uniform stroke of five inches. The chisel is provided with the automatic reversing device of

H. B. Smith, allowing it to be reversed by power with a friction band and at the same time holding the chisel bar firmly while in motion and preventing any possible deviation from its proper place owing to wear or loose joints. The escapement is performed by hand so that the chisel can be reversed at will, independent of the treadle. The table is made either as here shown or arranged to clamp the piece of timber to be mortised, and the whole moved by rack and pinion. The firm deserves credit for the manner in which it has endeavored to overcome as far as possible the inherent difficulties in this class of machines.

The trip- or helve-hammer approaches nearer to the hand-hammer in its action than any other mechanical agent of its class, and for this reason is better adapted to certain peculiar kinds of work. There have been various causes, however, operating against its use, one being the difficulty of making proper connection with the driving power. The sudden shocks which it produces on shafting in starting, the irregular motion and the varying power required, all prevent the use of rigid connections, necessitate the adaptation of slipping belts, and require strict application of the principles of elasticity in the entire construction of the machine. Even with all this, the wear and tear in the ordinary hammers, as usually built, is far beyond what occurs with other machines, tending to counteract any inherent advantages that this special form may possess. THE BRADLEY MANUFACTURING COMPANY, OF SYRACUSE, NEW YORK, has placed on exhibition one of its RUBBER-CUSHIONED HELVE-HAMMERS, represented by the engraving, on page 113, which it claims possesses great advantages and improvements over any other hammer of its kind in use. With the exception of the helve, which is of wood, the entire hammer is constructed of iron and steel, so proportioned as to dispose of the material to the best possible advantage. The helve is hung upon two hardened adjustable steel centres and almost perfectly balanced, motion being given to it by a broad eccentric with an iron hub, a bronze shell and a cast-steel strap, all so perfectly fitted as to reduce friction to a minimum and to allow complete adjustment. Rubber cushions are provided and so arranged as to absorb the concussion of the blow of the hammer and materially decrease the strain and jar which ordinarily obtains. Set screws in the upper and lower sockets of the oscillator allow of adjustment to these cushions. The bearings throughout are of the best quality anti-friction metal, except those of the main shaft, which are of bronze; an adjustable eccentric is used, easily regulating the length of stroke required, and a universal joint connection prevents the possibility of binding or heating. By the method adopted of raising and lowering the husk, dies varying an inch in thickness may be used without shimming up either end, thus preserving the key-ways and hammer bolts. In securing the hammer-head to



Milling Machine: Brainard Machine Co.

the helve, rubber cushions are used beneath the nuts and collars of the bolts, absorbing all concussion, preventing loosening or breakage and increasing the elasticity and flexibility of the blow. A foot treadle around the bed of the hammer allows the operator to stand in front or on either side and by a gentle pressure bring the tightener in connection with the belt on the drive-pulley, varying the stroke as desired. On removing the pressure, the brake acts at once on the balance-wheel and the hammer is brought to a stop instantly, with the helve always up. The action is the nearest approach to that of the human arm that it seems possible to obtain, being accurate and powerful, perfectly adjustable in length of stroke, rapidity of motion and weight or force of blow, and entirely under the control of the operator. Water, steam, or any other power may be applied.

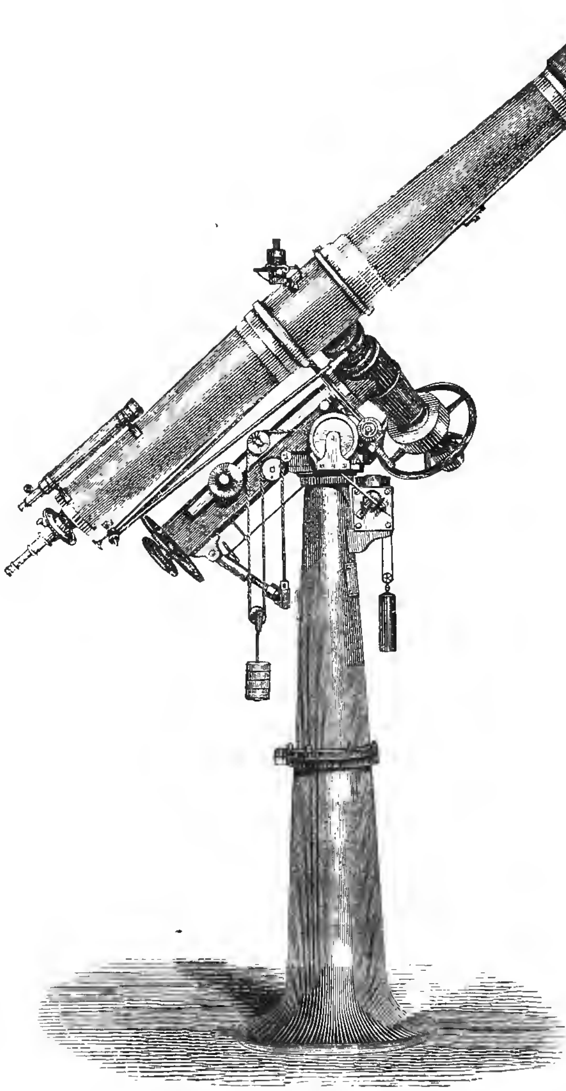
It is claimed that not more than half the power is required to do a given amount of work that is necessary in the direct steam hammer. There is no liability to corrosion of steam chest, sticking of valves or freezing and bursting of pipes in winter from non use. For intermittent use it is exceedingly well adapted, always responding to the touch of the treadle, be it once per day or once per week. Its *drawing* capacity and accuracy of stroke give it great advantages over the vertical or dead-stroke hammer. The play required in the guides or ways of the latter for expansion of the ram under heating, allowing it to run loose enough to shuckle, is fatal to nice die swedging. In this hammer, the centres being away from all heat, it strikes equally well whether the head is expanded or not. It is claimed that as a drawing hammer it has no superior, and it is under such perfect control that a block of iron three inches square may be reduced to one-eighth inch square under the one hundred pound hammer without adjustment. A simple device allows adjustment from one power to another, as from a sixty pound to a forty pound hammer, in a few minutes. It is claimed that no hammer in use possesses the elasticity of stroke which this does. Objection is sometimes made to helve hammers because they do not strike perfectly square on different thicknesses of work, but this is obviated in the construction of the dies, and in swedging it gives no trouble.

A certain class of machines technically known as Milling Machines have long been used in a somewhat crude state for a few special kinds of work, such as in the manufacture of fire-arms and sewing-machines, where the cheap and rapid duplication of interchangeable parts was impossible with any other form of apparatus. The name arose from the kind of cutting tool employed, specifically known as a *mill* and consisting of a revolving wheel on the periphery of which the cutters are arranged like cogs to a mill-wheel, the action of the machine being directly the reverse of that in the lathe, the tool revolving on the work instead of the work on the tool.

When attempts were made to apply these machines to general work, defects were revealed so marked as to preclude their employment except in few cases. This led to important improvements and developments on the old type, until of late years their capabilities have been largely extended and much more generally understood, and their use has grown rapidly in favor especially in the United States, and has become a necessity in almost every metal-working establishment.

THE BRAINARD MILLING MACHINE COMPANY and its General Superintendent, Mr. Amos H. Brainard, with whom the subject has been a special study for many years, claim considerable credit for the improvements that have been effected and for the introduction of machines for general use, combining the requisites of capacity, convenience and power, together with beauty of design and perfection of workmanship. This Company manufactures Milling Machines exclusively, of various classes, and makes quite an extensive display in the Machinery Hall. What is known as its STANDARD UNIVERSAL MILLING MACHINE, holds the first position in importance among all the varieties produced, having all the movements and power of the plainer machines, with far greater range and capacity, and being applicable to an almost endless variety of work quite impossible with ordinary machines. Four different sizes of this class are made, all upon the same general plan, and we select for illustration the third, which is perhaps the most desirable for ordinary use, its weight, capacity and power being sufficient for general and quite heavy work without its being too large for quick handling and rapid running.

The engraving on page 115 is taken from a photograph of the machine as it stands at the exhibition, set for cutting a long, conical blank, spirally and automatically, an operation considered one of the most difficult and complicated ever required of a Milling Machine, and necessitating the use of a special mechanism. Its framing consists of a large square or four-sided column, fixed on an ample base, upon the front of which is mounted a knee, which may be elevated or depressed by a screw worked by bevel-gearing and a crank; a dial and finger attached, allowing of adjustment to the one-thousandth part of an inch. The knee supports a carriage which traverses upon it, and on the carriage is mounted a work-table, moving independently and having T shaped slots on its upper face, carefully milled lengthwise and crosswise, exactly in line with and at right angles to the feed, for the purpose of securing work. The table also has an oil channel entirely around it. Upon the top of the column is the driving cone, full geared, giving six speeds. The main arbor or spindle is of solid forged steel, and upon its front end a screw is cut so that a chuck or

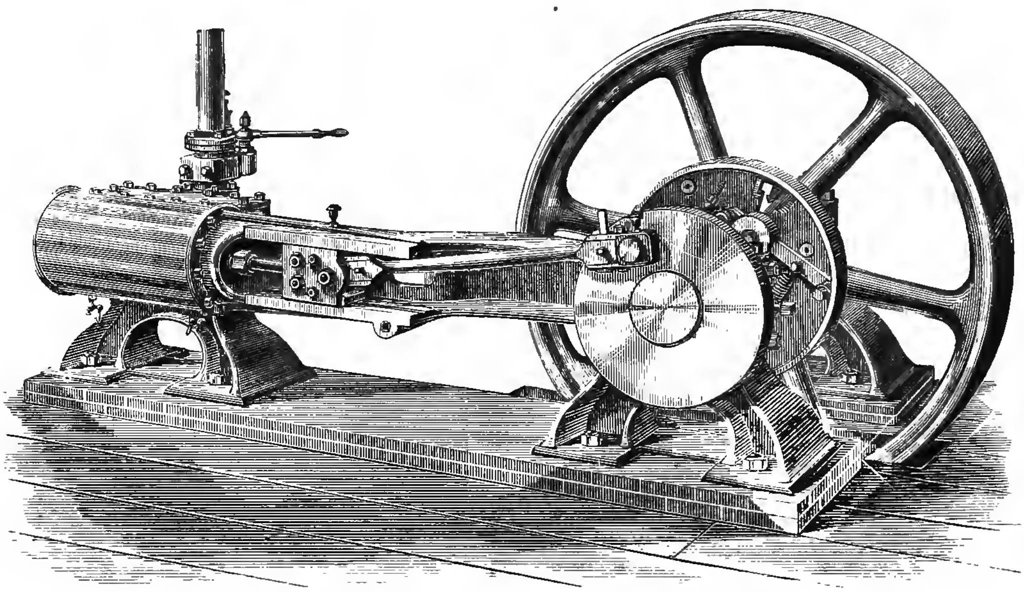


Equatorial: Fauth & Co., Washington, D. C.

face plate may be attached. At the extreme top is a projecting arm which carries an outside centre support for the outer end of a mill spindle, allowing the use of cutters to a distance of fourteen inches from the front of the machine. This arm, notwithstanding its solid connection, can be easily removed when not required, or if desired to make other attachments. Automatic feed gearing is provided which is hung upon the back end of the spindle, connecting with a worm and worm gear which drives the feed-screw. The feed work is independent of any movement of knee, carriage or table, and careful provision is made, especially in the feed work, for wear of running parts and for taking up all slack motion. The feed-screw runs in bronze bushings, and bronze collars are interposed between running bearings to obviate wear and diminish friction. The spiral cutter, as shown, cuts a right-hand spiral, but a simple change of gearing causes it to cut a reverse or left-hand spiral, and both were cut upon the same piece of metal in the presence of visitors. Upon loosening three nuts the spiral cutting attachment may be removed, leaving the work-table flush and unobstructed. Various attachments are provided, such as a universal head, by which spur and bevel gears can be cut, and work milled at any angle or position; a rotary vise and many other devices, allowing an almost endless variety of work to be performed; fluting taps and seamers, finishing nuts and bolt heads, key-seating shafting, making all the cutters required for the machine, &c. Even without any of the special attachments the machine is admirably adapted for plain milling, and is in every respect far in advance of the common style of machine. As it appears in the engraving it weighs about 1800 pounds, has a perpendicular range of 18 inches; the carriage will traverse 5 inches, and the work-table has a movement of 18 inches upon the carriage. The feed may be operated either by hand from either end, or automatically, as desired. A door is provided in one side of the main standard which being hollow, furnishes an ample tool closet.

Messrs. Fauth & Co., of Washington, D. C., exhibit in the Main Building some excellent Astronomical and Geodetic Apparatus, among which we would mention particularly a fine Equatorial Telescope, which, although smaller than many others in use, is of a size best adapted for working under all circumstances, and belongs to that class of instruments by means of which with patient labor many of the best results in astronomical research have been achieved. The engraving on page 118 gives a very fair idea of the instrument. It has a clear aperture of nearly seven inches, a focal length of eight feet, and the lens was manufactured by Alvin Clarke & Sons, the celebrated opticians of Boston, Massachusetts. It is mounted on a pedestal which accompanies it, and very little expense is requisite to place it in working position,—a matter of considerable importance to those of limited means. Azimuth and latitude adjustment have been provided, allowing it to be regulated for almost any quarter of the globe, thus permitting great range of locality in its use. The great care that has been taken in designing the instrument, and the close attention that has been paid to the comforts and conveniences of the observer—giving him a perfect control over the whole machinery without compelling him to move from the eye-piece, thereby dispensing with the aid of an assistant—is one of the marked features of the apparatus. It can be turned to any quarter of the heavens with the greatest ease, and the operator without leaving his post, may readily move it in declination and right ascension to find the object he is seeking. Motion is given by clock-work, with which it may be connected or disconnected at will, and the clock may be adjusted to follow stars, planets or the moon with the utmost precision. The hour circle reads to single seconds of time and the declination circle to five seconds of space, two opposite verniers being used to each circle with lenses attached for reading. The position micrometer is a wonderfully accurate piece of workmanship, combining in itself four distinct motions, and is especially adapted to measure minute differences of declination and positions of double stars. One division of the micrometer screw is equal to one ten-thousandth part of an inch. The attached circle permits angles of position to be read off to single minutes. The field of the instrument can be illuminated at pleasure with different colored light, as some stars show best in this way, or it may be left dark for very faint objects and only the spider lines illuminated. Messrs. Fauth & Co. have made every endeavor to bring the construction of this instrument to perfection, as regards symmetry of form, kind of material employed, and style of workmanship, and inspection shows that their efforts have been crowned with success.

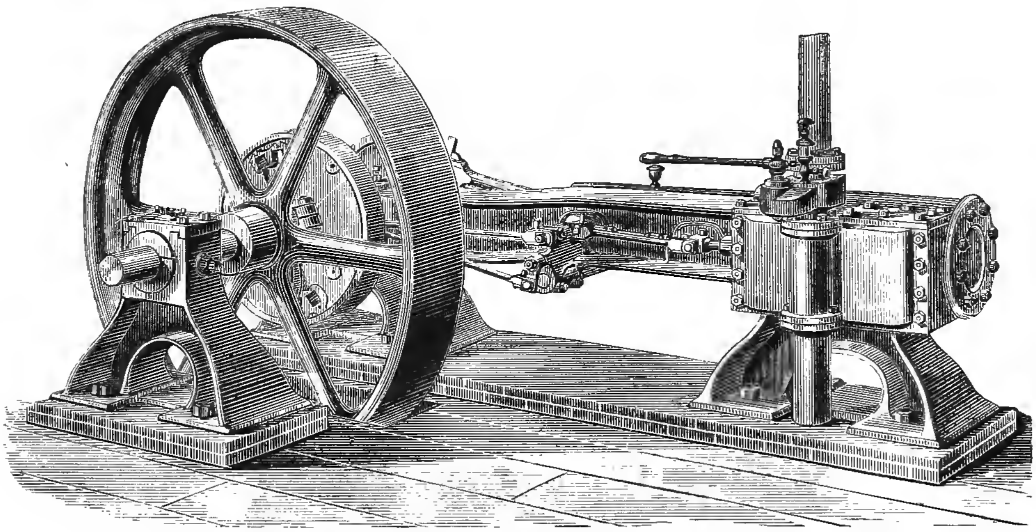
The Buckeye Engine Co. of Salem, Ohio, exhibits one of Thompson's "Automatic Governor Cut-off Engines," as manufactured at its establishment, which deserves close attention from all those interested in the economic application of steam. The consideration of this subject involves an important principle in the use of steam expansively, the energy being much more effectively given out for the same amount of force, exerted on the piston of an engine, if the steam be used expansively at a high pressure, than if worked full stroke on an average pressure, and less steam required for the same work in the former case than in the latter. Of course, taking the same pressure of steam in both cases, more work can be obtained with full stroke pressure than with expansion, but it is at a waste of steam, and the question under consideration is to do the amount of work required with the greatest economy. Where the cost of fuel is no object, certain reasons may make the use of the ordinary engine working at full stroke, preferable, but these need not be considered here. An important advantage in expansive working also obtains in wear and tear, the shocks and jars to the engine being much less than if worked with full stroke pressure.



Automatic Governor Cut-off Engine, Fig. 1: Buckeye Engine Co.

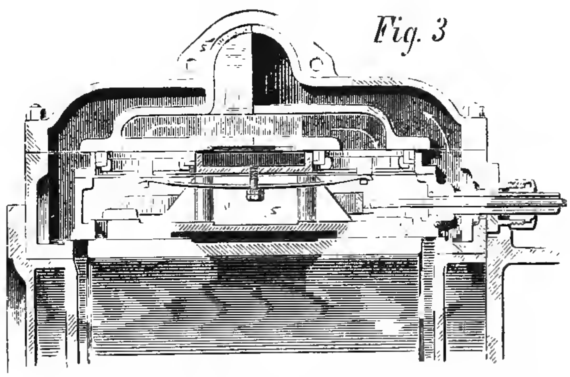
In the case of the ordinary slide-valve, working with a continuous motion, there appears to be great difficulty in securing all the advantages of a cut-off, it being impossible to give a full flow of steam and a sudden cut-off. The maximum of economy requires a full boiler pressure to be carried into the cylinder at the commencement of the stroke, and mantained up to the point of cut-off, and the cut-off to be sharp, without causing a gradual reduction of the steam-pressure by what is called wire-drawing. Various methods have accordingly been adopted by means of valve gear, of holding the valve wide open, and suddenly closing when required, by a spring. The Corliss Engine is an example of a very successful method of accomplishing this object. In the case of the engine under consideration, the slide-valve is operated full pressure at full stroke, and a secondary valve is called into action at the proper time, to cut off the steam quickly from a full pressure to zero. When this valve is so controlled by the governor, as to cut off the steam earlier or later in the stroke as required, and maintain a certain desired uniform speed, under variations of load and steam pressure, it becomes an Automatic Cut-off, and as such it is represented in this engine, the action being very different from the wire-drawing or throttling-engine, where the governor performs its duty by throttling the steam more or less, on its passage to its work in the main steam-pipe.

Our illustrations, Figs. 1 and 2, engraved on pages 121 and 122, show



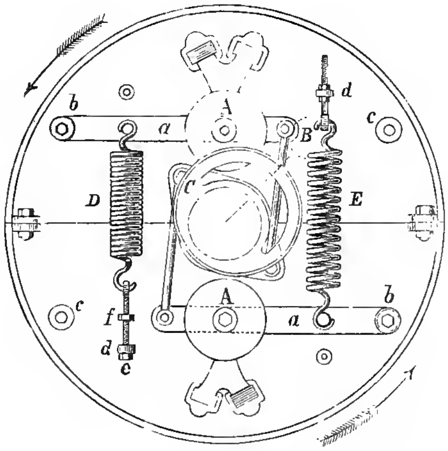
Automatic Governor Cut-off Engine, Fig. 2: Buckeye Engine Co.

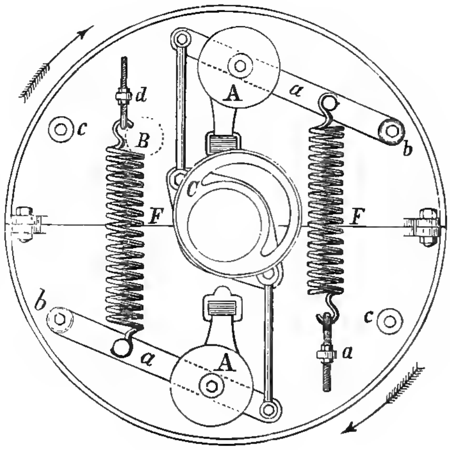
front and rear views of the engine on exhibition, it having a horizontal action, with a cylinder of sixteen inches bore, by thirty-two inches stroke. The principle involved in the automatic cut-off appears to be the only true one for the highest economy in the use of steam; it remains that the practical application of it shall be properly carried out. It is claimed by the makers of this engine, that it satisfies all the conditions necessary for this economy, and at the same time is so simple in construction, as to be very little more expensive in cost than an equally well designed throttling-engine, while it may safely be placed in charge of any fairly intelligent and careful engineer. The peculiar points of the engine are the slide-valve and the governor. Fig. 3, which we engrave on page 123, gives a section of the former. This slide-valve is in reality a small moving steam-chest, into the interior of which, the entire supply of live steam is admitted, and passes from thence to the cylinder by ports near its end which are made to coincide alternately with the cylinder ports. The exhaust steam from the cylinder passes out into the steam-chest at the end of the slide-valve, and follows on by ample passages to the exhaust-pipe, going downward freely and directly out of the way, and avoiding, even at the highest speed, that back pressure so often caused by the tortuous passages so common in many other valves. The indicator cards which have been taken of the working of the engine, show with what perfection the valves perform all their functions. The arrangement gives great advantages in allowing the face of the valves to be placed as close to the bore of the cylinder as a proper consideration of thickness of metal, for strength will permit, and by this means reducing the clearance or waste room to a minimum. The openings in the back of the valve admitting the live steam are fitted with self-packing rings, so as to insure a steam-tight connection, and the area of these openings is made as small as possible consistent with the proper holding of the valve to its seat, making it as nearly balanced as practicable or desirable. By removing the top of the valve-chest which contains only exhaust steam, the working of the valve may be seen, and any leakage detected and remedied. The main valve is operated by a fixed eccentric, and the cut-off valve works inside of the main valve, the stem passing through a hollow main valve-stem, and is operated by an adjustable eccentric, through the medium of a compound rock-arm device and connections as seen in Fig. 2. A small rock-shaft works in a bearing in the main rock-arm and moves with it, making the movement of the cut-off valve relative to its seat in the main valve, just the same in reference to both time and extent, as would occur if the valve worked in a stationary seat and was attached directly to its eccentric. The main valve eccentric rod works horizontally and the cut-off eccentric rod inclines downward, so that its attachment to its rocker-arm is on a level, or nearly so, with the centre line of



Automatic Governor Cut-off Engine, Fig. 3: Buckeye Engine Co.

main rock-shaft. The cut-off eccentric is automatically adjusted by means of two weighted levers connected with springs, and contained in a circular case fastened on the engine-shaft. This regulator or governor is illustrated by Figs. 4 and 5, which we engrave on page 124, the former showing the position of parts when it is at rest, except spring D, which is not adjusted, and the latter showing their position when the engine is at its maximum speed. It must be stated however, that the two figures are for different governors and adapted to run the engine in opposite directions, one being in arrangement the reverse of the other. It will be noticed that extra holes c, c, are provided in the case so that the same governor may be changed in arrangement in a short time, to allow the engine to be run either way as desired. When the

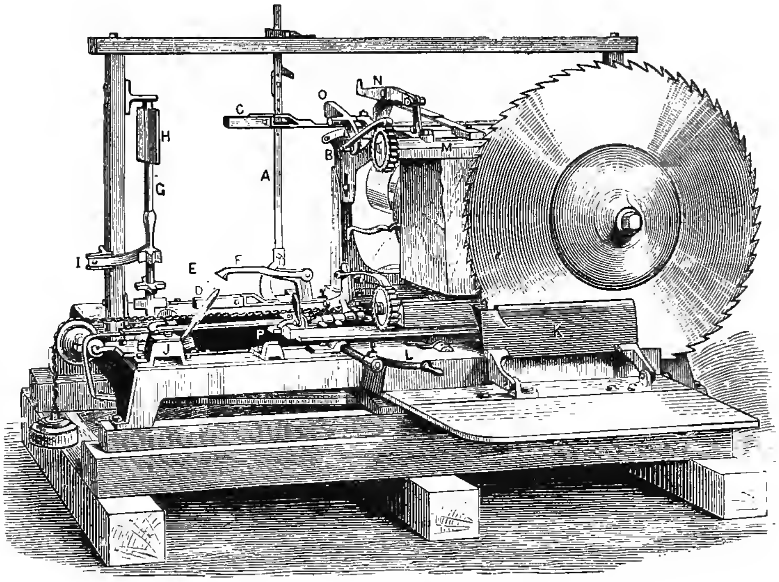




Automatic Governor Cut-off Engine, Figs. 4 and 5: Buckeye Engine Co.

speed of the engine becomes too rapid, the centrifugal force overcomes the resistance of the springs and throws the levers outward, advancing the eccentric forward on the engine-shaft and making an earlier cut-off. When the speed is reduced the springs draw the levers in, and make a later cut-off. Fig. 4 shows the position of parts for the latest cut-off and Fig. 5 that for the earliest cut-off. Set screws are provided to allow adjustment of the tension on the springs, which may be varied to suit the character of the work for which the engine is required. The makers claim great simplicity of parts, a reduction of noise in working to a minimum, very little clearance or waste room in the ports, close governing power, and great economy of steam, also full opened indication ports for all points of cut-off, and a free and unobstructed exhaust.

The Buckeye Engine Company also exhibits one of J. R. Hall's self-acting Shingle and Heading Machines of its own manufacture, which appears to possess considerable merit, and to fully meet all requirements of the trade. Our illustrations shown on this and the succeeding page, present front and rear views of the machine, and show its manner of construction. The cutting is done by a circular saw driven at a rate of thirteen to fourteen hundred revolutions per minute, an automatic device feeding and returning the block of timber under operation, and throwing it back and forth so as to cut alternate butts and points, while at the same time a simple and easily operated mechanism

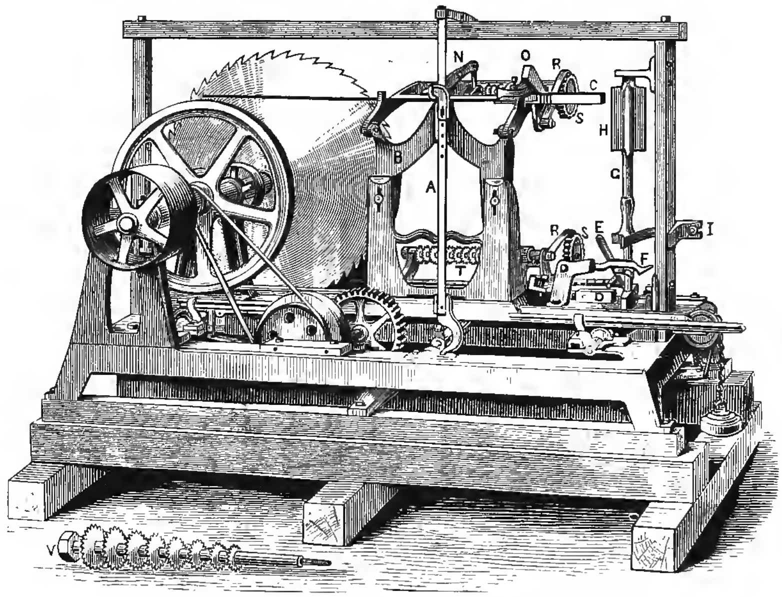


Shingle and Heading Machine, Front View: Buckeye Engine Co.

permits two or more butts or points to be cut in succession, if desired, and allows the rift of the timber to be kept vertical and in line with the saw, the sawyer having absolute control of the work. The machine may be adjusted in a few minutes to saw shingles of different thicknesses or different lengths without changing the uniformity of the taper or the evenness of the butts and points. It may also be arranged to cut parallel headings without interfering in any way with its excellence as a shingle machine.

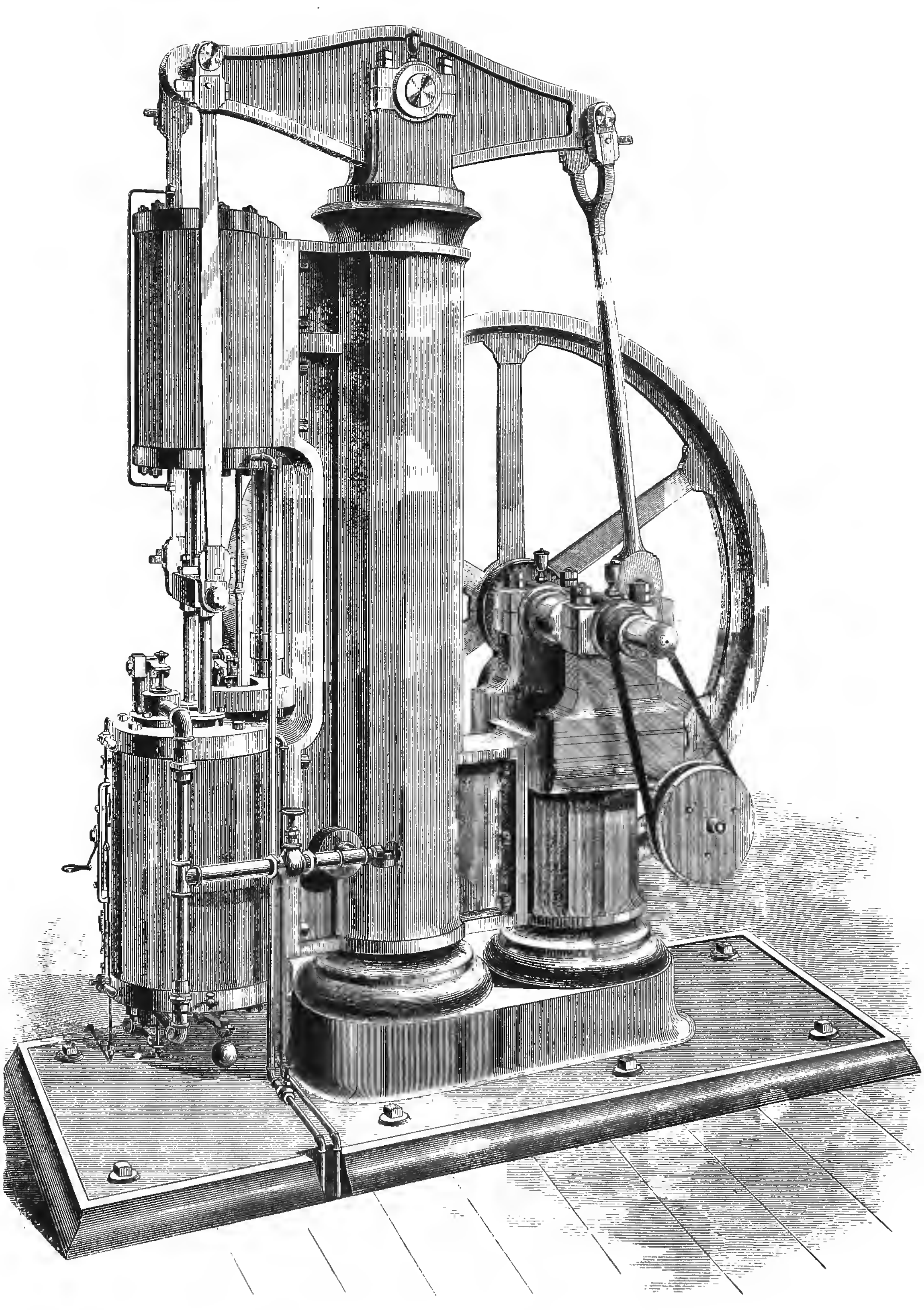
Two sizes of machines are built, one varying from fourteen to twenty inches in length of shingle, with widths up to fourteen inches, and the other giving lengths of sixteen to twenty-six inches, the limit of width being the same as in the first. Either the ordinary knife-jointer is furnished, or an excellent form of saw-jointer, which it is claimed increases the yield for a given quantity of timber about ten per cent., requiring however an extra man for each machine. The makers claim a capacity of ten to twelve thousand eighteen-inch shingles per day of ten hours, or twenty-five to thirty-five thousand if the shingles be jointed for the sawyer, these figures being for soft wood blocks or one-third less for hard wood.

In ordinary mechanical operations where a steady motive power of medium or high pressure is required, nothing has yet been found as economical, efficient and ready of application as the steam engine. Where, however, a low power



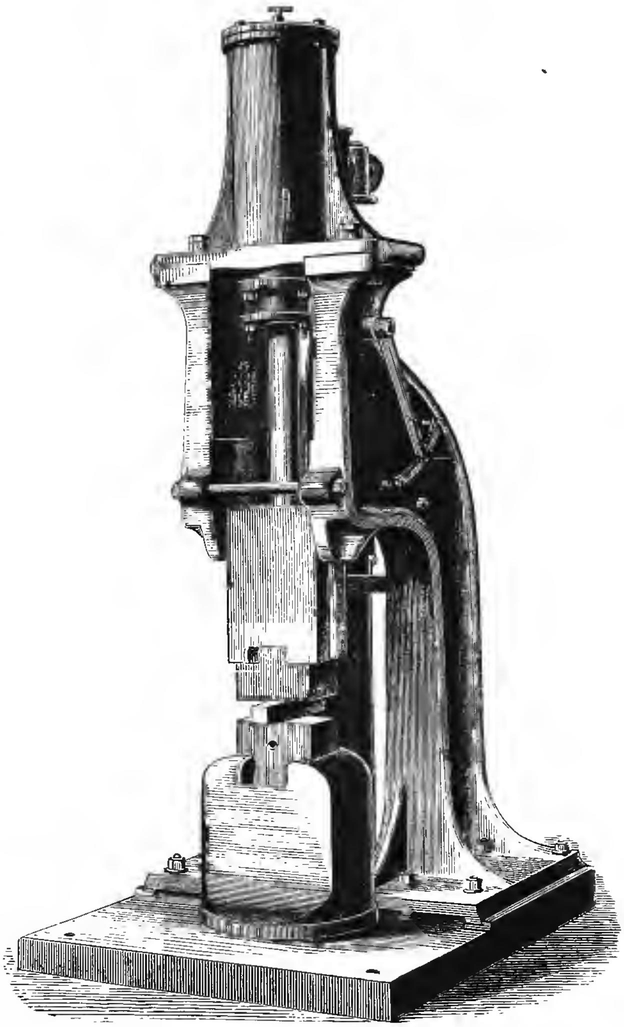
Shingle and Heading Machine, Rear View: Buckeye Engine Co.

is wanted, especially if it is intermittent, the steam engine becomes too expensive, requiring a costly form of apparatus, a skilled attendant, and a certain quantity of steam constantly on hand to bring it into action quickly, to say nothing of the danger almost always attendant more or less on its use. In the progress of the present age, a motor is every day becoming more a necessity which shall combine safety, economy and convenience; shall be always ready without waste while not in use, and shall be simple in details of construction and easy of management without skilled attendance; or, in other words, an engine is required that shall be eminently a domestic motor, and that may be put into our private residences, or used on our great agricultural farms to be managed by the ordinary servant without risk of fire, explosion or increase of insurance fees. The various hot-air, electric and gas engines are all tending to this end, with more or less success. One variety of engine we have already described, and we would now like to draw attention to another, shown at the Exhibition, which appears to merit particular notice. We refer to the BRAYTON READY MOTOR or HYDRO-CARBON ENGINE, the invention of MR. GEORGE B. BRAYTON, as manufactured by the PENNSYLVANIA READY MOTOR COMPANY, and shown by the accompanying illustration. This engine is really a hot-air engine in which the cylinder and furnace are one. It was originally designed for the combustion of gas, but now uses the ordinary crude petroleum, which is mixed with a certain proportion of atmospheric air and burned in the cylinder without explosion, the power so produced being expended on the piston, which works silently with a steady pressure just as with steam in the steam engine. The apparatus consists essentially of a working cylinder in which operates a piston connecting with a fly-wheel; an air-pump for compressing air; two cylindrical reservoirs for compressed air, one serving as a working reservoir and the other as a reserve to start the engine after any length of time it may be stopped; and an oil-pump for forcing oil into the combustion chamber, a few drops at a time, where it is mixed with a supply of compressed air in such quantity as the requirements of the work demand. Several forms of engines have been constructed, the original ones being all single-acting. Recently, however, double-acting engines have been made, our engraving illustrating a ten horse-power vertical engine of this class as shown at the Exhibition, and the latest improvements have been made in a horizontal engine, also double-acting, in which even the slide-rests for the piston are dispensed with, the motion being taken up by a rocker on the upright which supports it. The pistons of both cylinder and air-pump have the same construction with metallic packing-rings as in the steam engine, and the working-cylinder is surrounded by a jacket through which water circulates either by a very small running stream when available, or by continuous circulation from a reservoir, so as to secure a low temperature in its walls. In the single-acting engine the piston becomes quite hot after long working, and it is necessary to keep it regularly supplied with lubricant in order that it may work properly. In the last double-acting engines constructed, however, a great improvement has been effected in making the piston with two rods, both of which with the piston are hollow.



Brayton Ready Motor or Hydro-Carbon Engine: Pennsylvania Ready Motor Company.

These are connected by flexible tubing with the water circulation, which passes first through the hollow piston and rods, then down through the water-jacket of the air-pump, and finally through the cylinder-jacket, keeping everything cool. The tarry products of combustion, it is found, then condense on the piston and cylinder, and provide a quite sufficient lubricant without necessitating any outside supply, the engine running smoothly indefinitely.. In these last engines a six-by-nine-inch cylinder has furnished five horse-power net, showing the great capability of the power at command.



Double-acting Steam Hammer, Fig. 1: B. & S. Massey, Manchester, Eng.

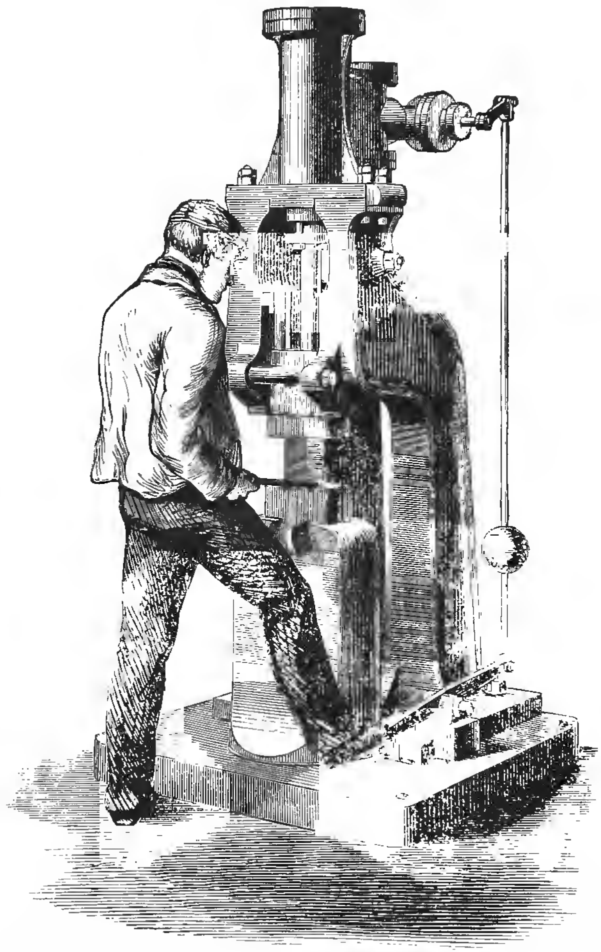
The oil-pump is provided with a hand-crank by which a few drops of oil are pumped in at the beginning to start the engine. It then works automatically, an adjustment being provided to regulate the supply as required. The oil is forced through a ring of felting and a series of small holes in a state of vapor into contact with the compressed air, both mixing and passing into the cylinder through the meshes of three separate sheets of wire gauze where it is inflamed, a plug being removed from the side of the cylinder for the purpose and re-inserted. The engine starts off at once, and attains its required speed in a few seconds, saving all the time and fuel required in the use of a steam engine to accumulate pressure. The necessary valve is provided for the escape of the products of combustion by an exhaust-pipe to a chimney. A governor regulates the supply of air to the cylinder, and a safety-valve is provided, adjustable to any required pressure by which surplus air escapes from the reservoir.

The efficiency of the engine consists in the expansion by heat of the air introduced and the products of the combustion, carbonic acid and steam, the mixture of air and oil being such as to burn without smoke, thus securing a maximum economy of fuel. The great difficulty of rapidly imparting heat to air has hitherto prevented the most economical application of hot air as a motor, but the question appears to be practically solved by Mr. Brayton's method of intimately mixing the air and fuel before combustion. Explosion is impossible, and as combustion is confined to the interior of the cylinder and is perfect, no sparks being thrown from the exhaust, there is no danger of fire. The machine is of simple construction, not liable to get out of order, readily repaired if it does, and easily managed by any ordinarily intelligent person, the fire being extinguished and the engine stopped by merely closing the throttle-valve. Continuous use for fifteen months appears to establish the fact that no destructive action takes place in the cylinder. The governor acts as a variable cut-off, regulating the speed so readily that but little variation is noticed when the work is thrown on or off, and speed can easily be changed to answer any requirements. The amount of oil consumed it is claimed amounts to an average of one gallon of crude petroleum per horse-power for ten hours' service.

MESSRS. B. & S. MASSEY, of MANCHESTER, ENGLAND, make a fine exhibit of STEAM HAMMERS, which present some peculiarities of design different from the usual steam hammer, and appear to operate with great efficiency. They are double-acting and work without jar or shock, giving blows dead or elastic, and of any degree of intensity, rapidity of action or length of stroke desired, the larger hammers being controlled generally by hand, and the smaller ones arranged so as to work both self-acting and by hand. The action is therefore completely under control, and can be varied according to the kind of work to be done. Generally with self-acting hammers there is great difficulty in obtaining the heavy "dead" blow so often required; but in these, by means of a hand-lever connected directly with the valve, the hammer may be changed instantly from self-acting to hand-working, and perfectly "dead" blows delivered at any time without the least delay. Their small hammers are particularly intended for smiths' work, being applicable to the lightest kinds of forgings, such as usually done by hand, and their use is rapidly replacing that of hand-work, resulting in great economy of labor, fuel and material even in the smallest smith-shops. The hammer shown by Fig. 1 is of a class comprising several sizes, and exceedingly convenient and easy to operate with, allowing ready access on three sides, and, owing to the double standards on the fourth side, with opening between them, permitting long bars to be worked on the anvil in either direction. The arrangement for working the valves in these hammers, as already stated, is a combination of self-acting and hand-worked gearing, and it is different from that ordinarily employed, being without the usual cams or sliding-wedge. As the hammer rises and falls when in action, a hardened roller on the back of the head slides on the face of a curved lever, which rotates about a pin near its upper end, and is held by a spiral spring always in position against the roller. At every movement of the hammer this lever operates a valve-spindle and regulating-valve, the length traveled by the hammer being controlled by another lever attached to the fulcrum-pin of the curved lever, and by which this pin may be raised or lowered by hand, and the points at which the steam is admitted or allowed to escape varied at pleasure. A guard-plate and catch permit this governing lever to be fixed at any point desired. The regulating-valve is hollow through the centre, being really a double piston open at both ends, with a number of ports for the steam to enter and escape, arranged all around on the sides, and holding it in perfect equilibrium. The ports open and close very quickly, and allow great rapidity and force of action to the hammer, as many as two hundred and fifty blows per minute being struck with a pressure of from forty to sixty pounds, with the length of stroke entirely under command from a few inches to nearly two feet, and variable without checking the machine.

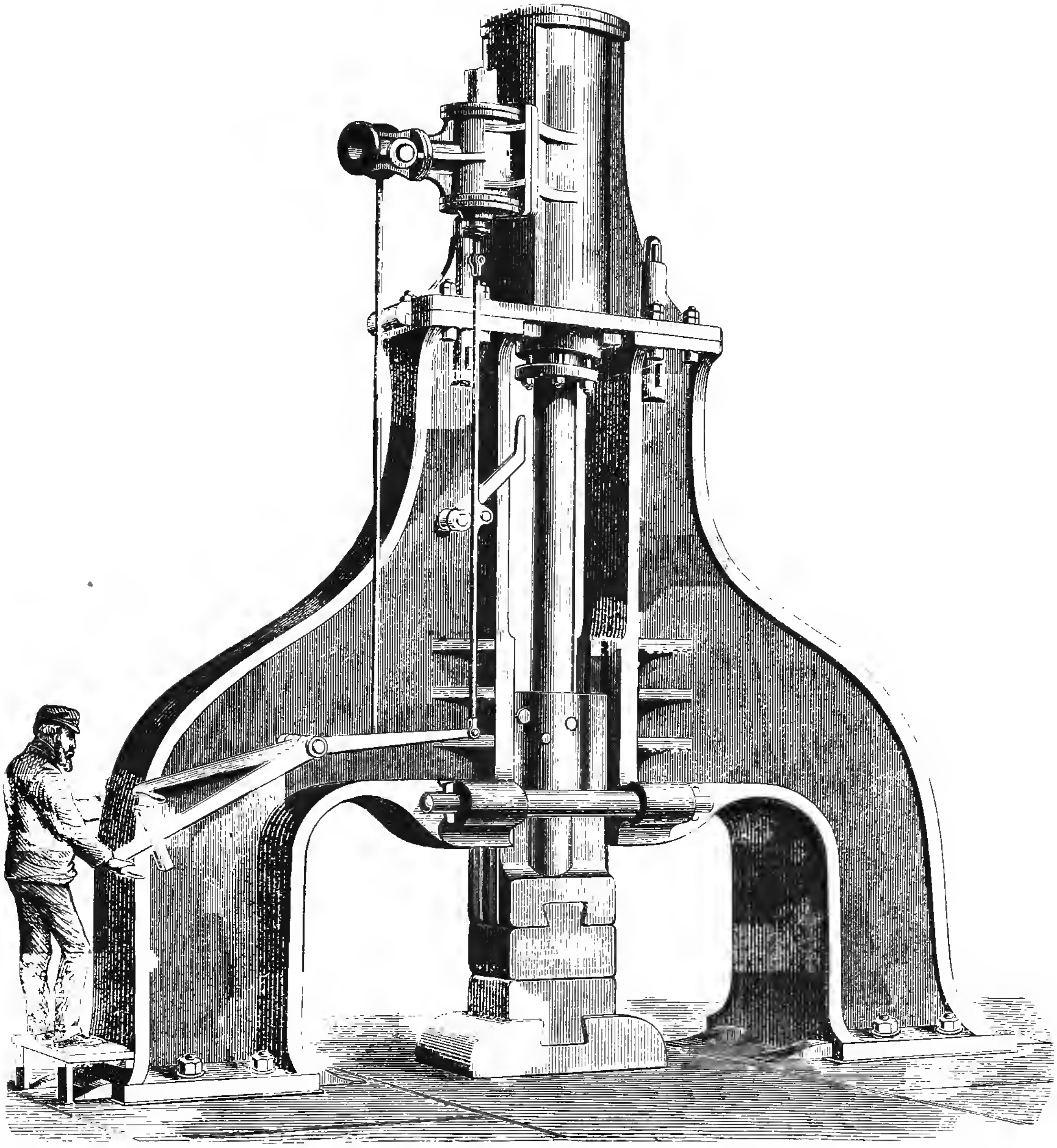
Ramsbottom's Steel-packing Rings are used on the hammer-piston, which is forged in one solid piece with the rod, and the head is of hammered scrap-iron. The anvil-block is a heavy casting made separate from the base and turned to fit a bored hole in the base plate so as to assure its being kept to its true position.

Fig. 2 represents a light hammer, only a half hundredweight, intended for forging files, bolts, cutlery, etc., and operating with a foot-treadle, so that the workman may have both hands free for the proper manipulation of his work. The foot-treadle is omitted in some cases. This hammer has been worked up to a speed of four hundred blows per minute. Fig. 3 illustrates one of the large size hammers running up to a ton or more in weight. Fig. 4 represents a steam stamp intended especially for die-forging, and regulated either by the foot or by hand. When steam is turned on, the hammer rises to the top of stroke and keeps that position until directed downwards by the action of the operator. It then descends with a single dead blow, performing its work, and rises again into its original position, which it retains until the workman is ready for another stroke. It is wonderful how many articles formerly so expensive are now made by die-forging, being stamped out from the red-hot iron nearly ready for use, requiring in most cases very little work to fit them up, and resulting in great saving of labor. Bolts, rivets, nuts, screw-keys, wrenches, and other tools, and even such articles as sewing-machine shuttles, are made in this way with the greatest accuracy, economy and despatch.



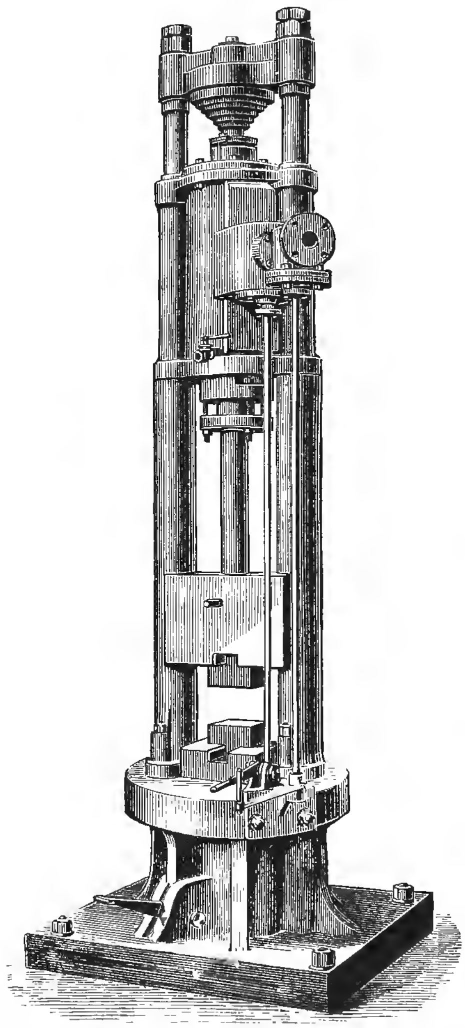
Steam Hammer, with Treadle, Fig. 2: B. & S. Massey, Manchester, Eng.

In the manufacture of cars and in heavy railroad timber-work generally, the joining of the frames, instead of being accomplished by means of a mortise and tenon, as in ordinary building, is done by letting the ends of the cross-timbers into the longitudinal ones, thus giving much greater strength at the point of junction. The depression or groove in which the end of the cross-timber rests is technically called a gain, and a machine that is used for the purpose of cutting these grooves is called a Gaining Machine. Messrs. C. B. Rogers & Co., of Norwich, Connecticut, exhibit a timber Gaining Machine



Large-size Steam Hammer. Fig. 3: B. & S. Massey, Manchester, England.

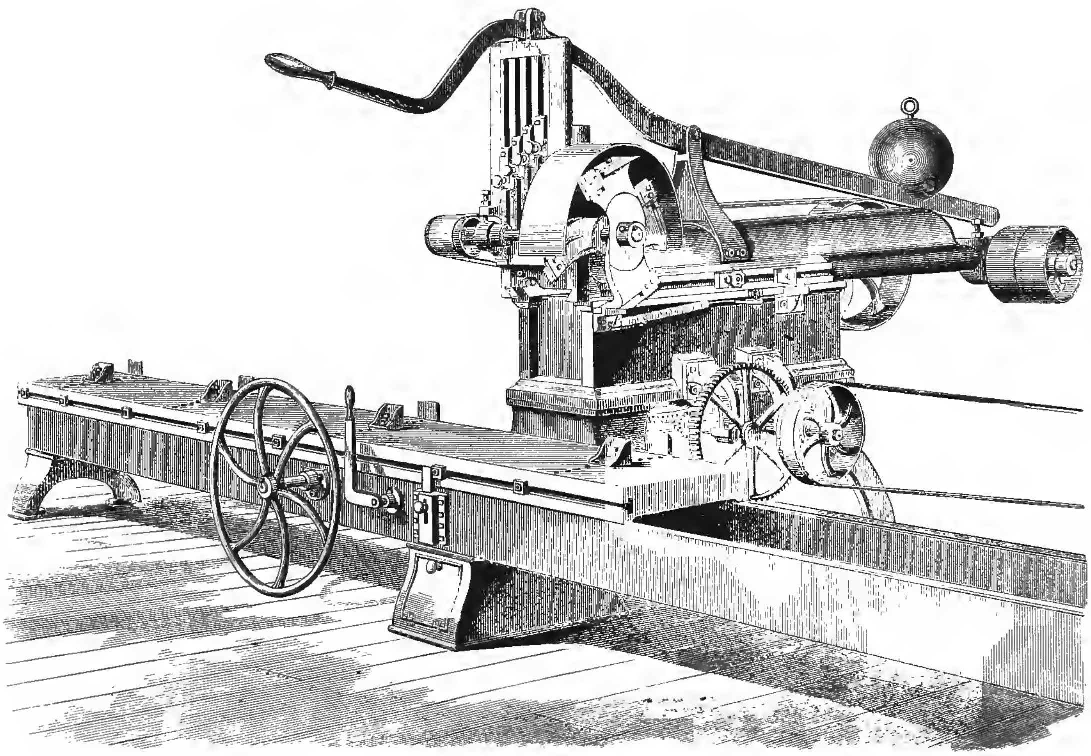
of their own manufacture, which has attracted considerable attention and does them great credit. The engraving on page 136 gives a fair view of the machine, which, being intended for the heaviest kind of work, has been made strong, heavy and substantial in every part, its weight being five thousand pounds. It is furnished with a table, to which the timber to be operated on is clamped, this table moving on ways and having adjustable stops to indicate the points at which gains are to be made. A revolving cutter-head is attached to a frame joined by sliding-gibs to a standard placed at right angles to the table, and an arrangement of gearing and belting is provided for the necessary rotary motion. The cutter-head is made in two sections, which are adjustable longitudinally on its shaft to any width of gain required, the desired depth being regulated by means of a balanced lever set at the proper elevation by adjustable stops. The head and frame at the will of the operator are made to move transversely across the table, reversing automatically and stopping after return. In operation, the timber being clamped to the table, the cutter-head is set by the lever at the proper elevation indicated by the stops; a lever in front throws the feed in gear, and the head moves across the timber, cutting the gain and returning to its first position, where it stops automatically. The table is then moved on its ways to the point marked for the next gain, and the operation is repeated. The machine is readily controlled by the operator, and after being once adjusted for any particular class of work it becomes almost automatic in its action. The points of excellence claimed for this machine by the makers are, its extreme simplicity, combined with every requisite for accomplishing its desired purpose; the great ease with which every motion is controlled, even when operating on the heaviest classes of work, and the automatic precision with which this work



Steam Stamp, Fig 4: B. & S. Massey, Manchester.

is performed. Its peculiar feature is the reciprocating motion given to the revolving cutter-head.

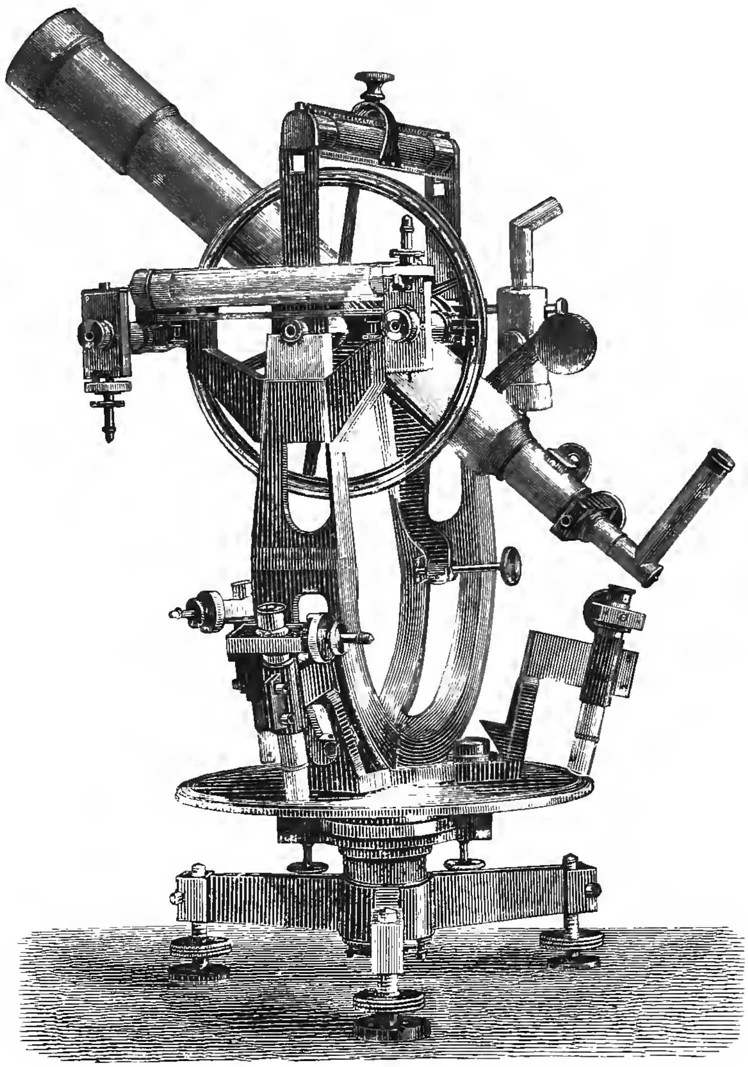
We have mentioned before the fine exhibit of astronomical instruments made by MESSRS. FAUTH & CO., of WASHINGTON, D. C., and we refer to this exhibit again to call attention to an exceedingly perfect ALTITUDE AND AZIMUTH INSTRUMENT, which has been purchased by the United States Coast Survey Department for triangulation and determination of azimuth. The altitude of a star or other body is its height above the horizon expressed in degrees, the greatest altitude of course being ninety degrees. The azimuth is the angle made by the meridian and the vertical circle in which a heavenly body is situated, and is measured along the horizon from the north or south towards the west, according as the north or south pole is elevated above the horizon, to the point where a circle passing through the zenith and the body cuts the horizon. The instrument of which we speak, and which is represented by the engraving on page 137, from the nature of its construction is employed in the measurement of vertical and horizontal angles, and may be used as a transit for time observation, also for double zenith distances for latitude, and will determine the astronomical position of any station. For geodetic purposes it is used in primary triangulation to measure the angles with the utmost precision. It has two graduated circles and a telescope, the planes of the circles being at right angles to each other, one called the azimuth circle being connected with a solid support, on which it is leveled and kept in a horizontal position, and the other called the altitude circle, being mounted on a horizontal axis, which also carries the telescope like a transit. The design and construction of the instrument are quite novel, combining all the advantages of a repeating instrument without its defects. The horizontal limb, which is thirteen inches in diameter, is graduated to five minutes, and may be read off by means of three microscopes at different points to the nearest single second, these microscopes being illuminated by prisms which derive their light from overhead, and are effective for any position of the circle. This circle may be shifted if desired, so as to bring different parts of the graduation under the microscopes, and thereby eliminate any error or eccentricity in division. The vertical circle is ten inches in diameter, and is graduated the same as the horizontal circle, but is read by only two microscopes, a very sensitive level, reading to single seconds of arc, being affixed to the microscopes to note any deviation from the vertical. This circle may also be shifted for position. Both circles are entirely free from clamps, these being attached to the centre, by this means avoiding the great risk of strain. The clamps and slow motion have differential screws. For time observation a striding level of the utmost perfection is supplied, which is set over the hard pivots of the telescope axis, so as to note any deviation from the meridian, the level being ground to a radius of about two thousand feet, each



Gaining Machine: C. B. Rogers & Co., Norwich, Connecticut.

division of its graduation representing a second of arc. Both this and the level over the microscopes of the vertical circle have air-chambers to correct the bubbles for changes of temperature.

The telescope has a focal length of twenty-four inches and a clear aperture of two and a half inches, its glass being of uncommon excellence, as is proved by the fact of its showing the companion star of Polaris. The micrometer on the eye-piece measures to the one-hundred thousandth part of an inch, and is used for determining differences of zenith distances of stars in computing latitudes. For convenience in observing near the zenith, a rectangular eye-piece is provided. A lamp is placed opposite the microscopes of the vertical circle to throw light through the axis down to the field and render the cross lines visible. This instrument is well entitled to the award which it has received, not only for novelty of design, but for execution and workman-

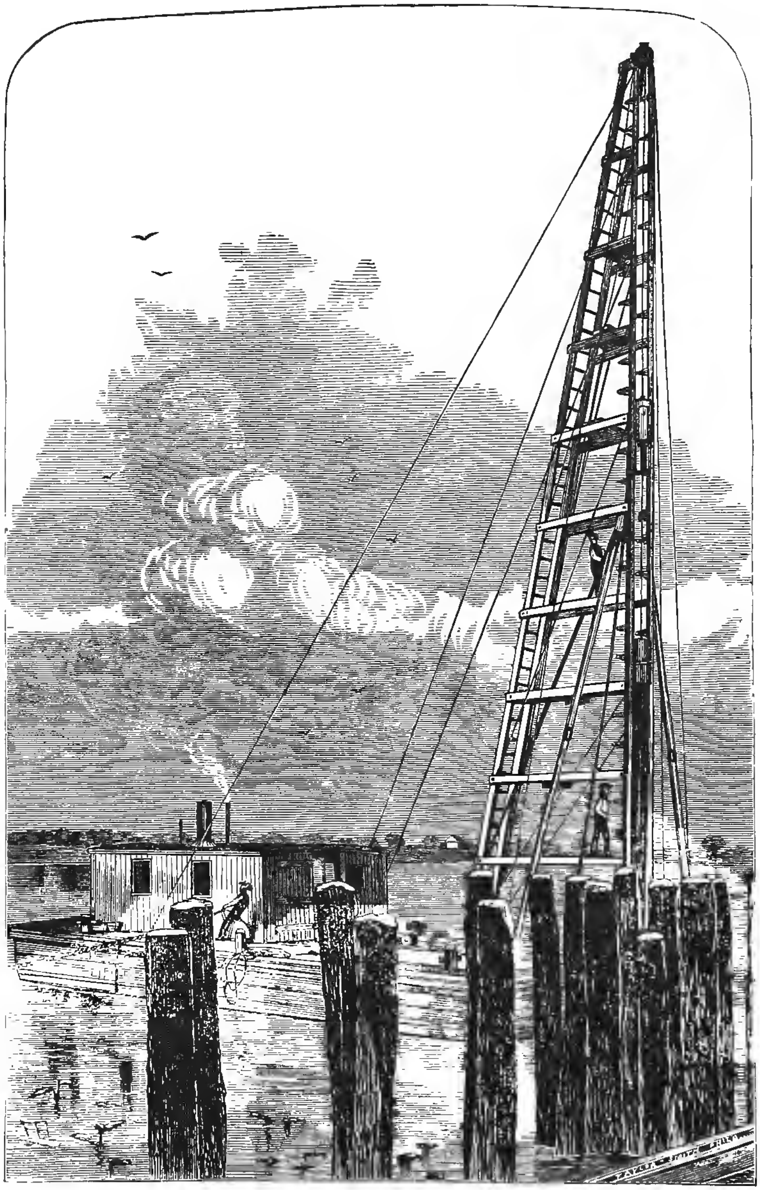


Alt-Azimuth: Fauth & Co., Washington, D. C.

ship, fully confirming the encomiums which have been passed on it by so many astronomers.

One of the most novel inventions that American ingenuity has brought into practical use during the past few years is the Gunpowder Pile-Driver of

Mr. Thomas Shaw, of Philadelphia, and well worthy of its place in the great Exhibition. The originality consists in the adaptation of a material as a motive



Gunpowder Pile-Driver: Thomas Shaw, Philadelphia.

power, ordinarily so violent and destructive in its action as to be generally considered almost uncontrollable. Yet machines for driving piles by the use of gunpowder have been constructed under Mr. Shaw's patent, and have been in practical use in various parts of the country for several years with the greatest success, demonstrating high economy and efficiency.

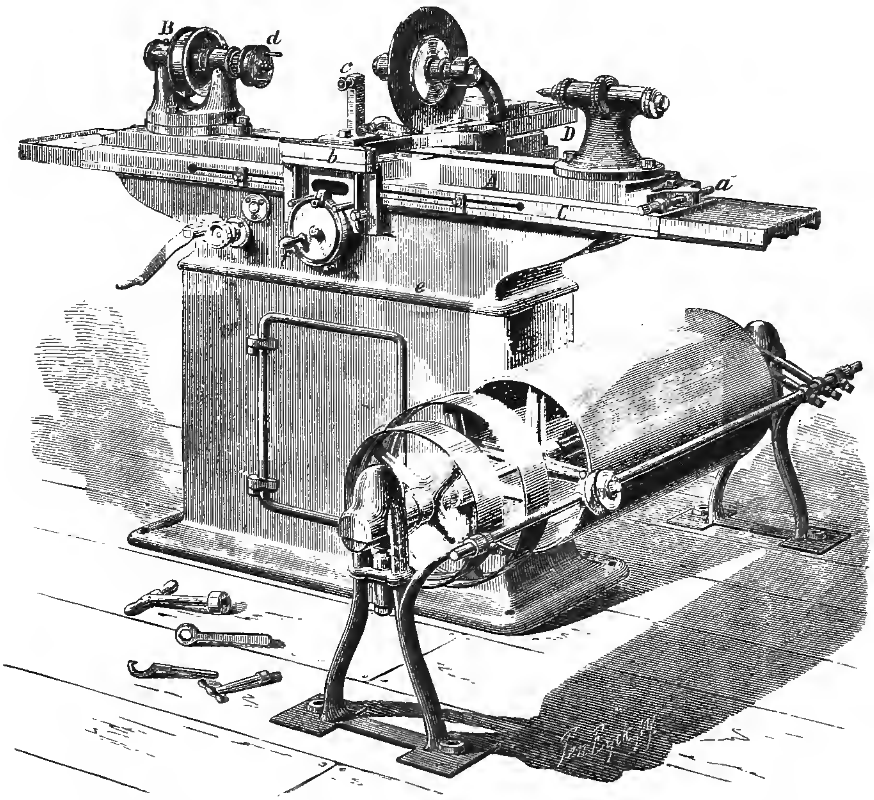
The machine is constructed of a strong frame-work of upright timbers, with inclined braces, formed into a ladder in the rear, the whole stiffened by horizontal struts and diagonal ties between. On the inner opposing faces of the uprights, guides are formed, in which a steel or iron gun and a ram move vertically. The gun rests on the top of the pile, being recessed on its under face for this purpose, and it is bored in its upper end to receive a plunger or piston, fitting nearly air-tight, which is fixed to and projects below the ram placed above. The upper end of the ram is also bored to receive a fixed piston projecting below a cross-head at the top of the guides, creating an air-cushion to check the upward movement of the ram should it be subjected to the force of an excessive charge of powder. In the rear of the uprights and placed parallel to them, running their whole length, are powerful double friction-brakes, operated by a compound lever near the foot of the machine, and used to check and hold the ram at any required point of elevation.

For expeditious working it is desirable to have a double-drum hoisting-engine in connection with the machine, and when so used the operation of driving proceeds as follows: A wooden block is placed across the mouth of the gun, and the ram and gun are hoisted simultaneously by one drum, which holds the gun, while the friction-brake is used to hold the ram. The pile to be driven is now raised to a vertical position by the second drum, and lowered in place until its foot rests on the ground. The gun is then lowered upon the top of the pile, keeping it firmly in place; and the block of wood being removed, a cartridge is dropped into the bore. The brake is now released, allowing the plunger to fall. On entering the bore it starts the pile downward, as in the ordinary pile-driver, and an explosion of the cartridge immediately following, the motion of the pile is vastly increased, the ram being at the same time projected upward, to be arrested by the application of the friction-brake. A second cartridge is now introduced, and the ram released as before, resulting in another explosion, which drives the pile still further, projecting the ram again upward. This operation may be repeated with great rapidity as often as necessary to force the pile to the proper depth. The plunger, by its sudden descent into the gun, compresses the confined air into a narrow stratum or cushion, preventing actual contact of the metal and at the same time generating heat, which fires the cartridge, the force of the powder being assisted by the expansive power of the air under the additional heat, and the principles of the hot-air engine called into action. The combination of all the forces developed creates an immense power, which pushes the pile down at the same time that it overcomes the momentum of the ram and projects it back to its original position.

With this machine, by successive explosions of cartridges, each composed of an ounce to an ounce and a half of common blasting-powder, a pile forty feet in length and fourteen inches in diameter may be forced its entire length into firm ground in one minute of time without the slightest injury to the timber, and entirely obviating the necessity of banding the head before driving. There appears to be no blow or concussion, the cushion or stratum of air in the gun acting as an elastic medium, and the pile being, as it were, forced into the ground as if by hydraulic pressure, instead of being pounded down as by the old methods. The sound condition in which the pile is preserved gives it greater sustaining power and lessens liability to decay. A large number of piles have been driven by this machine in the most satisfactory manner at the improvement works of the United States Naval Station, League Island, Philadelphia, both in the water and on shore. In wharf-work the superior alignment of piles driven by this method over the old plan is a great advantage, very much facilitating the work of capping and reducing the cost in labor and material. The machine possesses great simplicity of construction, controllability and readiness of manipulation, rapidity of work, and economy and efficiency of power.

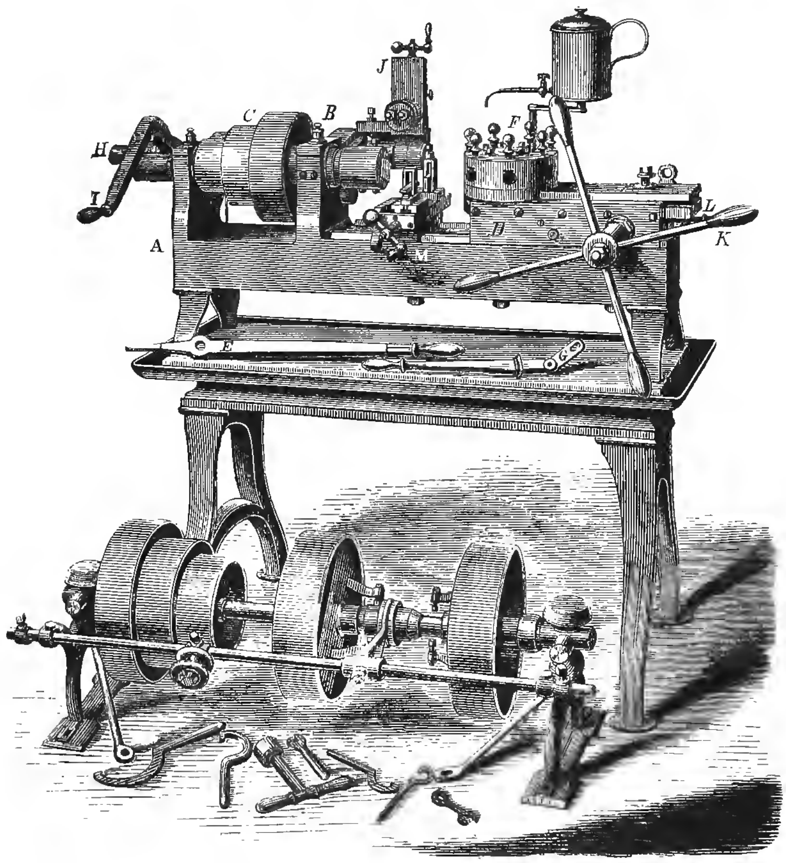
The Brown & Sharpe Manufacturing Company, of Providence, Rhode Island, with the same spirit which characterized its exhibit at Vienna, makes an exceedingly interesting and instructive display, in Machinery Hall, of that high class of tools for which it has achieved so great a reputation. These tools have chiefly developed from the requirements of the Company's general manufacturing business, which is conducted on an extensive scale, and they may therefore be said to represent the results of actual experience. In their construction, the uses for which each machine is intended have been well kept in view and every effort made to perfectly satisfy all requirements. As evidence of the character of work which these machines will execute we may mention that the firm has in its regular business manufactured over two hundred thousand Wilcox & Gibbs' Sewing-Machines, which uniformly attest its excellence.

Our first illustration, Fig. 1, represents the Company's UNIVERSAL GRINDING MACHINE, an exceedingly useful tool for performing a great variety of operations in grinding by the use of solid emery- or corundum-wheels, being



Screw Machine, Fig. 2: Brown & Sharpe Manufacturing Co., Providence, R. I.

especially adapted for the grinding of soft or hardened spindles, arbors, cutters—either straight or angular—reamers, and standards; also, for grinding out straight and taper holes, standard rings, hardened boxes, jewelers' rolls, etc. By means of an additional movable table, adjustable by a tangent screw and graduated arc, straight and curved taper-grinding may be performed with the centres of the machine always in line. The work may be revolved upon dead centres or otherwise, and the grinding-wheel may be moved over the work at any angle, producing any taper required. Graduated arcs are provided for grinding of taper holes and angular cutters. Wheels may be used from one-fourth inch to twelve inches in diameter, and the feed-works and slides of the machine are thoroughly protected from the entrance of grit or dust. A special chuck is provided to hold work in which holes are required to be ground. The spindle and boxes of the machine are of cast steel, hardened and ground. Our engraving shows also the overhead works, consisting of a drum, tight and



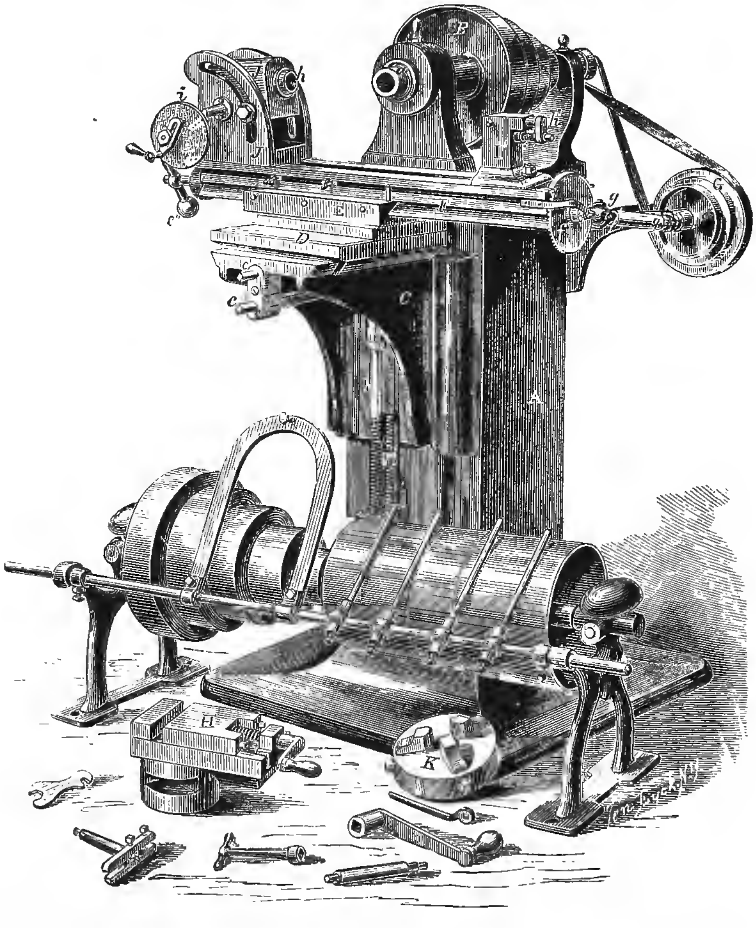
Universal Grinding Machine, Fig. 1: Brown & Sharpe Manufacturing Co., Providence, R. I.

loose pulleys, one iron pulley for driving the work and grinding-wheel, and adjustable hangers with self-oiling boxes. The weight of the whole, including the overhead works, is about two thousand pounds. This machine was purchased by a prominent firm in Alsace.

Fig. 2 shows the No. 1 Screw Machine made by this firm, together with the overhead works, the whole weighing about fourteen hundred and fifty pounds. By this machine may be manufactured all kinds of screws and studs such as usually required in a machine-shop, and nuts may be drilled, tapped and one side faced up; also many parts of sewing-machines, cotton machinery, gas- and steam-fittings may be made at great reduction in time and labor. It is claimed by the makers that as many screws can be made by one man with this machine as by three to five men on as many engine-lathes, and with much more uniformity in size. The size of hole through spindle is one and a quarter inches, and that in revolving head one and one-sixteenth inches, the length that can be milled being six inches. Smaller sizes of the Screw Machines are also made; one size, No. 3, being for the manufacture of screws used in sewing-machines, fire-arms, etc.; and another, No. 4, for still smaller work, such as screws for clockmakers, etc. The last machine has a patented device for opening and closing the jaws of the chuck which holds the wire from which the screws are made, allowing the operation to be performed in an instant without stopping, and effecting great saving of time when making small screws. It is often desirable, in threading screws and in tapping, to cut the thread up to a shoulder or to a given point, or to run the tap in to a shoulder or a given distance, and positively no further. With the ordinary tools this operation is quite difficult, causing great risk of breaking the threading-tool or injuring the shoulder of the screw. By means of a patent die-holder, however, manufactured by the firm, for use in the revolving heads of these machines, the matter can be accomplished without special skill or any risk of damage. Special tools are also furnished, if required, for making screws of any particular form or design differing from those usually made.

Fig. 3 shows the UNIVERSAL MILLING MACHINE of this Company, a tool that was exhibited at Paris in 1867, attracting marked attention and securing a very high award; again exhibited at Vienna in 1873, winning unusual distinction, and now coming forward at our own great Exhibition.

We have before mentioned in another connection the special functions and peculiar features of milling machines, and it is not necessary to repeat them again. This tool, besides having all the movements belonging to plain milling machines, possesses also an automatic movement and feed to the carriage, by which it is moved not only at right angles, but at any angle to the spindle, and stopping at any required point. Centres are arranged on the carriage, in which reamers, drills and mills may be cut, either straight or spiral, the latter right or left as desired, and spur- and bevel-wheels can also be cut. The head holding one centre can be raised to any angle, and conical blocks may be placed on an arbor and cut straight or spirally in either direction. Pulleys fourteen inches in diameter are used on the counter-shaft, the whole width of the three being fifteen inches. The total weight of machine, with overhead work, is about fifteen hundred pounds. The machine possesses an exceedingly

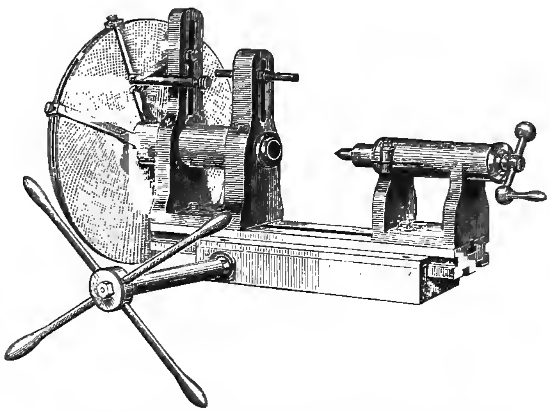


Universal Milling Machine, Fig. 3: Brown & Sharpe Manufacturing Co., Providence, R. I.

large range of work, and performs it with great excellence and accuracy. It is gotten up in very handsome style, and is well worthy of the attention which it has attracted.

In connection with this machine is a gear-cutting attachment, illustrated by Fig. 4, designed for the purpose of cutting gear-wheels with greater rapidity, and also for cutting larger and heavier wheels than can be done with the ordinary apparatus of the machine alone. It has a swing of thirteen inches, and is provided with an index of twenty inches in diameter, containing four thousand two hundred and ninety-four holes, which will divide all numbers to seventy-five, and all even numbers to one hundred and fifty. The screw with set nuts over the spindle is designed as a support to the wheel while being cut, and arbors fitted to the Universal Milling Machine can be used with this attachment.

The BROWN & SHARPE CO. also exhibits a very large and heavy Universal Milling Machine, illustrated by Fig. 5 on page 147, which has been designed particularly to meet the wants of steam-engine and locomotive builders or those engaged in the manufacture of heavy machinery. As will be noticed by the weight, which is three thousand eight hundred pounds, it is more than double the size of the smaller machine. It is built with the same essential features and motions, in enlarged parts, the only difference being that it is back-geared, giving six changes of speed, and having also the same number of changes of feed. The same ideas are carried out on a much larger scale than ever attempted before, and as there are more chances of error in a large machine than a smaller one, the errors being magnified as the machine increases in size, it is evident that the difficulties of construction have been augmented accordingly. The spindle-boxes are of hardened cast steel, and together with the spindle-bearings are carefully ground and are provided with means of compensation for wear. A cutter-arbor, projecting fifteen inches, may be carried by the spindles, being supported by an adjustable centre at the outer end. Cutters may be used up to eight inches in diameter. The spiral clamp-bed will move horizontally upon the knee in a line with the spindle of the machine six and one-half inches, and the vertical movement of the spiral bed-centres below the spindle-centres is eight and three-quarter inches. The spiral bed may also be set at angles of

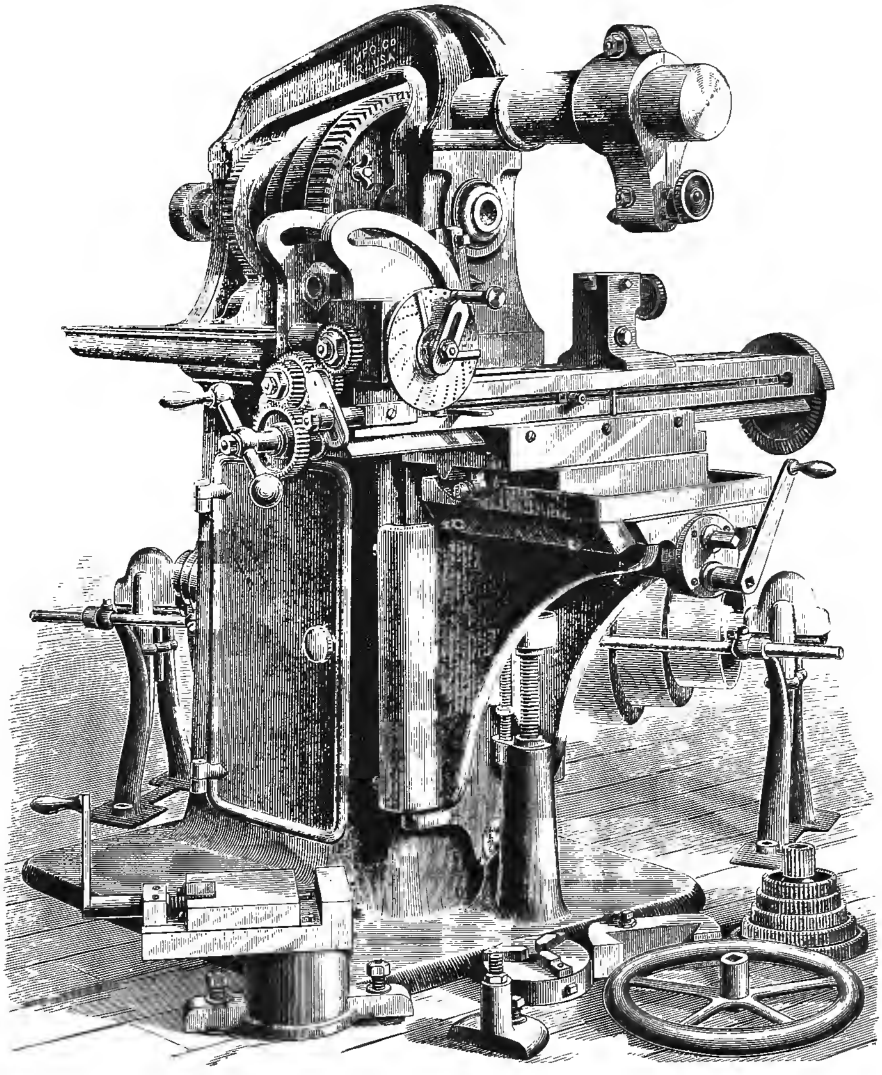


Gear-cutting Attachment: Brown & Sharpe Manufacturing Co., Providence, R. I.

thirty-five degrees each way from the centre line of spindle, and may be fed automatically twenty-two inches, taking also twenty-two inches between the centres, and will swing eleven and a half inches. The hole through the chuck and spiral head is one and a half inches, and the vise-jaws open three and three-eighth inches and are six inches wide and one and five-sixteenth inches deep. The pulleys on the counter-shaft are sixteen inches in diameter, the whole width of the three being twenty-two and a half inches. This machine was purchased by Fried. Krupp, the famous gunmaker of Essen, Prussia.

We must not omit to mention the Patent Milling Cutters which are made by this Company, for milling parts of sewing-machines and other articles of irregular figure, and also for making the teeth of gear-wheels. They may be sharpened by grinding without changing their form, the operation being capable of repetition over and over again until the teeth are entirely worn out, without affecting in the least the standard shape of the work produced by them.

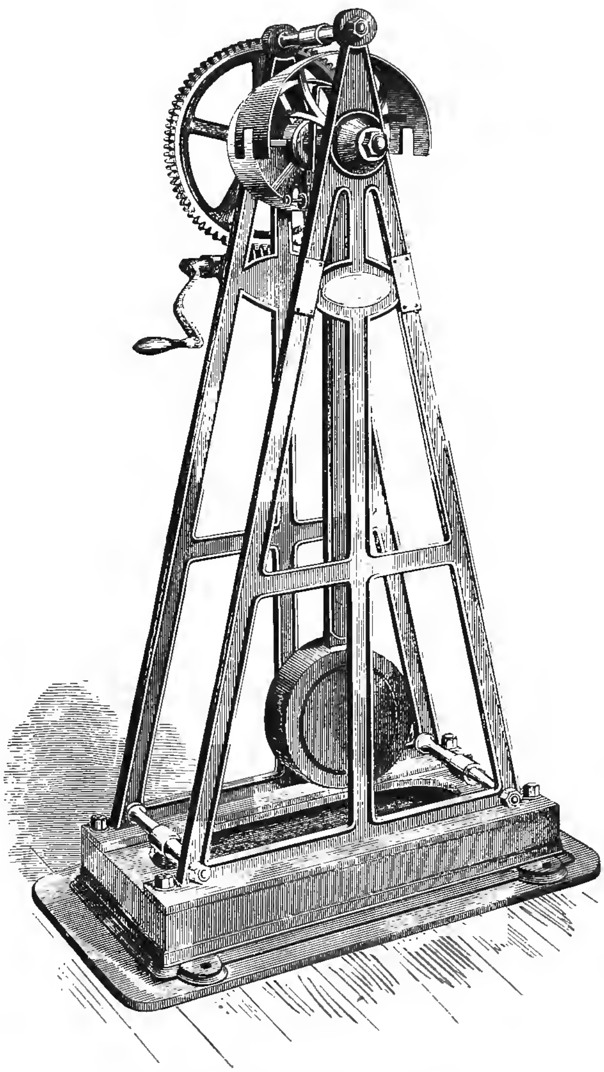
Ira J. Fisher & Co., of Kincardine, Ontario, Canada, represented by Alexander Thomson, of Fitchburg, Mass., as sole agent in the United States, exhibits a Bevel-Edge Boiler and Ship Plate Clipper, which appears to be an exceedingly efficient and complete working-tool, supplying a want long felt among steam boiler-makers and iron ship-builders. This machine, which is the only one on exhibition, entirely replaces the slow and objectionable process of hand-clipping or the expensive use of planers, doing a much greater variety of work than possible by the old methods and at considerably less cost. Our illustration on page 148 shows very clearly the design of the tool and its mode of working. It will cut the edges of plates to any required bevel, keeping the line of direction of the cut either straight, concave or convex, as desired. This capability of doing circular-work makes it exceedingly serviceable for Iron Ship-building. The plates require no fastening while under operation, and are placed on a truck or table and passed through the shear, the depth of the cut being regulated by a guard, which is adjustable by a screw, and can be readily changed without interference while the machine is in motion and the plate being cut. It is claimed that the capacity of one of these clippers runs from one to two hundred feet per hour, the work being done in a superior manner to that executed by planers, which will only do from two to three hundred feet per day on straight work. A hand-power machine is manufactured by the same party, provided with a concentrated power appliance under Mr. D. L. Kennedy's patent, by which it is said two to three hundred feet of clipping may be done per day on three-eighth inch plate with one man on the lever. The machine appears to combine great simplicity, efficiency and durability, and has received an award of a medal and diploma from the Commission.



Large Universal Milling Machine, Fig. 5: Brown & Sharpe Manufacturing Co., Providence, R. I.

The STEVENS INSTITUTE OF TECHNOLOGY, now well known both at home and abroad, and attracting considerable attention as the highest representative of a technical school of mechanical engineering at the Exhibition, makes an exceedingly creditable and interesting display in the Main Building, which has been arranged with a view of illustrating—first, the methods of instruction employed, as seen by instruments, models, etc.; second, the results obtained, as shown by work produced by students; and third, the contributions to the progress of science, as exemplified by apparatus used in original investigations, samples of new substances discovered and published papers. There are exhibited a number of instruments of precision such as a linear dividing engine of large size and great accuracy, a spherometer and Dore's polariscope, also an extensive assortment of illustrative apparatus, a large induction coil for producing statical electricity, President Morton's vertical lantern with special attachments, and a number of instruments for delicate researches, Regnault's apparatus for heat, Tyndall's for radiation, and Thomson's for electricity. In the department of engineering are a number of models of elements of machinery and construction, working models of pumps, steam-engines, etc. The collection of engineering relics is exceedingly interesting, and several remarkable historical relics are exhibited. Here is the high-pressure condensing engine, water tubular boiler and screw which in 1804 drove John Stevens's first steamboat eight miles an hour on the Hudson, and the twin screws used with the same engine in 1805. Here also is Fulton's own drawing for the engine of the Clermont and one of his autograph letters. In the Chemical department are found various rare chemically pure substances prepared in the laboratories of the Institute, the new hydro-carbon Thallene and a number of its derivatives first discovered by President Morton, also an extended series of anthracine derivatives, etc., many of these being the only representatives of the substances found in the entire Exhibition. The work of students is very well represented. There are specimens of drawings, designs worked out and in no sense copies, the conditions being given and the work planned, calculated and executed by the student as if in actual practice, being a much higher grade of work than mere copying; also apparatus and machines actually made by the students, as the Odontoscope designed and constructed by Mr. J. M. Wallis, of the class of '76, for the purpose of testing the teeth of spur-wheels as to their being of the correct form, an oil-testing machine built by the class of '77, and many other interesting specimens of work.

Among the instruments exhibited which are used in actual work is Prof. R. H. Thurston's Autographic Testing Machine, an apparatus that has so perfectly fulfilled the conditions for reliable testing of the strength, elasticity, ductility, resilence, and homogeneousness of materials of construction as to attract marked attention both at home and abroad, and win for its inventor a lasting reputation, being in use by the United States Government, by various private firms, where unusual care is exercised in the selection of stock materials, by different scientific institutions, and foreign orders for them being received lately from the Russian Government.



Thurston's Autographic Testing Machine.

This machine, of which we present an engraving on this page, consists essentially of two strong wrenches, which are supported independently of each other by a substantial framework, and have a space between them adapted to the length of any piece to be tested, this being held in between them, and having its centre and their axes all in the same horizontal line. One of these wrenches is revolved by means of a worm gear, the motion being transmitted through the test-piece to the other, to which is attached a weighted arm or pendulum, and causing this arm to swing outward from the perpendicular, and to react with a torsional strain upon the test-piece by an amount proportional to its weight and the angle it is made to assume with the perpendicular.

A cylinder is attached to and moves with that wrench which bears the worm gear, and around this cylinder is wrapped a sheet of profile-paper, upon which the apparatus makes its record by means of a pencil borne by the other or weighted arm and partaking of its motion. The direction of the motion of this pencil is changed, however, by means of a stationary guide-curve attached to the frame of the machine, the form of the same being such that its ordinates, and therefore the distance that the pencil is thrust forward, are precisely proportional to the forces tending to produce torsion on the test-piece, and developed by the weighted arm while moving up an arc to which the sines of the curve are proportional. The cylinder and the pencil having precisely the relative angular motion of the two ends of the test-piece, the curve described by the pencil upon the profile-paper is such that the ordinate of any point in it measures the force producing distortion at a certain instant, and its abscissa the amount of that distortion at the same instant.

When a piece is subjected to torsion, a range of distortion is obtained so great as to be easily measured, and the stresses are applied in the most favorable way to bring out all the characteristics of the material under test. The record of the test being made by the machine itself, avoids all errors of personal observation. The manner in which the registry is effected makes the automatic record peculiarly reliable and valuable, since, as the degree of distortion of the material and the resistance offered by it record themselves simultaneously and continuously from the initial strain to the point of final rupture, therefore the curve described by the apparatus is a complete record of every condition under which the piece has been tested, and of its exact behavior under these conditions. Such an automatic registry it is believed has never before been made.

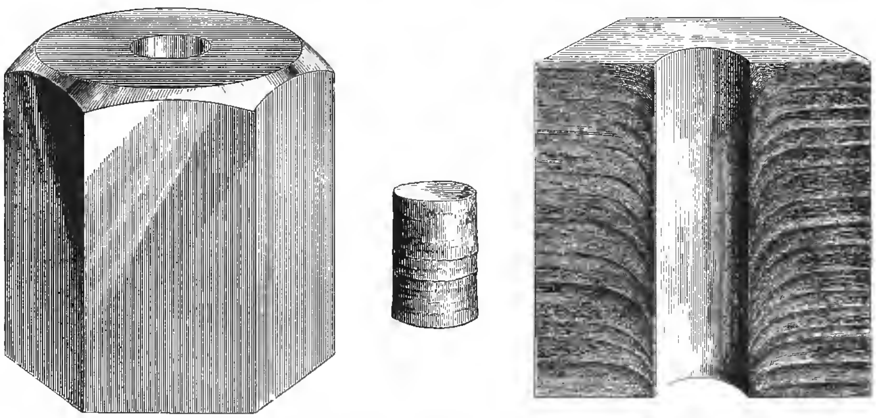
Every characteristic of the material is revealed by the diagram, which also affords a comparative measure of the ultimate resistance of the test-piece; its ductility; its homogeneousness as to internal strains, structure and composition, and many other properties of great interest and value that no previous testing apparatus has ever given.

This machine is of special value to the engineer in revealing the laws governing the resistance to stresses variously applied, in suggesting formulæ embodying those laws, and in furnishing the proper constants for these formulæ, as well as in modifying those now in use which are shown not to take into account important elements. The diagram affords unusual facilities for studying the molecular structure of materials; the effect of internal strains and the manner in which they are induced or relieved; the changes in character due to different compositions or to any peculiar treatment in manufacture, and the results of experiments made to determine the ways of improving the qualities of materials.

The inventor, by means of this instrument, has made and published to the world important discoveries in reference to the behavior of certain classes of materials under strains exceeding the elastic limit, and has also been able to throw much light upon the phenomena attending molecular action induced by changes of temperature, by external forces, and by special treatment. The machine is one that in the hands of the careful manipulator may be made to reveal the most valuable results, and is only another evidence of the great good which is accomplished by such a school as the STEVENS INSTITUTE OF TECHNOLOGY in the extensive facilities which it affords for invention and research.

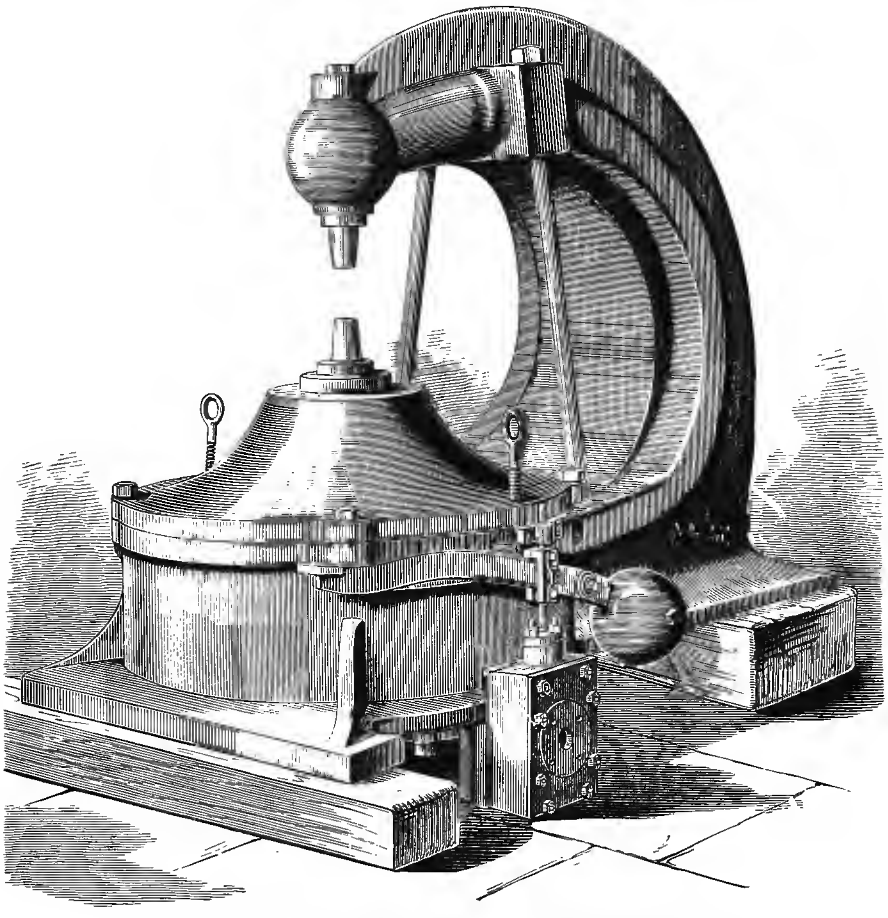
MESSRS. HOOPES & TOWNSEND, OF PHILADELPHIA, well known for many years as extensive manufacturers of bridge-rods, bolts and nuts, railroad splices, etc., make an exceedingly interesting and handsome exhibit in Machinery Hall of the various products of their works, artistically arranged in a neat pavilion, and attracting as many visitors by the beauty of the display as by the excellence in quality of the articles. Here are found car-forgings, truck-irons, washers and chain-links, square and hexagon nuts, boiler- and tank-rivets, bridge-machine-, and car-bolts of every description, all showing a high state of perfection in workmanship and finish.

One of the great specialties of this firm has been the manufacture of cold-punched nuts, and great ingenuity and skill have been brought to bear on this subject, resulting in the punching of nuts of a depth compared to diameter of hole that has never been achieved elsewhere. We have before us now a nut one and three-quarters of an inch in thickness that has been punched cold, with a hole only seven-sixteenths of an inch in diameter, as clean and straight and with as perfect faces as could possibly be desired. It has generally been considered that the limit in thickness of metal for punching was equal to the diameter of the punch, even if the latter was made of the very best steel and hardened in the most thorough manner, and that any greater thickness involved considerable risk of breakage to the punch. Here, however, is a nut four times the diameter of the punch in thickness, punched with apparently the greatest ease, and characterized by superior excellence of finish, allowing it to be used directly on fine work without further attention. This seemingly impossible result has been accomplished by using only the best material in the punch, making it accurately fit the die, and employing machines sufficiently heavy and accurate to insure that the iron being punched shall receive only direct vertical pressure without any lateral or bursting strains, the force applied to the punch being only such as it is capable of sustaining, and sufficient time being given to allow it to penetrate the metal at a rate depending upon the natural fluidity of its particles. One punch is exhibited, made from American steel—Midvale Steel Works—that has punched over two hundred holes, and



Cold-Punched Nuts: Hoopes & Townsend, Philadelphia.

is still in good condition. It is claimed that the iron after punching retains all the qualities possessed by it when it came from the rolls, and that the fact of its being cold-punched is a guarantee of its high excellence, a proof not obtained in the case of hot-pressed nuts. The metal in a cold-punched nut it is claimed is really strengthened instead of weakened, that portion around the hole being compressed and made more dense and stronger. It has been asserted in objection to cold-punched nuts that there was great roughness of holes from broken fibres of iron, and that the holes were also larger at one end than at the other, and almost always out of perpendicular to the faces of the nut. Messrs. Hoopes & Townsend claim to have entirely overcome these difficulties, bringing, with their method of working, an experience of over twenty-five years, and they state that they are able to furnish first-class nuts, cold-punched, with holes no larger at one end than the other, perfectly straight, perpendicular to the faces, and almost as smooth as if drilled, without any loosened fibres. Over three tons of cold-punched nuts have been tapped per day by this firm without even one being condemned on account of the threads pulling out, they being equal for all practical purposes to threads chased by lathe-work. In hot-punched nuts a hard and brittle scale is formed, which soon takes off the fine cutting edge of the tap, and the gauge is lost. On page 152 we give an



Steam Riveting Machine: Pusey, Jones & Co., Wilmington, Del.

engraving showing a section of a cold-punched nut, the surface of which has been planed and treated with acid so as to bring out the fibre. It will be noticed that the action of the punch has bent the lamina of the metal all downward, the nut being punched with its top downward, and it is claimed that this gives the iron much greater resisting power, the fibre standing, as it were, at an inclination to the bolt, and taking the stress on end instead of across.

Tests have been made with these nuts, confirming the superior qualities claimed for them. Cold-punching is productive of economy in the fact that there is no expense for heating the metal, and also that no scale is formed as in hot-punched nuts, and the taps are not worn out. It is stated by the firm that it has punched twelve tons of nuts with a single tap without wearing it out or causing any sensible loss of gauge.

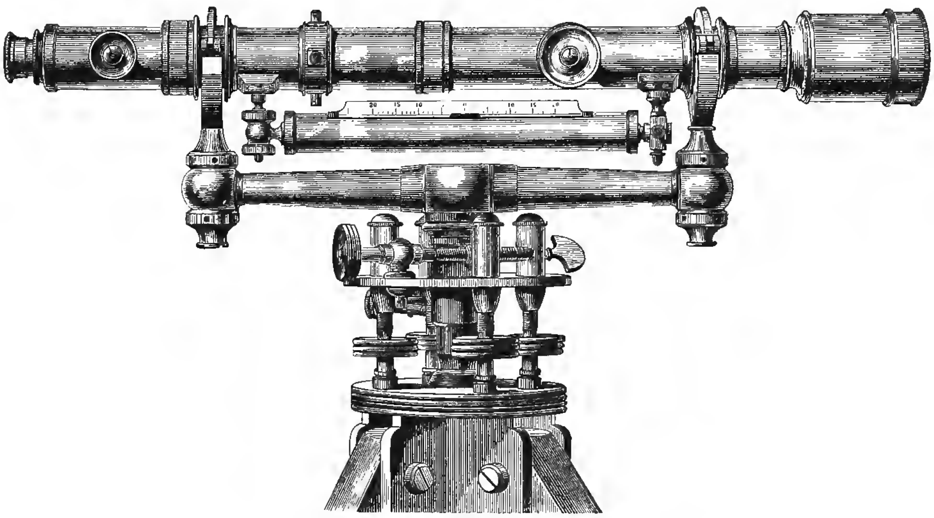
We have before mentioned the great importance that power-riveting has attained within the past few years, superseding hand-riveting almost entirely in all large establishments, and accomplishing not only great saving in time and labor, but also turning out work of much increased strength and perfection. These riveting-machines are operated either by hydraulic power or steam, and we desire here to draw attention to a Steam Riveting-Machine as exhibited in Machinery Hall by Pusey, Jones & Co., of Wilmington, Delaware, and shown by the engraving on page 153, that appears to be particularly well adapted for iron ship-building and bridge-work—in fact any work consisting of **I** beams, channels and angles, or of flat plates in conjunction with them. The parts to be riveted together are first joined and held in position with respect to each other temporarily by bolts at intervals, as is the usual custom, and are manipulated on the machine by crane-power. The rivets are heated in quantities in small furnaces provided for the purpose, and put in place in the rivet-holes by boys, the work being moved along under the riveting-stamp as rapidly as they are inserted. The stamp operates vertically by direct steam pressure on a large piston, the operation being governed by a foot-lever, seen in front on the engraving, the short arm being weighted. The pressure of the foot admits the steam, and when the rivet is driven, the foot is removed, and the action of the weight raises the lever and opens the exhaust.

It is claimed by the manufacturers that the capacity of this machine is equal to that of ten gangs of hand-riveters, the attendance of but one skilled workman, three laborers and a boy being required in working it.

Another exhibit made by this firm, and not mentioned on its list nor entered in the catalogue, is the iron work of the Machinery Hall itself, and all who have examined it, especially that in the roof seen from the galleries at the east and west ends of the building, and decreasing so regularly and beautifully in the distance as the eye glances from truss to truss, will testify to its neat and accurate workmanship, as well as to the care and ability of the contractor, Mr. Philip Quigley, who framed the timber-work and erected it.

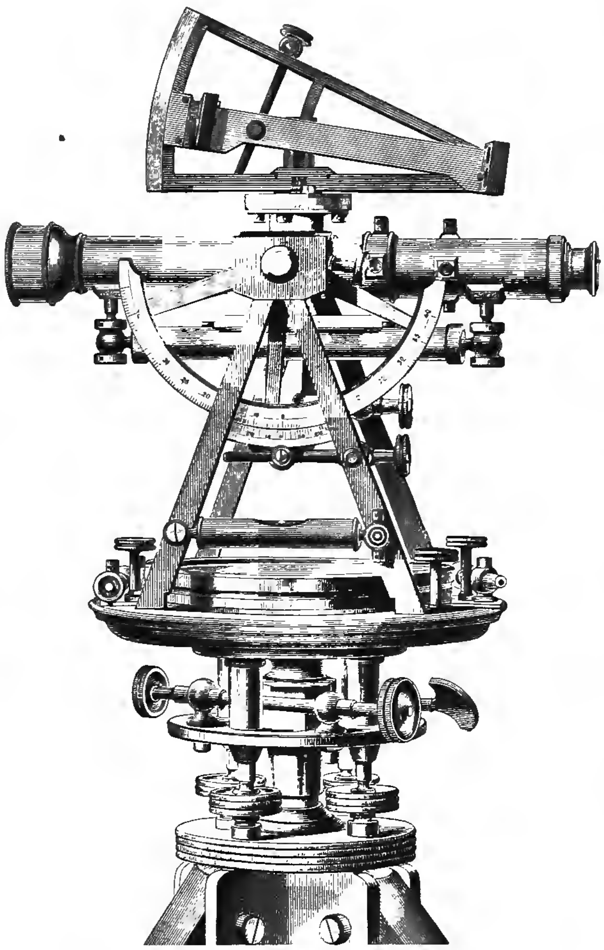
MESSRS. W. & L. E. GURLEY, OF TROY, NEW YORK, make a large display of the various instruments used by the civil engineer and surveyor, from among which we select two of the most important for illustration.

The ENGINEERS' TRANSIT, as shown by the engraving on page 157, has a telescope of eleven inches fixed in an axis supported by two standards, and turning readily in its bearings, so that it may be rotated in a complete revolution or "transit," and enable sights to be taken in opposite directions. The telescope has connected with it a long spirit-level, a vertical arc of three inches radius, and a clamp with slow-running tangent-screw, these appliances enabling level lines to be fixed and vertical angles measured. The vertical arc is divided upon a silver-plate surface, and by means of a vernier at the lower part may be read to ten seconds of arc. There are two horizontal circular plates revolving freely on each other about concentric vertical axes, the upper carrying the standards for the telescope, and supported by a tapering spindle, which fits into a hollow cone carrying the lower plate. A clamp with tangent-screw connects the two plates, and a compass circle is fixed to the upper plate, properly divided and furnished with magnetic needle. The lower plate, called the limb, is divided around an inside edge into degrees and fractions of a degree, and figured to every ten degrees. The upper plate has two opposite verniers, with divisions to correspond with the lower plate, and will give readings for angles to ten seconds of arc. Spirit-levels are attached to adjust to the horizontal, four leveling-screws being provided for the purpose. The instrument is supported upon the usual three-legged stand or tripod, and so far it does not differ essentially from those in general use for engineering purposes for many years past, being, however, an exceedingly fine and accurate piece of workmanship. The special novelty in the instrument consists in the solar apparatus attached above the telescope, forming an important addition to the ordinary transit. The system of public land surveys adopted in the United States since the beginning of the present century, requires such lands to be laid out in areas, the boundaries of which shall be truly north and south, east and west, or, technically, meridians and parallels. To readily determine these lines the Solar Compass was devised by William A. Burt in 1835, and has ever since been the standard instrument of the Government surveyor. The Solar Apparatus here shown, and which is essentially the same as the instrument just named, consists mainly of three arcs with their appliances: the latitude arc, represented by the vertical arc attached to the axis of the telescope and previously described; the declination arc, a segment in a vertical plane shown in the engraving above the telescope; and the hour circle, a horizontal circle surrounding the little disk above, and fixed to the centre of the telescope axis. The declination arc has a movable arm attached, which has at each end a small rectangular block, containing a little lens with a small silver plate opposite



Y Level: W. & L. E. Gurley, Troy, N. Y.

to it, marked with two sets of lines, enclosing a square of precisely the proper size to contain the image of the sun when focused upon it by the other lens. The declination circle is divided and figured from zero to thirty degrees, with vernier attachment. The hour circle is divided into one hundred and twenty equal parts, and figured on each half of the circumference from one to twelve, being read by an index attached to the frame of the declination arc to five minutes of time or closer if desired. In taking an observation for true meridian, the transit is set up and carefully leveled—the latitude of the place, the declination of the sun for the given hour, and the proper time set off upon their respective arcs. The whole instrument is then turned horizontally until the sun's image is brought within the square of the silver plate, and being securely clamped in this position, the telescope indicates the true meridian. Any angle may now be laid off from the meridian, and the bearings of lines determined independent of the needle, which latter shows its variation from true north and south. This solar apparatus may be readily removed and put aside or replaced at will, without interfering in any way with the ordinary use of the transit, thus combining the advantages of both instruments.



Engineers' Transit. W. & L. E. Gurley, Troy, N.Y.

The other article selected is a Y Level, shown on page 156, an instrument used in determining levels, fixing grades, etc., and holding a most important position in a list of the essential tools of the civil engineer. The one here exhibited has a powerful telescope twenty inches in length, to which is attached underneath, a long and delicate spirit-level, provided with a scale, so that the bubble may be readily and accurately centered. This telescope, as well as that in the transit already described, has an adjustment of the slide-tube of the object-glass, which insures its moving in a right line, and enables the engineer to take long or short sights in any direction without deviation, and so correcting what is termed the travelling of the object-glass. The telescope-tube is supported in a Y at each end, with a clip or band above, swinging on a pin in one arm of the Y, and held in its place in the other by a movable tapering pin. When these pins are loosened, the telescope-tube may be revolved in the Y's, or taken out and reversed in position, end for end, these movements being required in making adjustments of the instrument. The Y's are supported in the ends of a horizontal bar, and provided with two nuts to each for adjustment, so that the longitudinal axis of this bar may be made parallel to the centre line of the telescope. The bar at its centre is connected to a vertical spindle, which revolves accurately in the hollow frustum of a cone in the head of a tripod socket, the latter having two parallel plates with ball and socket connection and four leveling screws. These screws, in both this instrument and the transit, are covered at their upper ends by caps or thimbles, so as to effectually exclude all moisture or dust. A clamp with tangent movement is provided for fixing the instrument in the bearing of the spindle, and when unclamped, a little screw below the upper parallel plate of the tripod head, working in a groove in the spindle, prevents it from coming out unless desired, while still permitting it to revolve freely. The tripod head may be unscrewed from the legs, and both it and the upper part of the instrument may be separately packed away in a box for safe transportation from place to place. The arrangement of the details, as seen by the engraving, allows of a long socket or spindle, while still bringing down the whole instrument as close as possible to the tripod head—both matters of great importance in the construction of any instrument of this kind.

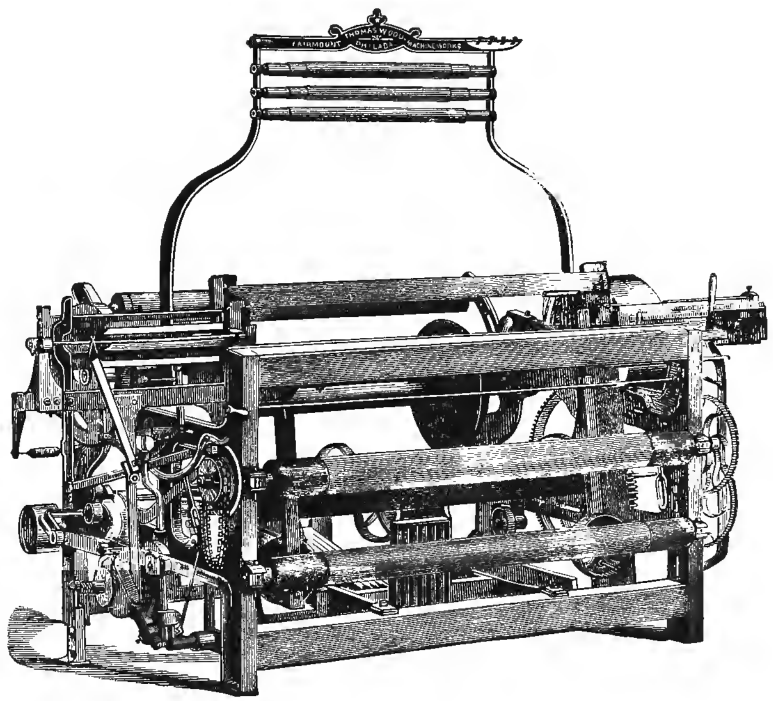
This firm has introduced the use of the new metal, aluminium, so remarkable for its lightness, and now manufactures these instruments of this material, saving nearly one-half in their usual weight, at a cost, however, of about fifty per cent. advance on the ordinary prices.

Quite a number of looms of various kinds are shown in the Exhibition, most of them in practical operation, attracting crowds of visitors, all interested in the curious automatic movements and apparently marvelous results accomplished by these machines. Even those most experienced in such matters find a fascination in watching the passage of the shuttles to and fro, and observing the pattern as it is gradually and so beautifully worked out.

Weaving may be defined to be the making of cloth by the intersecting of threads. Those running lengthwise of the material are called warp or chain, and those across, woof or weft. Taking into consideration a loom machine generally, without reference to any particular type, the essential parts may be described as follows: A substantial framework is used as a support for the whole apparatus, in one part of which is a horizontal roller, called the beam or yard roll, longer than the width of the cloth to be made, on which is wound the warp, all laid out flat, each thread side by side. These threads pass in a plane, horizontal or nearly so, through the heald, a sort of comb dividing them regularly, towards another horizontal roller parallel to the first, and at the other side of the frame, called the cloth-beam or breast-roll, upon which the fabric is wound as it is woven. Between these the warp is kept tightly stretched by the action of weights on the roller, or by some equally efficacious means. An arrangement of tight vertical cords intersects with the warp-threads in a plane at right angles to the plane of the warp, there being one vertical cord to each warp-thread. On the line of intersection, these cords have loops or metallic eyes, and each separate warp-thread passes through the eye of the cord belonging to it. Now it is evident that by raising or lowering the cords, the corresponding warp-threads will be also raised or lowered at the crossing points, out of their plane. In plain weaving, two frames are used, in which these vertical cords are stretched, alternately in one or the other, and the mechanism is so arranged that the frames are alternately raised and lowered by the motive power, whatever it may be, successively elevating and depressing the alternate threads of the warp, and giving a space between them for the passage of the thread of the weft, which being wound upon a shuttle, and perfectly free in its action, is made to fly back and forth for each movement of the warp-threads, the motion being given to it as to a stone from a sling or a ball thrown from the hand. The weft-thread is in this way alternately passed or woven through the threads of the warp, a mechanical arrangement, called a batten, at every throw pressing it up tightly home, and producing a firm finished material. The general principles are the same, either in the simplest or most complicated machines. If it is desired to weave patterns, mechanical movements can be designed by which the warp-threads are not always raised and lowered alternately, but according to some regular law for the particular pattern. In the Jacquard loom this is done by means of perforated cards. Then for the weft-threads a number of threads of different colors can be used, each on its own shuttle, the receptacles holding and throwing these shuttles being so arranged mechanically as at the proper time, depending upon the figure or pattern woven, the particular shuttle desired shall be brought up in position and thrown back and forth until its turn comes to be replaced by another.

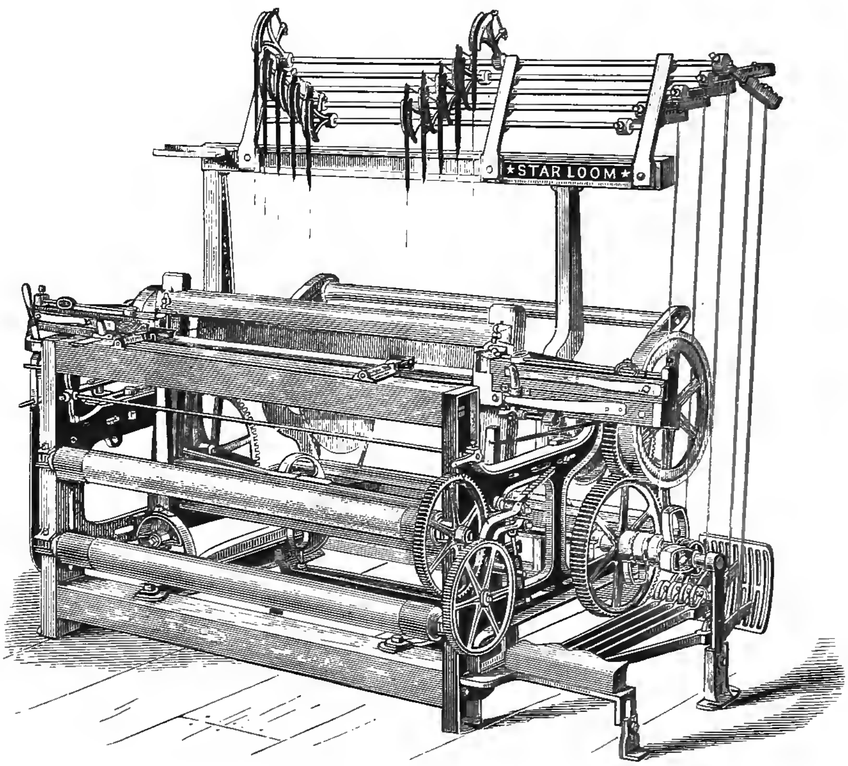
Various other modifications are made to suit certain kinds of work, such as the weaving of the different kinds of carpets, etc., and invention has a large field for operation.

We desire more particularly to call attention here to some excellent looms exhibited by MR. THOMAS WOOD, OF FAIRMOUNT MACHINE WORKS, PHILADELPHIA, who has made a specialty of the manufacture of Power Looms; Reeling, Spooling, Winding Machines, etc., and has attained a high reputation for his productions.



Three-Box Sliding Cam Loom: Thomas Wood.

Fig. 1 shows his "Three Box Sliding Cam Loom," which is a roller-loom, with an improved sliding cam twilling motion and a box motion, patented in 1873, and since improved. It has but few parts, is of the simplest construction, very strong, and so easy of management that one overseer can take charge of almost as many three- and four-box as of single-box looms, with but very little more work. The box-motion is supplied with a sliding clutch, so that in case of any interference with the operation of the shuttle-box, the motion will unship, and so remain until the box is relieved, when it passes back into gear, thus preventing breakage of parts and stoppage of the loom consequent on the jamming of the shuttle or the lodging of the picker in the box. The picking motion is very complete, the cams adjustable, and each part is independent in its own adjustment. Wrought-iron crank-shafts are used, with cast sleeves shrunk on them, very much increasing the diameter and gaining the benefit of two cast-iron surfaces wearing together without the sacrifice of the light wrought-iron shafts. These looms can be run at as high a rate of speed as yet attained by any other box-looms, and it is claimed with less expense in



Star Loom: Thomas Wood.

findings, power, breakage, and wear of parts. A four-shuttle loom, with these improvements operating all the boxes, has been working during the Exhibition on heavy cottonades and plaid flannels at a speed of one hundred and thirty-eight revolutions per minute.

Fig. 2. represents his "Star Loom" with "Outside Shed Motion," which weaves the goods face side up and is capable of being worked at a high rate of speed. It is furnished with the same pick and box motions as the sliding cam loom, and is especially adapted to the manufacture of Jeans, Cassimeres,

Alpacas, Delains, Cheviots, Plaid Dress Goods, Sheetings, Shirtings, Osnaburgs and all kinds of light and heavy twilled goods. Two of these looms have been in operation during the whole time of the Exhibition on a great variety of work, a single shuttle one at a speed of one hundred and seventy-six revolutions per minute, and a three shuttle one at one hundred and sixty-five per minute.

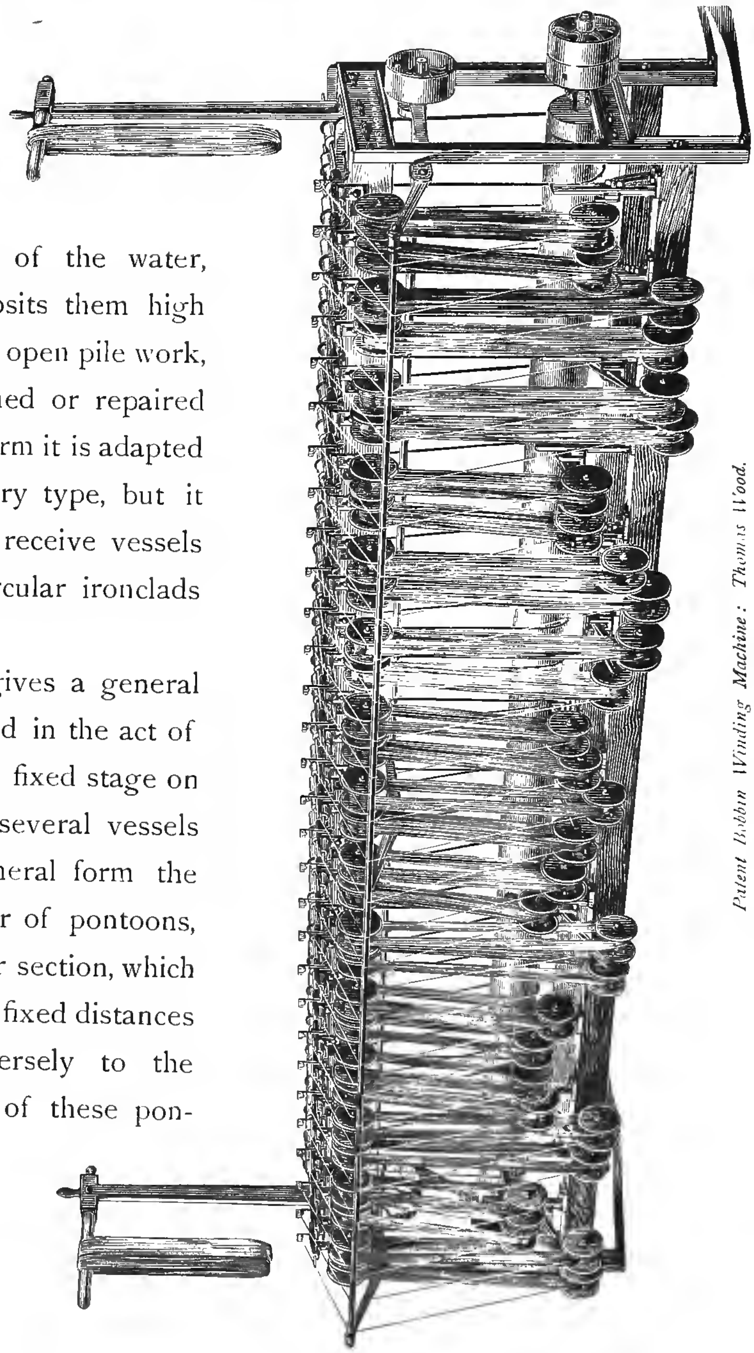
Fig. 3. gives one of Mr. Wood's "Patent Bobbin Winding Machines," intended to wind direct from the hank or skein to the shuttle bobbin. It is furnished with double anti-friction cones to form the bobbins, a loose pulley to each spindle, yarn regulators on the traverse bar, and adjustable levers and reels for carrying the hanks. By the use of these cones the friction on the yarn is reduced, thus preventing the burning or shading of even the most delicate colors while at the same time a perfect formation of bobbin is acquired. This machine obviates the labor and waste necessitated by spooling, and the floor space occupied by the spooling machine is gained. Each of these machines gained an award of a medal and diploma.

The Educational Department in the United States in its different branches has been exceedingly well represented at the Centennial Exhibition and has attracted great interest, especially from foreigners, so much having been done by the General Government, by the various States and by munificent gifts of individuals to provide for the education of the masses by furnishing great facilities at very low charges and often entirely free, as to merit special attention. In 1862 Congress granted to each State thirty thousand acres of public lands for every senator or representative to which it was entitled, the income of which was to be appropriated in perpetuity to educational institutions where the leading feature should be the prosecution of such branches of learning as are connected with agriculture and the mechanic arts, including in addition military tactics, and allowing also other general scientific and classical studies; the purpose being to "promote the liberal and practical education of the industrial classes in the several pursuits and professions in life." The grant allowed one-tenth of the appropriation to be used in the purchase of experimental farms, but no portion for buildings. The share of the State of New York was 990,000 acres, and in 1865–67 the Cornell University of Ithaca, having already a gift of five-hundred thousand dollars from Hon. Ezra Cornell as a foundation, was established by charter and the entire income of the land grant secured to it so long as it should use it effectively in aid of the objects intended by Congress. Additional donations of nearly one million dollars have subsequently been given to the institution, its library, collections, etc. have rapidly grown and it stands to-day as one of the representative colleges of the country. Practical and scholarly studies are given equal value, the aim being to furnish the best facilities possible for each, to encourage their combination and to allow a wide liberty of choice, affording the student a mental discipline of varied character, while at the same time bearing directly upon his selected profession for life. The engineering school is very large and the opportunities for practical work in the mechanical department most excellent. The University Machine Shop makes an exceedingly creditable exhibit in Machinery Hall, and we have the pleasure of presenting on page 165 engravings of two specimens of the work of its students made from designs of the Director, Mr. John E. Sweet. Fig. 1. shows two Standard Surface Plates of remarkably perfect construction and so truly surfaced that when one is placed upon the other it will float on the thin film of air held between them, or if this be crowded out, they will adhere so tightly together as to require considerable force to separate them. Fig. 2. shows a Measuring Machine designed for obtaining measurements from zero to twelve inches and reading to the one ten-thousandth part of an inch. It is more especially intended for use in the manufacture of standard gauges and is peculiar in the method of taking the measurements, in its range, and also in the fact that any imperfection in the measuring screw can be corrected. Its construction is sufficiently shown by the engraving, and it is believed to be the first if not the only one of the kind built in this country.

MESSRS. CLARK & STANDFIELD OF 6 WESTMINSTER CHAMBERS, LONDON, ENGLAND, make an interesting exhibit in the British section of the Machinery Hall of working models of their GRIDIRON STAGE DEPOSITING DOCK, for which they have been awarded a medal and diploma here, as well as at the Paris Maritime Exhibition of last year.

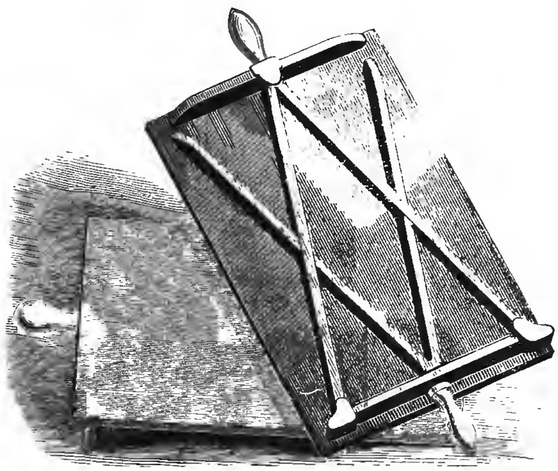
The manner in which this dock operates may be seen almost at a glance, and in giving a description of it, we think we cannot do better than avail ourselves of a paper read by Mr. Latimer Clark before the Institution of Naval Architects of England, on a large special dock of this form which his firm have recently constructed at their works on the Thames and are now erecting at Nicolaieff on the Black Sea for the accommodation of the circular and other ironclads of the Russian Government. From this paper we make copious extracts.

The Depository Dock differs from any other that is known, either constructed or designed, in that it not only raises vessels out of the water, but, when required, deposits them high and dry on fixed stages of open pile work, where they may be cleaned or repaired at leisure. In its usual form it is adapted to vessels of the ordinary type, but it can be readily altered to receive vessels of any kind, or dock circular ironclads of whatever size.

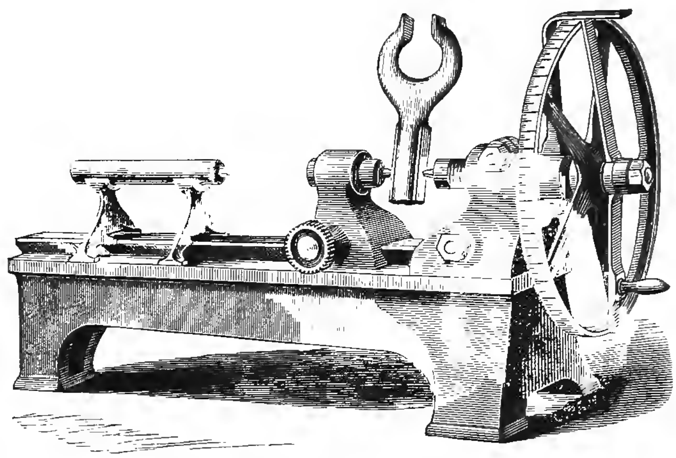


Patent Bobbin Winding Machine: Thomas Wood.

Fig. 1, on page 167, gives a general view of a dock of this kind in the act of moving a vessel on to the fixed stage on which there are already several vessels under repairs. In its general form the dock consists of a number of pontoons, either of square or circular section, which lie parallel to each other at fixed distances apart and range transversely to the length of the dock, each of these pontoons being permanently connected at one end to a longitudinal structure, which forms the main side of the dock, and projecting outwards from it, in the same way as the fingers of the hand,—the whole structure in plan resembling a comb. When the dock is lowered to receive a vessel, the pontoons are submerged, but the side to which they are attached is never placed entirely under water, there being left a sufficient height to allow a freeboard of six or seven feet, when the pontoons are sunk beneath the bottom of the vessel. When the dock is raised, the tops of the pontoons are well above the water and the side stands several feet higher than the deck of the vessel which is being supported. Fig. 2, on page 169, gives a plan of the dock, A, A; A, being the side and B, B, B, the pontoons, Fig. 3, on page 169, shows an elevation submerged, having an outrigger attached and ready to raise a vessel, and Fig. 4, on page 169, is the same, as raised and floating on the water with the vessel. The form of elevation without the outrigger resembles the letter L. It is evident that such a form as this, viz., a dock with only one side to it, would be entirely unstable when submerged, unless the necessary stability were imparted to it by some such means as is accomplished by the outrigger. This outrigger consists of a broad flat pontoon, divided into numerous compartments and loaded with concrete ballast until half submerged. Its form gives it immense stability and it carries along its middle line a row of rigid upright columns, which project through the pontoon some distance above and below, and are stiffened by struts; the top and bottom of each column being hinged to a pair of parallel bars or booms C, C, which are also hinged at their opposite



Standard Surface Plates: Cornell University



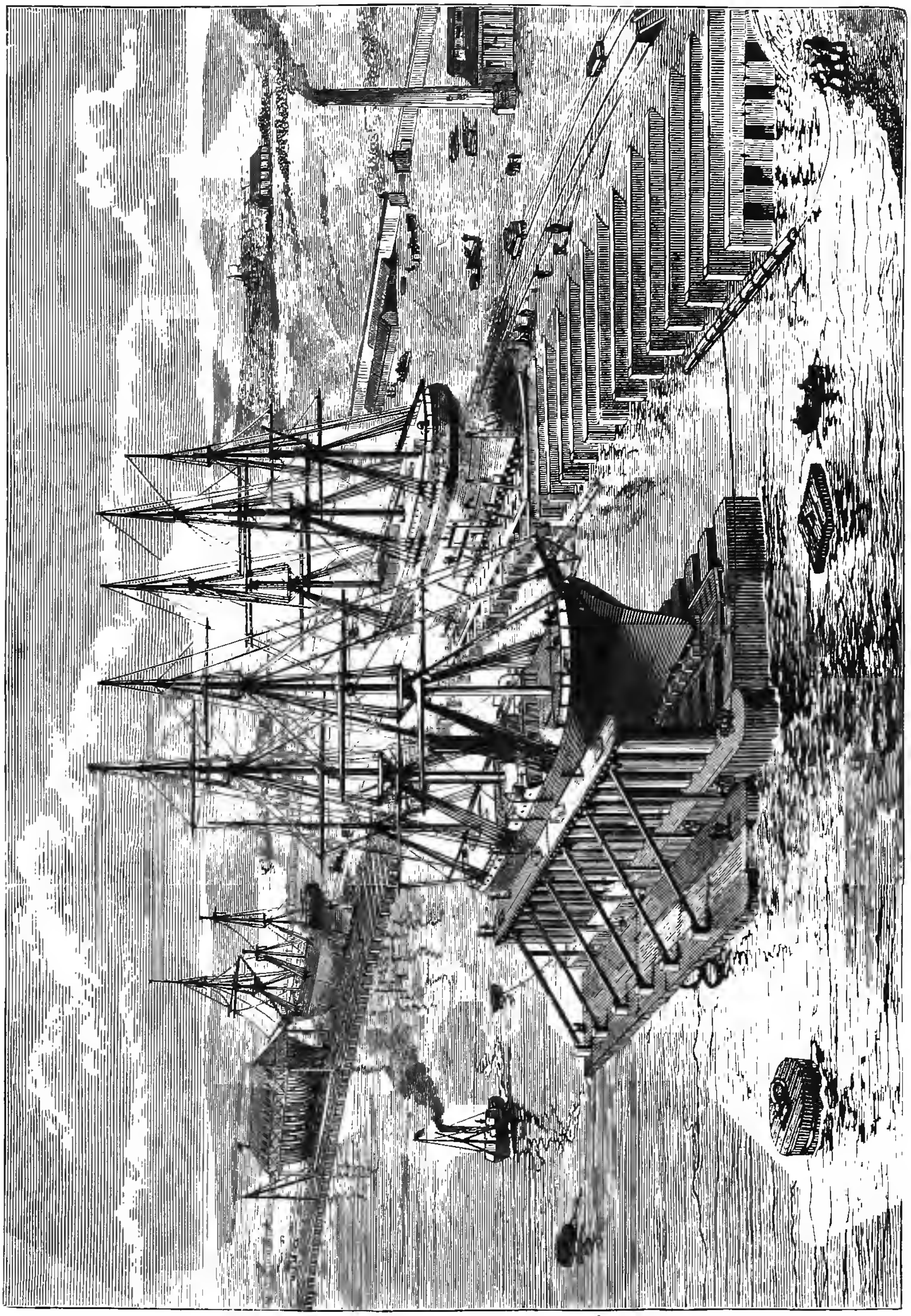
Measuring Machine: Cornell University.

ends to the sides of the dock, so that the outrigger remains stationary, while the dock is free to be raised and lowered vertically, the action of the parallel bars always retaining it in a horizontal position.

Each of the fingers or pontoons is usually divided into about six separate compartments, by means of five transverse vertical bulkheads, and the side of the dock to which the pontoons are attached is formed of a series of parallel, vertical columns, as shown, or is made as a long box girder, divided by numerous bulkheads into large water-tight chambers. Its height may vary from twenty to fifty feet or more, its width from ten to fifteen feet, and its length is made about equal to that of the longest vessel intended to be docked. The pontoons are made about twice the length of the beam of the largest vessel, so as to be available for paddle-steamers; their height is from ten to twenty feet, depending on the buoyancy required, and their width from seven to fifteen feet.

The machinery for working the dock is carried in the vertical columns or in the chambers of the side, as the case may be, and consists of a number of powerful pumps worked in the usual manner. When it is desired to submerge the dock, the necessary valves are opened, and water admitted to the compartments of the pontoons, thus gradually lowering it to the required depth, its horizontal position being at all times maintained by its connection with the outrigger. The vessel is then floated over the pontoons, the water pumped out until the keel takes its bearing on the blocks; the bilge-blocks are hauled into place by chains in the usual manner, and the vessel being firmly blocked and shored, the pumping is continued until the whole is raised to the full height required, and the valves are then closed. It will be seen that the dock in this position, with the ship on it, has very great stability, quite independent of the outrigger, which, having performed its duty of controlling the dock when submerged, is no longer of service, and may be entirely removed if desired, as seen in Fig. 5. Without it the dock is much narrower than any other form of dock, and can with great facility be floated through very narrow entrances or channels. The vessel can now be examined, repaired and painted as in any ordinary dock, or may be moved from place to place.

The great feature of this system consists in the fact that the vessel may be easily lowered on to a fixed staging along the shore, and deposited high and dry as seen in Fig. 6, leaving the dock free to raise or lower another



Gridiron Stage Depositing **Dock** *: Clark & Standfield.*

vessel, or any number of them, one after the other. This staging consists of a series of piles driven into the ground in rows parallel to each other, and at right angles to the shore, which are capped by horizontal timbers and placed exactly the same distance apart, centre to centre, as the pontoons. (See Figs. 2 and 6.) The height of the vessel above the water is greater than the height of the staging, so that when the dock with the vessel on it is brought alongside the staging, the pontoons can enter freely between the rows of piles, the vessel being carried directly over the staging without touching it. The dock is now slightly lowered by admitting water into the pontoons, until the vessel rests upon the keel-blocks on the fixed staging, when bilge-blocks are placed under the bilges, and the vessel securely shored, the dock being then lowered a little more to clear everything, and finally drawn out from the staging, free for use again to receive other vessels. The vessels may be removed again into the water by reversing the process.

In viewing the question of the stability of this dock during its operations, it is essential to consider it as consisting of two very distinct portions—the side and the pontoons—the latter taking no part whatever in the raising or supporting of the vessel, but simply giving stability during submersion. It must be clearly understood that the lifting power is applied solely and wholly in the pontoons directly beneath the vessel, and not in the side, the pontoons being provided with a certain number of hermetically-sealed chambers, into which the water cannot enter, and which are sufficient at all times to give them a surplus of buoyancy, so that they can only be submerged by forcing them down by the weight of the side, water being pumped into the latter to carry them down. Similarly, in raising the dock, the water is pumped only out of the pontoons, that in the side flowing out by gravity, and the lifting power comes from the pontoons alone, the dock having no tendency to turn one way or the other. Some power is necessary, however, to keep the dock horizontal in all stages of submersion, and this is furnished by the outrigger, which gives a stability of several hundred tons, although, with ordinary management, not more than a ton or two of this should ever be brought into action. The valve-engineer is provided with a spirit-level, and if the dock shows the slightest tendency to depart from the horizontal, he adjusts his valves or shuts off the pumps so as to make the proper correction. There are more than one hundred water compartments connected with the pumps by separate pipes, each pipe with its own valve, and all are brought to the valve-house and divided into four groups, corresponding with the four quarters of the dock, each of which is governed by a principal valve, thus enabling the action to be controlled throughout with the greatest ease.

In docking ordinary vessels it is not absolutely necessary to make use of

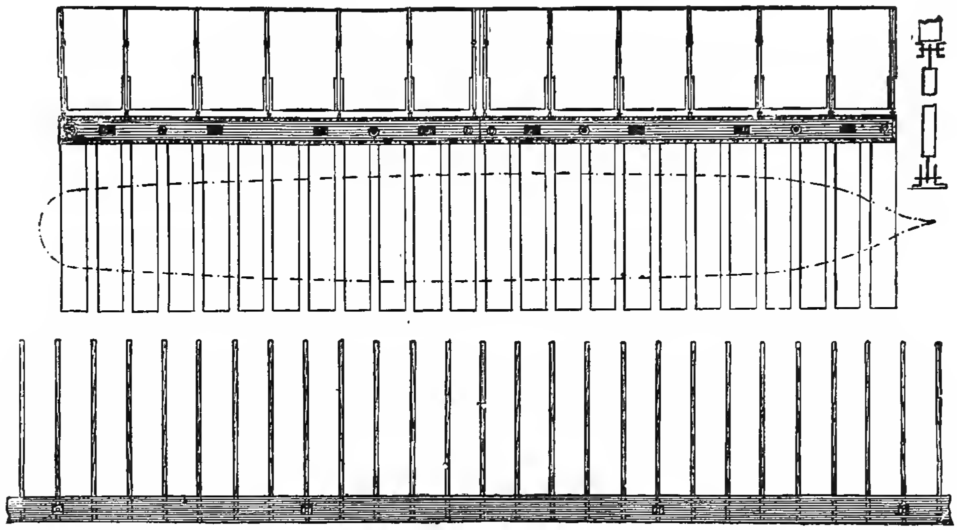


Fig. 2.

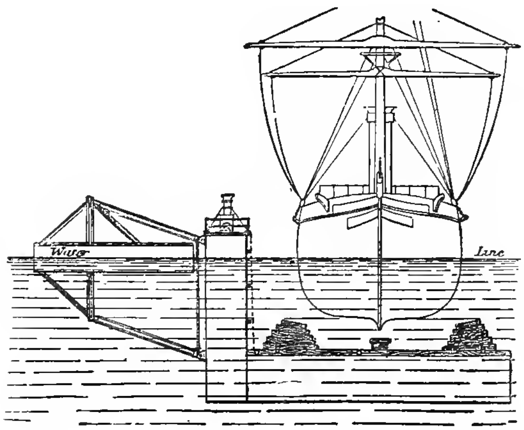


Fig. 3.

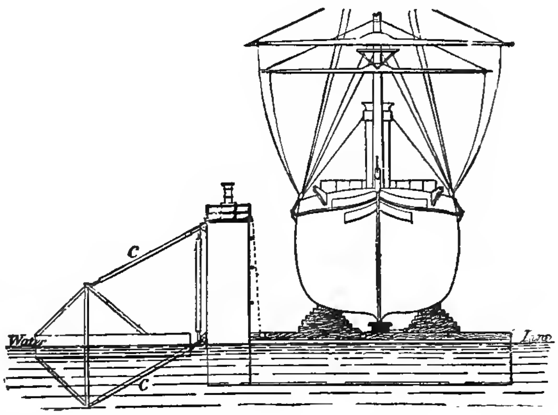


Fig. 4.

Clark & Standfield's Gridiron Stage Depositing Dock.

cradles, although they may be employed with advantage in many cases. These cradles may either have side shoring frames, as in Fig. 5, or may consist only of a platform of longitudinal iron girders, stiffened transversely and provided with the usual keel- and bilge-blocks. In either case, the cradle and vessel are lifted bodily and deposited on the staging together, to be removed again in the same way. There must evidently be sufficient depth of water at the particular spot where the vessel is raised to allow the dock to be lowered to receive it over the blocking; but when docked, only a depth somewhat less than the height of the pontoons is required, and the whole may be floated into shallow water or wherever the staging is fixed, the latter being of indefinite length to suit the requirements of the port.

The Depositing Dock is usually designed in two equal parts, each of which is capable of readily docking the other for purposes of cleaning and repairs, or of being used as a smaller but complete dock. Fig. 2 shows these parts

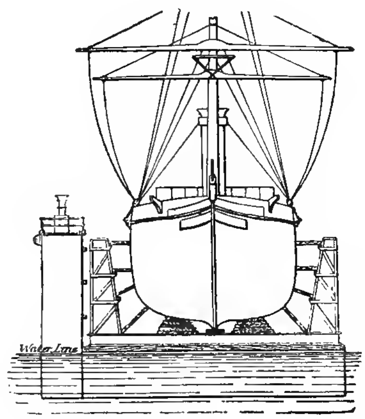


Fig. 5.

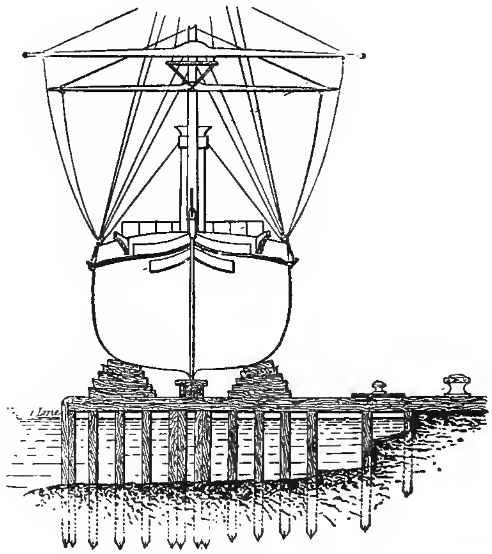


Fig. 6.

Clark & Standfield's Gridiron Stage Depositing Dock.

connected to receive a vessel of ordinary form, and Fig. 7 represents them as arranged for a circular iron-clad; Fig. 8 showing the same with one side and its outrigger removed preparatory to depositing the circular vessel on the staging. The size of the dock may be increased with great facility whenever the growing trade of the port renders it necessary, by simply adding a third section in the centre, without any alteration of the existing portion, and at an expense not exceeding what would have been incurred if made the full size at first. This constitutes an important advantage over other forms of docks. The dock possesses great economy of first cost and working, requiring no fixed foundations, and being easily removed from place to place. It is very much quicker in its operations than an ordinary graving dock, as in the latter the whole space of the dock requires to be pumped dry, while in this only a weight of water equal to that of the vessel has to be raised, and that through a smaller height. The heaviest vessel can, if necessary, be raised in a little more than an hour. With this dock vessels can also be transported over shallows, and railway trains may be taken across ferries from one side of a river or lake to the other. The complete train is run on to a cradle resting on the

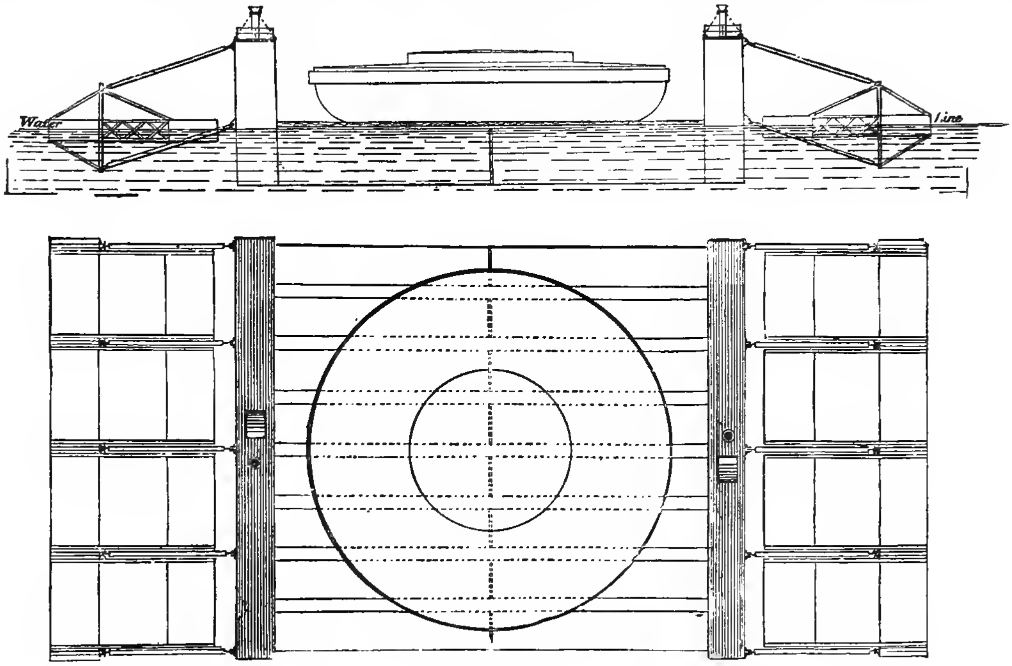


Fig. 7.

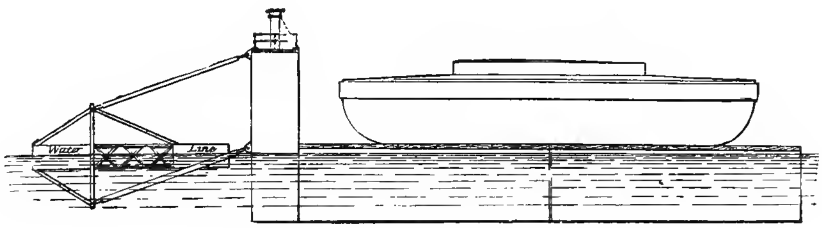


Fig. 8.

Clark & Standfield's Gridiron Stage Depositing Dock.

piles, and then lifted away by the dock, which is provided with false bows and fitted with propellers, and carries the whole across to a similar staging on the opposite shore.

The advantages claimed for this dock may be summed up as follows, and are thus stated by Mr. Clark:—

"1. With one dock any number of vessels can be docked and deposited high and dry out of water on wooden platforms, in a convenient position for cleaning and repairs, along the waste sloping shores of a river or wet dock.

"2. The provision for an additional length of staging at a comparatively nominal cost is equivalent to the building of an additional dock.

"3. As the dock is used ordinarily for lifting vessels on and off the stages, it can be kept at all times ready to receive disabled or other vessels, which can be at once deposited on a stage, and the dock left free for further use. In this respect it has a great advantage over all other descriptions of graving docks.

"4. A vessel can be placed upon the staging, cut in two, and lengthened by lifting one-half further along the staging by means of the dock.

"5. Vessels can be conveniently built on these stages on an even keel, and launched without the slightest strain, and without the risk and cost of launching, and without occupying the space required for the formation of ordinary ship-ways.

"6. Vessels, when on the dock or stages, are thoroughly exposed to the action of sun and wind, allowing paint to dry and harden rapidly, and affording great facility for examination and repairs.

"7. The dock, with or without a vessel, may be readily transported from place to place, for the purpose of raising or depositing vessels at different points.

"8. The dock will not, under any circumstances, sink, even if all its valves be intentionally left open.

"9. One-half of the dock can be readily raised level upon the other half for the purpose of cleaning or repairs.

"10. By the use of air, which may be stored in some of the chambers under compression, a vessel may be raised, sighted and lowered again in less than an hour.

"11. These docks, if constructed in the first instance too small for the requirements of trade, can be at any time enlarged to any extent at the same rate per ton as the original cost.

"12. The docks are capable of receiving vessels of any size or length, or of a width too great to pass through ordinary dock-gates—such, for example, as circular iron-clads of one hundred or one hundred and fifty feet in diameter.

"The durability of vessels laid up high and dry on the stages would be immensely increased, and at a few hours' notice a whole fleet might be lowered into the water."

Before the Nicolaieff dock was built, the largest dock-entrances in existence did not exceed one hundred feet, and it is believed that no entrance so wide as one hundred and twenty feet had hitherto been proposed. Circular iron-clads were designed in the Russian navy, however, up to one hundred and sixty feet in diameter, and even larger vessels talked of, and the want of some method of docking such vessels was one of the most serious difficulties to be overcome in connection with the introduction of these circular war-vessels.

Messrs. Clark & Standfield's plan, it is seen, met the point, and the Nicolaieff dock was designed under the supervision of Admiral Popoff, who made numerous modifications to meet the special requirements of his Government, the construction being commenced in January, 1876. It agrees with the general description we have given. Its side is two hundred and eighty feet long, forty-four feet six inches high, and twelve feet broad; the pontoons are seventy-two feet long by eighteen feet deep, and fifteen feet broad, and the clear space between them is five feet. For special reasons it has been made so as to divide into three lengths—two of one hundred feet, and the centre one of eighty feet—each furnished with its outrigger and complete in itself, having separate engine-rooms, engines, pumps, and valves. The pontoons, instead of being permanently fixed to the side of the dock, are made easily removable and mutually interchangeable. They can also be connected end to end, so as to increase the width of the dock to any extent. No divers are required in making these connections. Each pontoon is divided into six compartments by upright bulkheads, and the four central compartments are again divided by horizontal bulkheads into upper and lower chambers, the upper chambers being hermetically closed, so that when all the other compartments are filled with water, the pontoon alone will float perfectly level, with its deck a little above the water surface. The Nicolaieff dock will raise a vessel of four thousand tons in a little more than an hour.

It is hardly necessary for the general reader, to enter further into the details of construction and working of one of these docks, or to describe the excellent arrangements for controlling the buoyancy of the pontoons or fingers to any extent that may be desired. We would refer, for fuller description, to the "Transactions of the Institution of Naval Architects, London, 1876."

Messrs. Clark & Standfield have also in the Exhibition a working-model of a Floating Dock of the ordinary form, but without closed ends, which they call the Tubular Dock. Its great peculiarity consists in its being constructed entirely of cylindrical tubes, making it unsinkable, very strong and capable of standing rough weather, while at the same time very light and easily transported from port to port. It can be furnished with pontoons, on which vessels may be lifted within the dock and then floated away, quite clear of the water, to any convenient place for repairs, etc. Pontoons of different sizes may also be added at any time, each pontoon being of course equal in working efficiency to an additional dock.

The American Bridge Company, of Chicago, Illinois, makes a handsome, exhibit in Machinery Hall, the most prominent feature of which is an exceedingly complete and beautiful model of the new Point Bridge, now being erected by this Company across the mouth of the Monongahela River at Pittsburgh, Pa., from designs prepared by Mr. Edward Hemberle, the Company's engineer.

The bridge is constructed on a stiffened chain suspension principle, the design of which is believed to be novel. It very much resembles at first sight that adopted by Mr. T. Claxton Fidler, of Great Britain, for suspension-bridges, but on closer examination will be found to differ from it quite essentially. Various plans have been suggested to stiffen a suspension chain independent of the roadway trusses, and some methods have been put into practical use. These systems all consist of two suspended chains or members with stiffening bracing between them. In one case the chains are hung parallel to each other; in another, the lower chain is hung to a catenary line, the upper chain meeting it at the towers and at the centre of suspension, and the parts between being bulged out on a contrary curve, so as to form two lozenge-shaped figures. The latter is Captain James B. Eads' St. Louis plan reversed. In yet another case, Mr. Fidler's plan, the upper and lower cables meet at the towers and at the centre of suspension, these points being in the catenary line, while from the centre of suspension either way to the towers the upper cable is straight, and the lower cable is hung so as to fall below the catenary line, its maximum distance below being the same as the upper cable is above the catenary. In

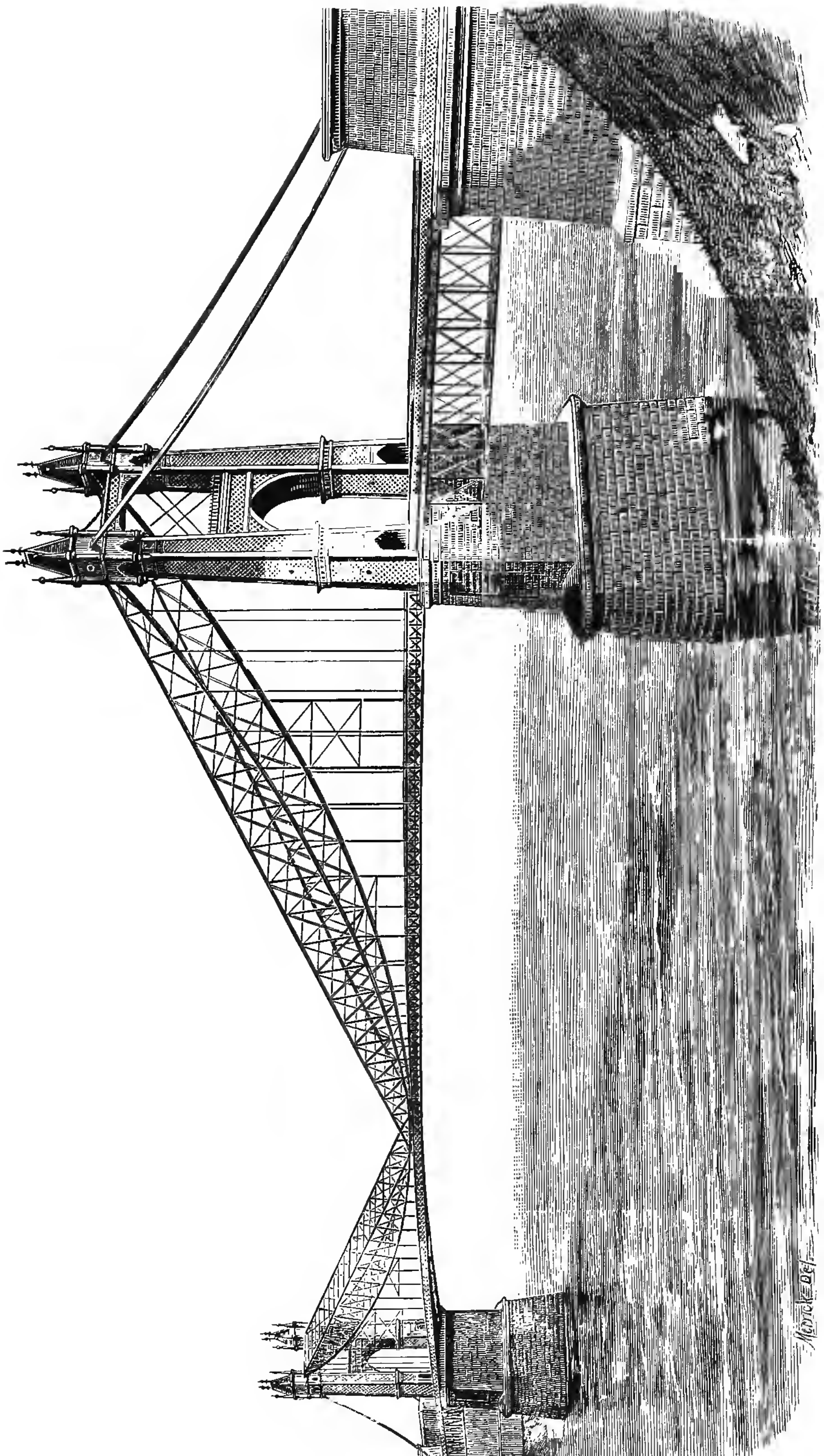


Fig. 1.—Point Bridge, Pittsburgh: American Bridge Co.

Mr. Hemberle's plan, as adopted at the Point Bridge, the lower cable is hung in the catenary curve, the same as in Captain Eads' plan, while the upper cable forms two straight lines as in Mr. Fidler's arrangement.

The system of two parallel chains possesses many disadvantages, and theoretical investigations would suggest Mr. Fidler's plan as the most advantageous and economical, the catenary line passing through the centre of the truss, and the top and bottom cables or chords remaining always in tension, under all conditions of loading, and assisting each other in carrying the full load. In Captain Eads' and Mr. Hemberle's systems, the lower cable forming the catenary line carries entirely the equally distributed load, the upper members being only of service in resisting the tendency to change of form in the curve of the cable from the action of the moving load, and being subjected to strains varying from tension to compression, depending on the location of this load. From investigations made by the AMERICAN BRIDGE COMPANY in reference to these three systems as applied to the Point Bridge, taking a permanent weight of about three thousand pounds and a moving load of sixteen hundred pounds per lineal foot, and an equal factor of safety for both loads, it is claimed that while Mr. Fidler's plan saves material in the chord members, both being subjected to tension only, and assisting each other in carrying the uniform load, it requires long bracing members; and as neither upper or lower cables are self-supporting in their proper curves, the erection becomes difficult under circumstances where false works cannot be readily employed; also that while in Captain Eads' plan the lower member, designed as a catenary chain, can be erected from cables and is self-supporting in its proper position, thus giving facilities for building the balance of the structure, still the top members do not add to the strength for equally distributed load, and are subjected to compressive as well as tensive strains, having also unpracticable shape and dimensions, and necessitating long bracing members. In Mr. Hemberle's plan, however, although the upper members do not add to the strength for equally distributed loads, and have to resist both compression and tension under various conditions of load, still it possesses the same advantages for erection as in Captain Eads' plan, and at the same time affords a more practicable shape and sectional area in the upper members for good cheap workmanship and for the purpose of insuring stiffness, giving bracing between them and the lower member of only about one-half the length required in the other systems. These are the reasons given for the adoption of this plan for the Point Bridge by this Company. It should be remembered, in this connection, that the adopted plan gives only one-half the effective depth for stiffness that is obtained in the other systems. It may be found, however, to work out better practically even with this disadvantage.

The structure consists of three spans, the main span being eight hundred feet from centre to centre of piers, with a clear elevation of eighty feet above low water at the mid channel of the river, and the two side spans one hundred and forty-five feet each, placed on a grade of three and four-tenths feet per hundred, and constructed as iron trusses entirely independent of any connection with the back chains from the cables supporting the channel span. This arrangement gave the advantage of allowing the back chains to be shortened, and thereby reducing the total length of bridge, and the side spans proved of great service as false works for the erection of the back chains, allowing free waterway below for floating ice and barges during high water. The height of the towers above low water is one hundred and eighty feet, and the deflection of the main cable eighty-eight feet. The roadway is twenty feet wide, with double tramways and one track for a narrow-gauge railway, having, in addition, two outside footwalks of six feet each. The piers for the towers and the abutments and anchorages are founded upon timber platforms sunk to a gravel bed. The towers are constructed entirely of wrought iron, except the bases of the columns, and are built up of eight columns each, four columns braced together for supporting each chain, each column being two feet square, and having a sectional area of sixty-four square inches at the base, and fifty-four square inches at the top. The caps are formed of two box-girders five feet in depth, each resting on two columns, and having on top, across from one girder to the other, five box girders seventeen inches deep, on which steel plates are placed to form a bed for eighteen steel rollers, four and three-eighths inches in diameter and fifty-one inches long. On top of the rollers rest other steel plates, and on these are placed the saddles, consisting of twelve wrought-iron plates twenty-six inches wide and two inches thick, the connection with chain-links being made with pins six inches in diameter.

The chain-links are twenty feet six inches long, centre to centre of pins, the latter being six inches in diameter, and the links are two by eight inches in section, except where they bring only a single shear on the pins, when they are made one by eight inches. The width of heads is sixteen inches. The back chains have each twelve links of two by eight inches section, or eleven of two by eight inches, and two of one by eight inches, the sets of links thus alternating from twelve to thirteen in a set. Each back chain has therefore a sectional area of one hundred and ninety-two square inches. The anchor-plates are of cast iron, eight by ten feet area, and the connection is made with the back chain by a six-inch pin. The main chains are composed of fourteen and eleven links in a set alternately, the sectional area decreasing towards the centre. The top chords of the stiffening-truss are composed of channels and plates, forming a rectangular section twenty two inches wide by thirteen inches deep, with full tension splices. The top and centre joint connections are made by forged bars twelve inches wide, with a head on one end, and the other end riveted to the chord. The last section of the top chord is not put in until the whole bridge is finished, so as to insure correct length, and the condition that the stiffening-trusses have no strains from dead weight. The posts of the trusses are made of I beams and plates, and all tie-rods are

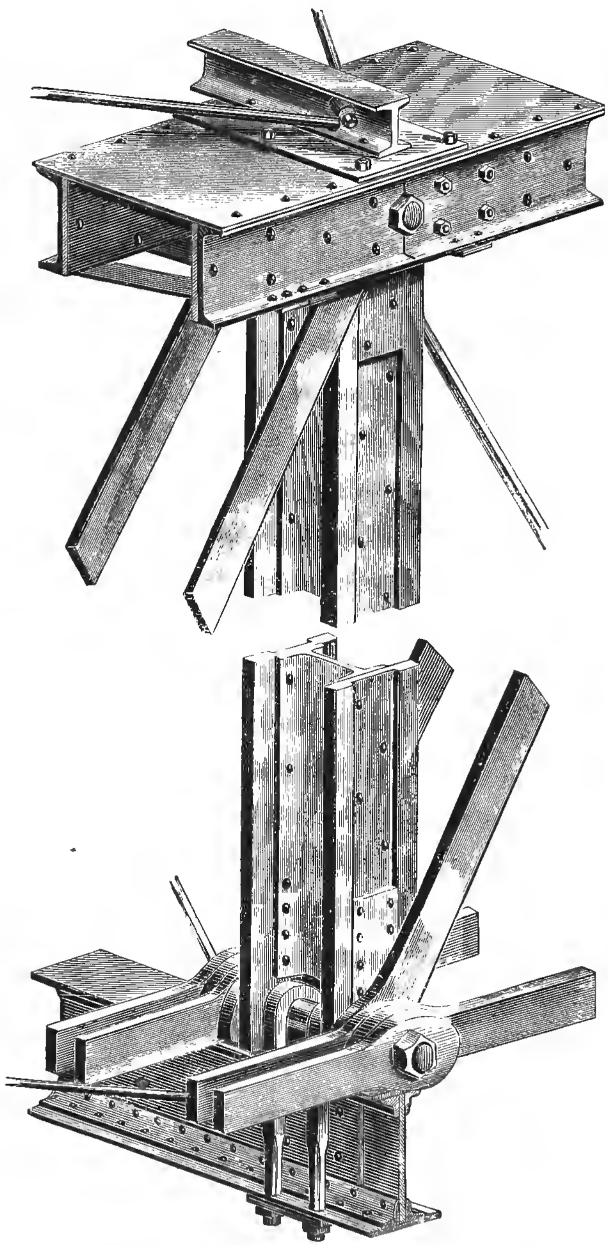


Fig. 2.—Point Bridge, Pittsburgh: American Bridge Co.

adjustable. Our engraving, Fig. 1, shows the general character of the structure and the system of trussing adopted between the upper and lower cables, the details of which are given in Fig. 2. Lateral and diagonal bracing is provided between the top chords and also between the chains, proportioned so as to resist the effects of wind-pressure.

The roadway girders are eight feet high, and form a hand-railing. They

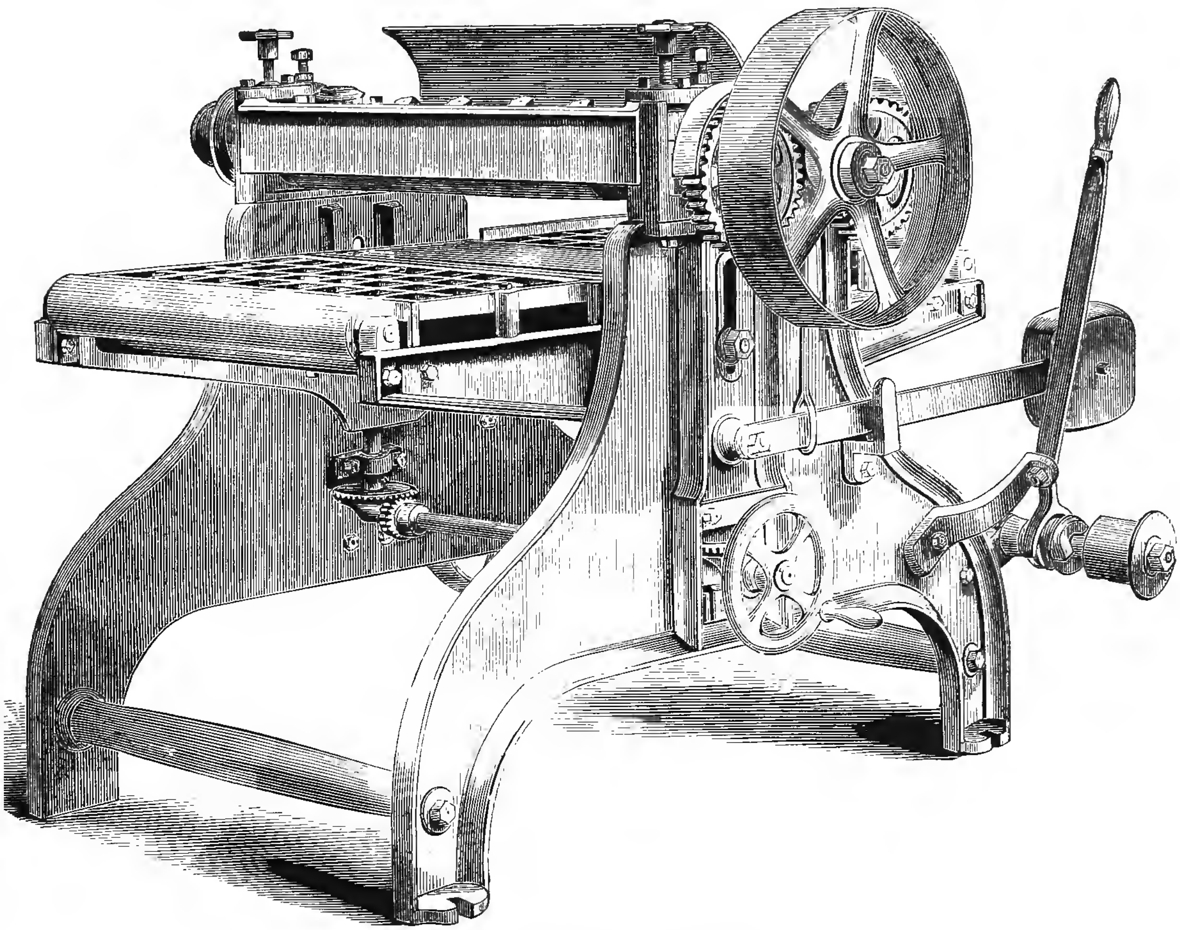


Fig. 1.—Pony Planer: Goodell & Waters.

have expansion-joints every hundred feet, and are suspended from the chains by flat bars at distances of twenty feet apart, struts being used at the expansion-joints to form rigid connections at these places. Cross-girders, three feet in depth, connect the stiffening-girders at intervals of twenty feet, and support two lines of iron stringers, wooden joists being placed on this iron system to carry the flooring. A double system of tie-rods secures lateral stiffness to the floor, and the wind-pressure is taken up by horizontal steel-wire cables placed underneath and secured to the floor.

The bridge is designed for a moving load of fifty pounds per square foot of flooring for the trusses, towers and chains, and for seventy pounds per square foot for the floor system and suspenders. The maximum stresses allowed are six tons per square inch in the main chains, four and one-half tons in the towers, five tons in the suspenders, and six tons for tension and five tons for compression in the upper chords. In erecting the structure, the main chains were raised from false cables, the links being brought into position by a traveling platform, and one chain was raised at a time. The cables were then shifted to the other side, and the second chain, weighing about three hundred and twenty tons, was completed in thirty working-hours. The balance of the bridge is being raised from the chains, the roadway is completed, and it is expected to have it ready for traffic by March 1, 1877. The total cost will amount to five hundred thousand dollars.

Wood planing machines may be divided into three classes—carriage-planing, parallel-planing and surface-planing machines. In the first class the lumber to be planed is fixed to carriages, which move on guides or rails entirely independent of the lumber itself, either as to its surface or its shape, and the cutting operation is usually performed by means of traversing heads, which revolve in an axis perpendicular to the surface being dressed, although this is not necessarily the method, as cross cylinders, running on an axis parallel to the surface planed, are also used. In the second class the lumber passes through feeding-rollers, which move it continuously between stationary guides and cutters arranged on a cross cylinder revolving in an axis parallel to the surface planed. It is evident that there may be one or more of these cylinders, making one or more cuts of the lumber at one operation if desired, they being set to different gauges. The operation of the machine reduces the lumber to a uniform thickness, or to thickness and width at the same time if required. In the third class a constant gauged amount of material is cut away from the surface of the lumber every time it is passed through the machine, without reference to a reduction to uniform thickness, the principle of action being the same as in the ordinary carpenters' plane, either revolving or stationary cutters being used in a fixed bed, and gauged above the surface of the bed by the amount of the cut.

Machines of the first class are the only ones that can be depended upon to produce material out of wind, and to always plane perfectly true. They require, however, a large amount of space, equal to double the length of the material to be worked, and are very slow in their action, the latter defect however being doubtless capable of much improvement by the use of revolving cross cylinders and improved methods of action. The second class is by far the most important of the three, and comprises at least ninety per cent. of all the machines used for planing in this country, including within its province the extensive list of moulding-machines. For planing and matching of boards, plank and all material that can be bent or sprung into a straight surface, the machines of this class have no equal either in speed or efficiency. Lumber may be dressed by them on one, two, three or four sides all at one operation. Machines of the third class

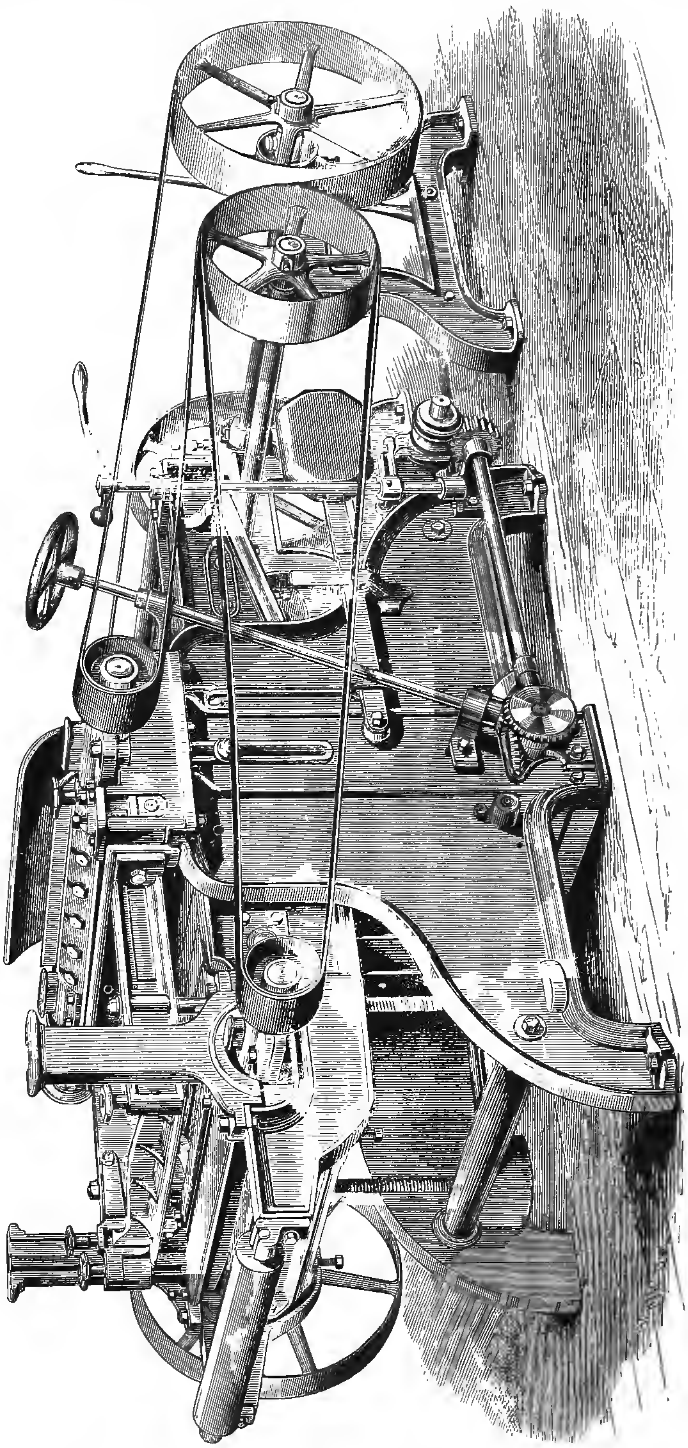


Fig. 2.—Endless-Bed Double Surfacer : Goodell & Waters.

might more properly be designated as smoothing-machines, and are of very limited application, although very useful in the special work for which they are adapted. It will be noticed that when machines of the second class plane on four sides at one time, the operation of the machine for two of these sides must be after the system of those of the third class.

MESSRS. GOODELL & WATERS, OF PHILADELPHIA, make an extensive exhibit of wood-working machinery, and we desire to call attention to some of their planing machines belonging to the class of parallel-planers. Fig. 1 illustrates their IMPROVED PONY PLANER, a machine designed especially for the use of carpenters, box-makers and those doing a general jobbing work, although it is a machine of great value for small work even in a regular planing-mill. It is readily adjustable to various thicknesses of lumber, is light running, starts up and stops quickly, and does the work for which it is intended better than is possible with a large and fast-feeding machine, and generally in about the same length of time. It is a strong, well-built machine, taking up but little room, has a capacity for material up to twenty-four inches in width, and from one-eighth to four inches in thickness, and may be run at a high rate of speed, feeding from thirty to thirty-five running-feet per minute. The cylinder is of steel, five inches in diameter, and carries two knives. It is moved at a velocity of from four thousand to four thousand five hundred revolutions per minute. Special machines with some slight modifications are made for cigar-box work and also for carriage-makers' use. These last machines will plane smoothly down to one-sixteenth inch in thickness without tearing up or clipping the ends of the lumber, and will work equally well on hard or soft wood. The counter-shaft used with these machines has tight and loose pulleys ten inches in diameter and six inches face. The driving-pulley for cylinder is twenty inches in diameter, with four inches face, and the counter-shaft should make from one thousand to eleven hundred and twenty-five revolutions per minute. These machines weigh from thirteen to fourteen hundred pounds.

Fig. 2 shows this firm's heavy ENDLESS-BED DOUBLE SURFACING MACHINE, which has recently been constructed from entirely new designs for the express purpose of correcting, if possible, every known defect in this class of machines. Endless-bed planers, when properly constructed, have been admitted for a long time to be the strongest and fastest feeding-machines known, and, taking the first cost into consideration, also the most economical for the user. The cylinders of this machine are both made entirely of steel, and have long heavy bearings running in the best Babbit metal boxes. The upper cylinder pressure-bar and pressure feed-rolls are mounted in one heavy casting firmly bolted to the sides of the machine, and the boxes of the lower cylinder are also tied together by means of a heavy yoke, so that the cylinder may be raised or lowered without the possibility of twisting or binding the boxes. The raising or lowering of the bed is accomplished either by hand or power, and the power arrangement is very simple and easily operated, consisting of a worm and gear, the worm, which is right and left, being fixed on the end of the feed-shaft and arranged to work endwise

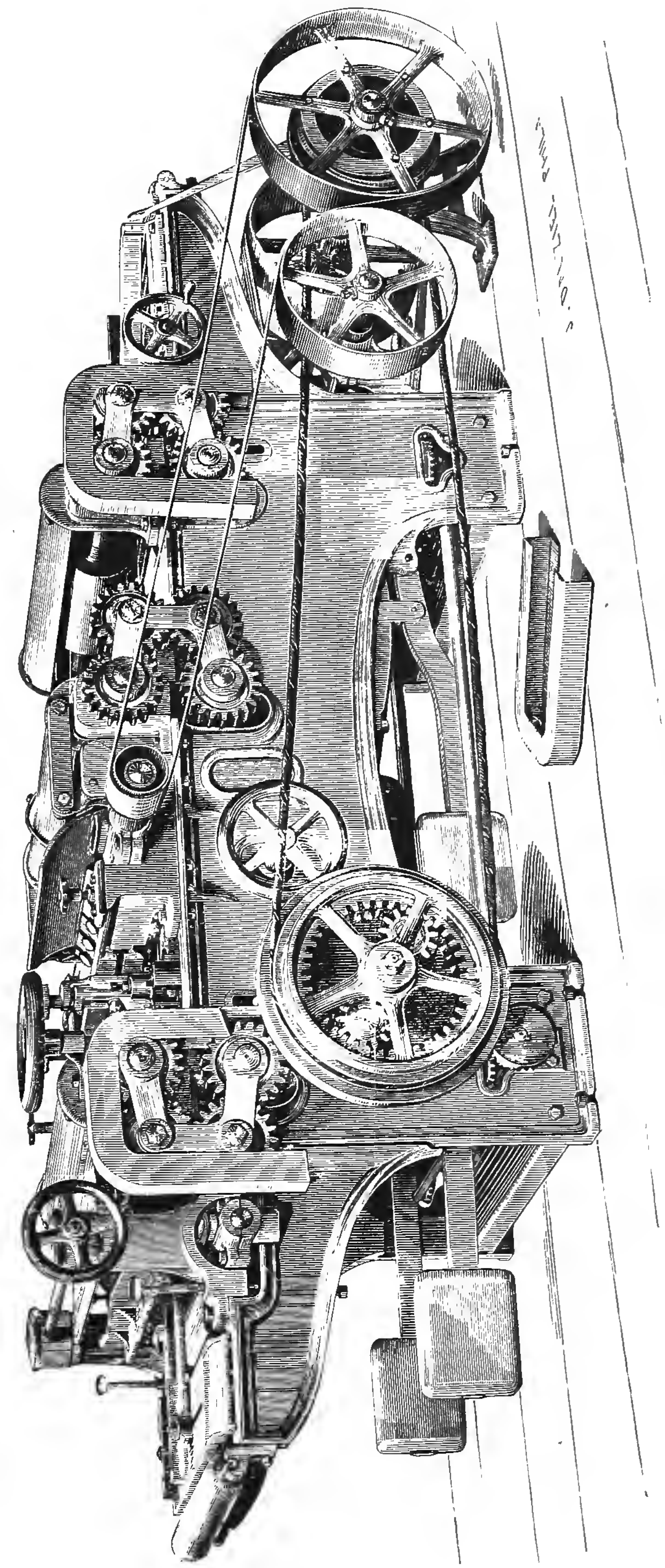


Fig. 3.—Double Surfacer and Matcher: Goodell & Waters.

on a spline, so that the operator may throw the right- or left-hand worm into gear at will, moving the bed up or down as desired. The lever for power-movement and the hand-wheel for hand-movement are both conveniently arranged above the bed of the machine and near the scale for indicating the thickness to which the lumber works. The plats of the traveling-bed are very heavy, and are connected by means of a butt-hinge joint, the centre of which is under the centre or opening between the plats. This carries the plats away from the lumber as the bed turns down over the carrying-wheel at the end, and does not allow them to raise or even press against the under side of the lumber, or give any interference with the work of the lower cylinder. When this style of connection is used, only one-half the number of joints occur in the whole bed as would obtain with the use of wrought-iron links. The bed travels on four self-oiling ways—two at the extreme ends of the plats, and two in the middle, the combined width of these amounting to twelve inches. There is no liability of getting out of order or of wearing. The lower cylinder can be reached, if the cutters require sharpening or adjustment, by simply lifting out the front roll, one piece of the adjustable bed, and turning back the pressure-bar, the whole taking less than half a minute to accomplish, and rendering the cylinder as convenient of access as it would be on a bench. The weight of this machine is five thousand pounds.

Fig. 3 represents MESSRS. GOODELL & WATERS' DOUBLE SURFACER AND MATCHER, which is constructed by them in the usual variety of forms, to work two, three or four sides, either as a regular flooring-machine operating to a width of fourteen inches, or as a combined Surfacer and Matcher, with a surfacing capacity of twenty-six inches in width and four inches thick, according to the requirements of the customer.

The machine as illustrated is of an entirely new design, combining some important improvements over the old type. It is adjusted to different thicknesses of material by raising or lowering the bed by means of four heavy steel screws connected to and operated by the horizontal wheel shown near the last set of feed-rolls. It is claimed that several advantages are gained by this method of adjustment:—

1st. The time required to change the machine from one thickness to another is so much shorter than by any other arrangement as hardly to admit of comparison.

2d. The boxes of the upper cylinder can never get out of line, as they are both made in one heavy casting, firmly bolted to the sides of the machine, and forming a part of the permanent frame.

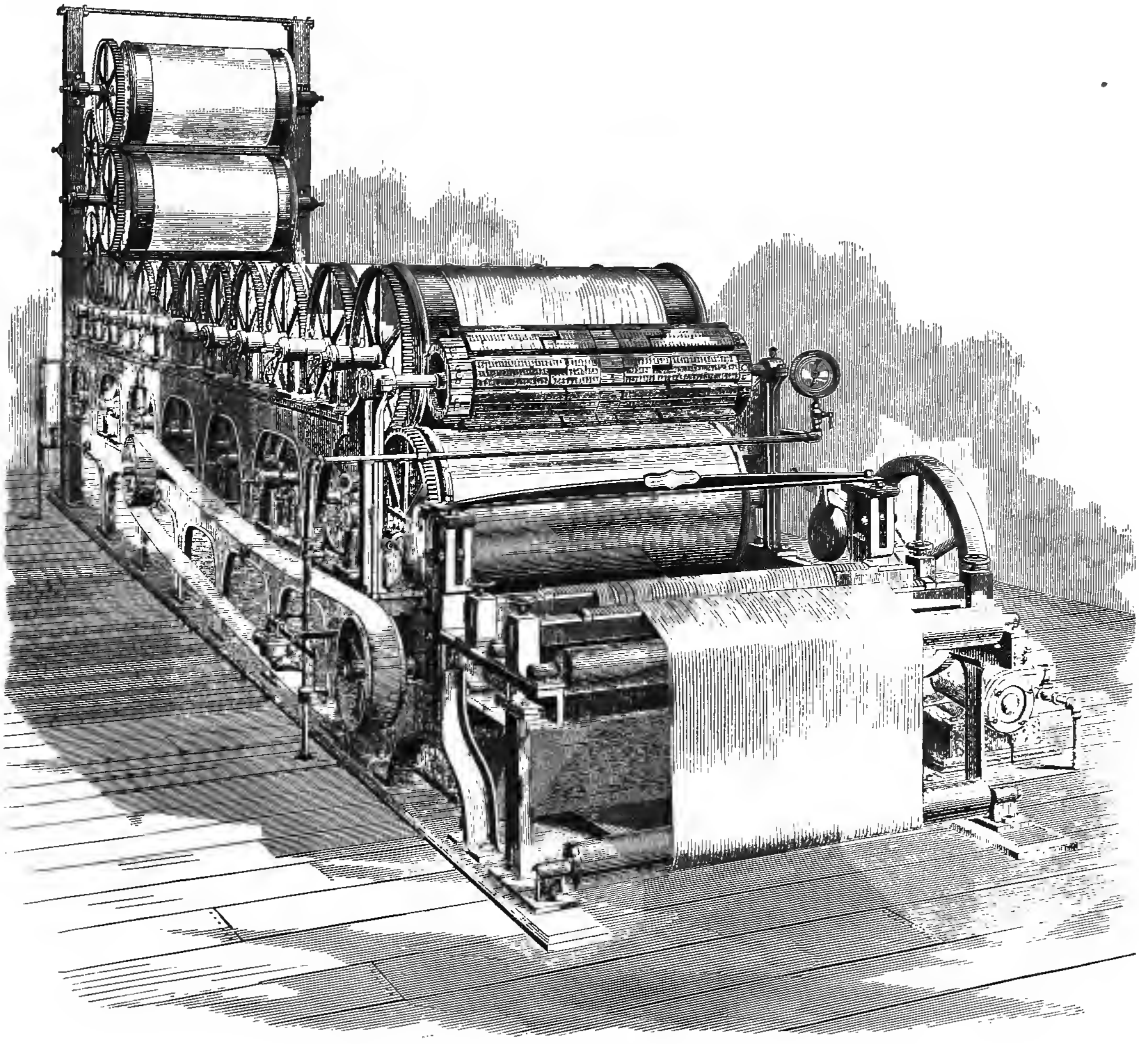
3d. The manner in which the feed-rolls can be weighted is very simple and effectual, requiring but a single rod of iron to make the connection between the weight-lever and the feed-roll boxes.

4th. The details of the machine are very much simplified; a less number of pieces are required in its construction, and there are no nuts or bolts to loosen in raising or lowering the bed, resulting in much less liability of derangement of parts; the height of the machine is less, making it much more solid and its members more easy of access; and finally, there is nothing on top of the machine which can become clogged with shavings or dust.

The manner of driving the feed-works merits special attention, being simple and very strong, enabling three grades of feed to be obtained in a space of only three and a half inches in width, and allowing a feed-belt of three-quarters of an inch in diameter, round, twisted or square, this size running very slack on three-cone pulleys, and giving ample power to feed the heaviest lumber. This great power is obtained by the use of planetary gearing shown inside of the feed-pulley, which increases the force four times, and gives to one small belt an effectiveness more than equal to a five-inch belt on the ordinary machine. This feed is stopped and started by means of an improved friction-clutch, which operates quickly without noise or jar, works freely, and does not readily get out of order. There are six seven-inch feed-rolls, the lower ones driven by a train of twenty-inch gearing, two and a half inches wide on the face, with a heavy and improved-shaped tooth, and the upper ones connected to the lower by heavy expansion gearing, making a very powerful feed. The cylinder- and matcher-heads are all made of steel, and run in self-oiling boxes. Tne upper cylinder has three knives, and is six inches in diameter, while the lower has two knives, and is five inches in diameter, both being fitted with beading-cutters which can be used or not as desired. The matcher-heads are six inches in diameter, with three knives, and the matcher-spindles are arranged to swing down below the surface of the bed, running in heavy hangers or castings, and supported by a three-inch screw. They will swing down out of the way by simply removing one bolt, and will be found very convenient on the combined machine. The machine is fitted with a good arrangement for holding the lumber to the guides, and is provided with all the pressure-bars, chip-breakers and other accessories necessary to make it complete in every respect. The counter-shaft has tight and loose pulleys twelve inches in diameter, eight inches in face, and should make eight hundred and fifty revolutions per minute. The weight of the machine is from six thousand to six thousand five hundred pounds.

In the various operations of making and printing cotton and worsted goods, it is very necessary to dry the material rapidly and evenly, and at the same time stretch or smooth it as in a process of ironing. For this purpose drying-machines are made in which steam is employed to heat rollers, around which the material to be dried is passed, and at the same time kept in a state of uniform tension.

MESSRS. H. W. BUTTERWORTH & SONS, OF PHILADELPHIA, have attained a high reputation for the manufacture of DRYING-MACHINES, and make an extensive exhibit in Machinery Hall of these and kindred appliances. The figure on page 187 represents one of their Drying-Machines such as are used for print-works, bleacheries and for drying cotton-warps and finishing tickings, osnaburgs, etc. This machine is arranged with twenty-four cylinders, supported by a framing, eighteen of them being on a horizontal and six on a vertical frame. The grouping of these cylinders in a horizontal, vertical or other direction may be modified to suit special requirements; and where the floor-space is contracted, the vertical arrangement is preferred. The frames of the machine are made of cast iron, being quite heavy in their construction, with broad planed surfaces, and hollow passages are cast in them for the transmission of the steam used in heating the cylinders and the return of the condensation, thus dispensing with outside pipes and connections. The steam passes into each cylinder and leaves it again by means of branch passages cast on to the frames and connecting with journals in which the axes of the cylinders run. The stuffing-boxes for the journals are packed from the front by an arrangement introduced by MESSRS. BUTTERWORTH & SONS in 1867, this packing, however, forming no part of the bearing. The advantages derived from this method consist—first, in the easy access given to the packing, which also lasts longer than in the ordinary arrangement; second, in an allowance of greater freedom for expansion of the cylinders than can be attained in any other way; and third, in furnishing an abundant length of bearing for the axles. This firm formerly packed the stuffing-boxes on the inner side, but this rendered them much more



Drying Machine: H. W. Butterworth & Sons, Philadelphia.

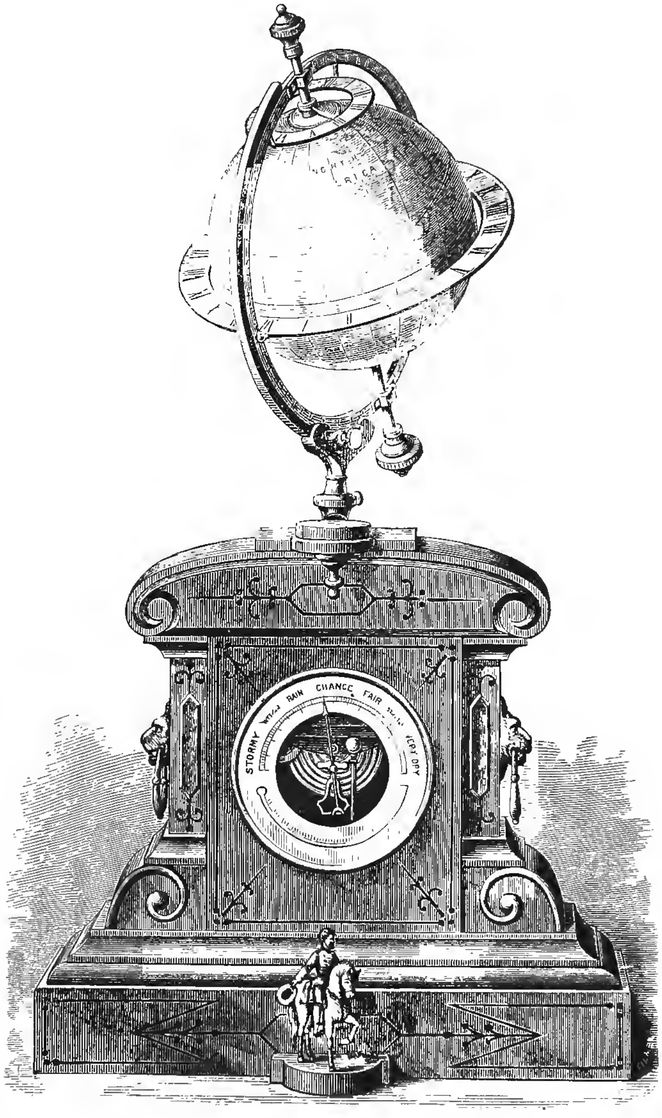
difficult of access, and at the same time there was a greater tendency for them to blow out with the steam pressure. The length of bearing also obtainable for the axles was much less. In drying-machines as usually constructed, the practice has been to introduce the steam to the cylinder by means of a steam-pipe connecting from the exterior through the end of the journal by a counter-sunk joint. This arrangement did not allow of free expansion and contraction of the cylinder, and caused the end of the journal to press against the end of the steam-pipe with more or less force, depending on the temperature to which it was raised, producing consequently more or less friction.

The cylinders of these machines are made either of copper or of planished tinned iron, more generally of the latter material, as it is the least expensive. Properly speaking, the material used for these cylinders is not "tinned," but is iron coated with a composition invented by Messrs. Butterworth & Sons, and especially adapted to resist the action of acids such as are used in print-works. Messrs. Butterworth & Sons are the only manufacturers of this material in this country. Motion is communicated from one cylinder to another by cast-iron gearing, seen very distinctly in the engraving. The cylinders are carefully made, but no special balancing is required such as is necessary in drying-machines for paper-making, the material to be dried in the present case being of much stronger texture.

In machines with wide cylinders, where more than one width of material is dried at the same time, the steam is so applied that each width is dried uniformly. A uniformity of temperature is maintained throughout the machine by allowing the steam to enter the top cylinder at one end, and the corresponding bottom cylinder at the other. The working pressure of the steam is usually from five to ten pounds per square inch, and it is controlled by a regulator manufactured by Messrs. Lock Brothers, of Salem, Massachusetts. The water of condensation is removed from the opposite end of the cylinder to that at which the steam enters, by means of Collins's Patent Trough, a device very extensively used in England, and quite effective in its operation, causing the water to pass out through the journal in a similar way to that by which the steam enters at the other end. The material to be dried, before entering around the cylinders, passes first through a "stretcher," made of brass, which prevents the edges from turning down, and smoothes out all wrinkles, delivering it perfectly even and regular. The tension of the fabric is controlled by passing it between three rectangular bars, alternating above and below them, one after the other, and around a roller; or in another way by means of a strap and weight attached to the roller, from which it moves on to the dryer.

Messrs. Butterworth & Sons have made nearly five hundred of these machines, which command almost an exclusive use in the print-works, bleacheries, and cotton and worsted manufactories in this country, and have also been sent to South America and to Italy. Their display at the Exhibition also includes a Dyeing-Machine for cotton-warps with three compartments, a Friction Calendar with three rolls, and a Drying-Machine with three cylinders, each sixty inches in diameter by thirty-eight inches long, which is designed to run in connection with a calico printing machine. The exhibit as a whole is exceedingly creditable not only to the firm, but to the manufacturing industries of Philadelphia.

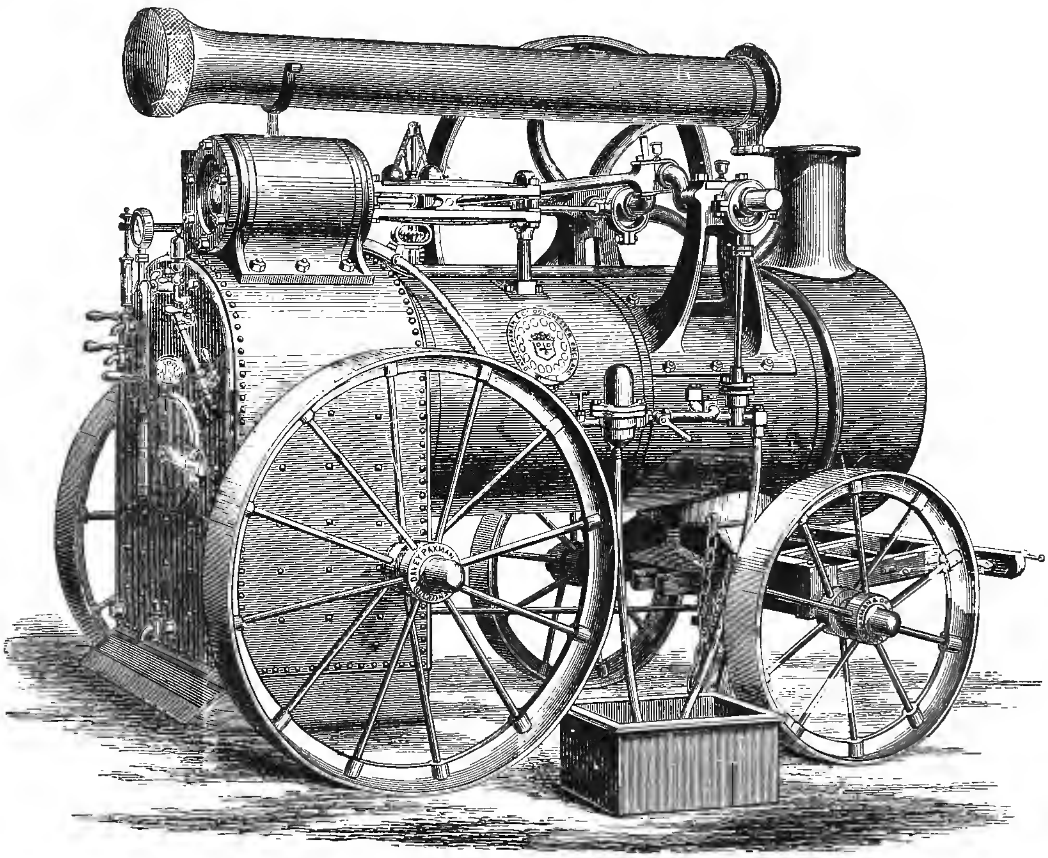
MR. L. P. JUVET, OF GLEN'S FALLS, NEW YORK, makes an exhibit of a TIME GLOBE, which has attracted a large amount of attention from its novelty, not only as a curious piece of mechanism, but also as possessing great simplicity of construction and usefulness. The instrument, represented by the accompanying engraving, consists of a terrestrial globe mounted in a vertical circle and provided with adjustment, so that its axis may be placed at the proper inclination and in the proper direction to give it exactly the same position as that of our earth. By means of chronometer mechanism within its interior, the globe is made to revolve once in twenty-four hours, and a fixed hour-circle, or zone-dial, surrounding it at the equator, gives the time of the various meridians or localities on its surface, while the mean time of the place where the instrument is in use is given in the usual way by a dial, with minute- and hour-hand placed, as shown in the engraving, at the north pole. To set the apparatus in operation for any particular locality, the hands of the clock-dial are moved until they accord with the time indicated by the longitude of that place on the zone-dial at the equator, care being taken that the globe occupies its proper sidereal position by the compass, and also gives by the zone-dial the actual time of day or night, as the case may be, for this locality. By means of a sliding vernier on the vertical circle, graduated to degrees, the latitude of any locality may be ascertained, and the proper inclination of axis may be given to the globe for the earth or for any other heavenly body. If the globe be set to the required inclination of axis for the earth, and is then placed in the light of the sun, with its axis parallel to the earth's axis—that is, the poles pointing north and south—then the light falling upon it will give not only the amount of light or darkness in each country, but will give it at the identical time in which it occurs. The instrument therefore notes the time, longitude and latitude of any place in the world, as well as the difference of the same between two or more places, and may well be called a universal time-keeper. The globe may be placed in any position without injury to the works, which are of the same construction as in an ordinary watch, and run eight days, winding up by a stem-winder connecting with a thumb-piece at the south pole of the axis. The globe is mounted on a handsome stand, which contains an aneroid barometer and a thermometer, making the instrument complete for all observations connected with time or weather, revealing at a glance the actual movements of nature at any time an observation is made. This instrument appears destined to be an exceedingly useful piece of school apparatus, bringing down to the comprehension of a child the most complicated movements of the earth, the alternations of day and night, and the connection of these with the divisions of time, and providing a new and valuable aid to those who teach by the object system. Mr. Juvet has received a medal and a diploma of the highest merit for his exhibit.



Time Globe: L. P. Juvet, Glen's Falls, N. Y.

Messrs. Davey, Paxman & Co., of Colchester, Essex, England, make an exhibit in Machinery Hall of a Portable Engine, which deserves particular notice from its construction, including several special features, and from the good results that it has given in trials abroad. The engine, as represented by the engraving on page 182, has a stroke of one foot, with a cylinder eight and five-eighths inches in diameter, the interior dimensions of the fire-box being one foot ten and one-half inches in length, two feet six and three-quarter inches in width, and two feet six and one-half inches in height above the fire-bars. The boiler is tubular, having thirty-nine tubes six feet five inches long, each, and two and one-quarter inches outside diameter. The total heating-surface amounts to one hundred and eighty-two and five-tenths square feet, of which one hundred and forty-six square feet come from the tubes, and the balance from the fire-box, the heating-surface of the latter being very materially increased by the introduction of ten special tubes, called Davey-Paxman tubes, three of these springing from each side-plate, two from the tube-plate, and two, shorter than the others, from the back-plate. These tubes curve upward immediately after leaving the plate to which they are joined, the whole tube, except the curved portion, being vertical, and they enter the water-space of the boiler again through the top plate of the fire-box. They are provided at the upper end with deflectors to prevent the water which rushes up through them from being projected into the steam space, and thus causing priming. These tubes furnish an exceedingly effective heating-surface, and the deflectors at their upper ends act as intended with great efficiency, as has been proved by working one of the boilers with the man-hole cover off and with the deflectors removed from some of the tubes, thoroughly convincing those observing the experiment of the important duty which the deflectors perform. The application of these special tubes to a locomotive-boiler, as in the present case, not only acts by giving additional heating-surface, but also increases the efficiency of the surface previously existing by improving the circulation in the water-spaces around the fire-box. Salt water has been used in one of these boilers without the least difficulty being experienced, the tubes remaining perfectly clean of deposit after some months of use.

With the exception of these special tubes, the boiler does not differ from the usual forms, but in the engine proper a peculiar arrangement of cut-off is provided, the suppression of the steam being effected by means of an independent expansion-valve actuated by cam gear. The cylinder with its covers is thoroughly steam-jacketed, and an ordinary slide-valve works in a very small valve-chest, another chamber being formed on the cover of this chest, in which the expansion-valve operates. This expansion-valve acts by rotating about an axis, having four ports formed through it, and according to its position it covers or uncovers five ports in the division between it and the main valve-chest, each three inches long by three-sixteenths of an inch wide, the movement of the



Portable Engine: Davey, Paxman & Co., Colchester, England

expansion-valve required for this purpose being only about one-quarter of an inch. The expansion-valve spindle at the end next the crank-shaft is encircled by a light cylindrical casing supported in a fixed position by a bracket attached to the boiler. A helical spring within this casing bears against an enlargement of the valve-spindle, and tends to force the spindle towards the crank-shaft. A sleeve, fitted with two cam-leaves of case-hardened wrought iron, slides freely up and down on that portion of the crank-shaft opposite the expansion-valve spindle, the leaves of the sleeve being broader at one end than the other.

These leaves, acting on a small friction-wheel or bowl on the end of the expansion-valve spindle, which is pressed against them by the helical spring, open that valve for a longer or shorter period at each half revolution, according as their broad or narrow ends are brought into use. The sliding-sleeve on the crank-shaft is connected with the governor, which controls its position, and

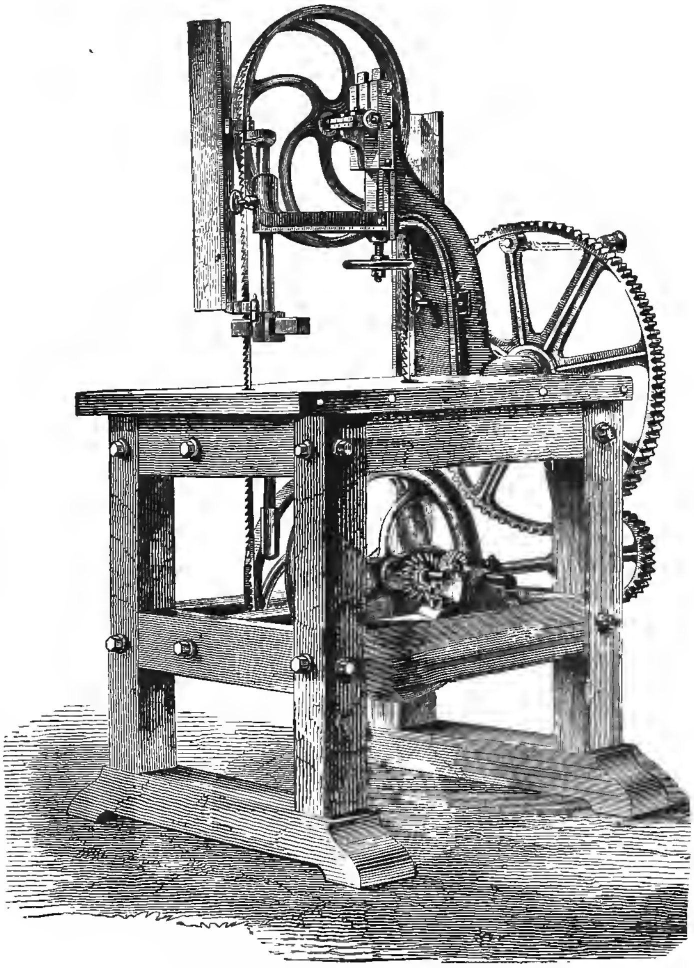


Fig. 1.—Endless Band Sawing Machine for Hand-power: F. Arbey, Paris.

therefore also controls the period of admission given to the steam by the expansion-valve. As the balls of the governor rise, the sleeve is shifted so as to bring the narrower end of the cam-leaves into action, and if the balls lower, the broader end comes into play. An India-rubber pad or ring is placed between a fixed collar on the expansion-valve spindle and a disk abutting on the spring casing containing the helical spring, so as to take the recoil of the valve-spindle when released by the cam-leaves.

The feed-water is heated as follows: It is first raised to a temperature of about ninety or one hundred degrees by leading into the feed-tube a portion of the exhaust steam, and when thus partially heated it is taken by the pump and forced through a heater placed on the top of the boiler, which is traversed by the exhaust-pipe, and from thence it is led through an annular heater situated in the upper part of the smoke-box under the base of the chimney, and finally into the boiler through a check-valve. During a trial at Cardiff, in England, some time ago, the water was by this arrangement heated to over two hundred degrees, the boiler evaporating from this temperature ten pounds of water per pound of coal, at the rate of two and eighteen-one hundredths pounds of water per square foot of total heating-surface per hour.

In that section of Machinery Hall devoted to France an extensive display of wood-working machinery is made by FD. ARBEY, OF PARIS (represented in this country by MR. EUGÈNE L. TOURET, OF NEW YORK), who has attained a high reputation, particularly in Europe, in this department of manufacture. His works, situated at 41 Cours de Vincennes, near la Place du Trône, are very extensive, and here are constructed all varieties of machines required in the fabrication of timber-work, such as sawing-machines, planers, mortising- and boring-machines, veneer-cutting and moulding-machines, wood-turning lathes, etc., etc. The different kinds of Fixed and Portable Log-Sawing Machines made by M. ARBEY are on the most approved models, operating with reciprocal-vertical, band- and circular-saws. They are used for squaring off logs and for cutting them up into scantling or plank, admitting logs up to thirty-nine inches in diameter. Those operating with a band-saw are best adapted for all kinds of curved work, and although applicable to straight work, are not so preferable as the reciprocal-vertical saws, requiring more skilled attendance. The latter machines are fitted with a large number of saws if required, all working at the same time, and cutting a whole log into plank or boards at one operation, as usual at many of the mills in this country. Special bogies are furnished for cutting on a curve, a very useful arrangement for many purposes—for instance, in the case of arches for wooden bridges, which are now very often cut directly from the log to the required curve. The machines are fitted with either wooden or iron frames, and the motive-power ordinarily required averages from four to six horse-power for the usual varieties of timber, the saws being well sharpened and the machinery well oiled. The timber moves on trucks, or on beds running over stationary wheels, being fed either by chain or rack-feed, adjustable to a rapid or slow motion as desired. A finer class of machines is made for sawing squared timber into scantling, floor-boards, veneers, etc. Most of these work with continuous roller-feed, an excellent device, drawing long or short pieces through with great facility, one piece pushing the other, but not powerful enough, however, for very heavy work, when chain or rack-feed must be used. Some machines are made for both heavy and light work, and have a combined roller and chain or rack-feed. In establishments where large quantities of planking are cut, a special adaptation of this system is made, the improvement allowing two pieces of timber to be cut at the same time, as many as sixteen saws being used, and both roller and rack-feed employed. The reciprocating veneer-sawing machine is an exceedingly exact piece of mechanism, the wood to be operated on being glued to a slide which feeds vertically against the saw, and is arranged with lateral adjustment for different thicknesses of cut. The power required is not over three horse-power, the saw making two hundred and forty cuts per minute. The blades are very thin, with finely set teeth, and are tightly strung.

M. Arbey makes quite a variety of circular-saws, which are separated generally into two classes—those with fixed and those with rising spindles, the former being made for straight- or cross-cutting, and the latter being adapted for grooving, tonguing, rebating, tenoning, and all kinds of joiner's and cabinet-maker's work. The raising or lowering of the spindle is effected by means of a handle placed in a convenient position above the table, and just enough of the saw is left exposed to give the proper depth of cut.

In the matter of Endless Band-Saws, all sizes and styles are made by M. Arbey, the larger kinds operating with self-acting feed, and capable of cutting heavy pieces of timber. Fig. 1 illustrates one of his Endless Band-Saws for Hand-power, and Fig. 2 one operating with Foot-Treadle, and provided with a canting iron table for cutting on a bevel. The frames of these machines require to be made very strong to allow them to be driven at the requisite speed without vibration, and to give the saw the required tension so as not to twist while cutting, and to prevent its slipping. M. Arbey states that after trying various kinds of covering for the wheels, he finds India-rubber to be the best. A knife-saw is used in one of these machines with great advan-

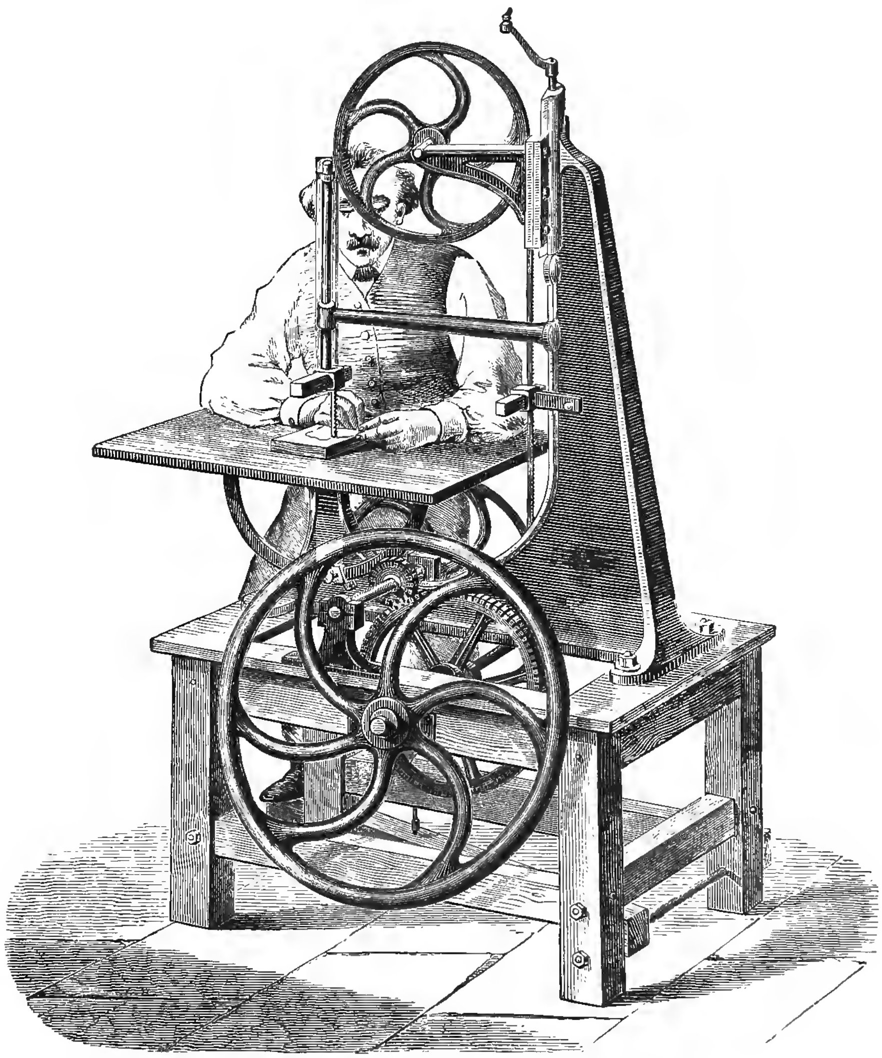


Fig. 2.—Endless Band-Sawing Machine, with Treadle and Canting Iron Table.

tage for cutting leather, cloth, etc.; and with a toothed saw of a certain kind, soft stone, zinc, etc., may be cut. These band-saw machines fill a most important place in wood-working machinery, accomplishing wonderful results at great saving of time and labor. A number of fret-saws are also made by M. Arbey of excellent design.

M. Arbey's great success appears to be in the construction of planing-

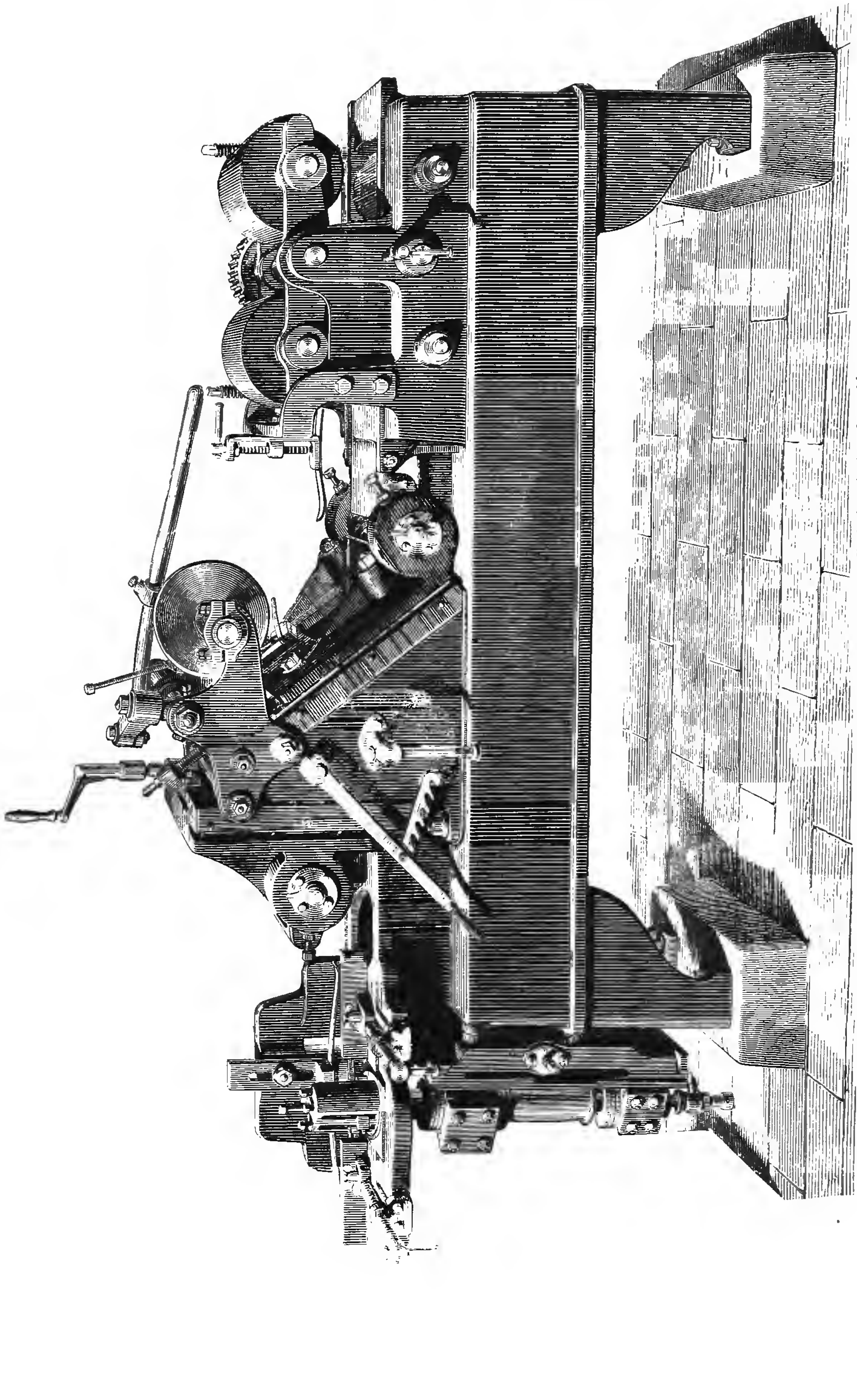


Fig 3.—Planing Machine, with Fixed Table and Continuous Feed, for planing four sides at once.

machines and turning-lathes. We have mentioned, in a previous article on planing-machines, the different types in use. M. ARBEY makes planers with movable and fixed tables and with revolving or reciprocating cutters. His great specialty, however, is with a particular form of revolving cutter having helicoidal blades (Mareschal and Godeau's patent), the axis of revolution being in a plane parallel to the surface cut. These machines are of the following kinds: with movable tables for trying up; with fixed tables and continuous feed for planing; with fixed table and continuous feed and side cutters for parquet-planing; and with fixed table and continuous feed for planing four sides at once. Our engraving, Fig. 3, illustrates one of the latter machines. The patent helicoidal or spiral cutters with which these machines are fitted are far superior in every way over the old-fashioned straight knives. The form and arrangement of the blades and their pitch is such that at the moment one edge ceases cutting, the next commences, and the knives are each cutting during the whole of the revolution, the machine making about two thousand per minute, and the shocks ordinarily given to the bearings are entirely done away with, thus eliminating the principal cause of their heating. The equal cutting of the knives does away with vibration entirely, so much so, in fact, that the machines may be erected on a common floor, lessening the expense of massive foundations, and the wear and tear is also correspondingly diminished. The knives always present the same angle to the wood, an angle which allows cutting across the grain, even if knotty, and of planing parquet-flooring already put together. The smoothness of the draw-cut is such that the use of a finishing-tool is not required. Another great advantage with this cutter is that it throws the shavings all to one side of the machine without clogging up the working parts, and entirely out of the way of the operator.

The knives used are very thin, only from four- to eight-hundredths of an inch in thickness, and are quite flat, being pressed closely to the spiral cutter-block by the back iron and nut, projecting only about eight- to twelve-hundredths of an inch. This makes them very economical, not only on account of their cheapness, but also owing to the short time required to sharpen them. The method of sharpening is an American idea, and it is accomplished very simply, without removing the knives from their places, by the use of a traversing emery-wheel, which does its work in a most accurate manner and with the greatest facility. As sharp knives are a necessity for good work, this improvement cannot be too highly valued.

These machines work wood either broad or narrow, thick or thin, along the grain or across it, without vibration, and with very small power, effecting an immense saving in sharpening and in wear and tear over the usual and older forms of machine. Those with fixed tables are used for parquet-flooring, mouldings and thin boards that do not require trying up. It is evident that any variety of cylinders may be used, with blades of corresponding form, to suit various kinds of work. Special machines are made on the same principle for recessing railway sleepers, for cask-making and for cutting long tenons.

M. Arbey makes a large variety of mortising-, tenoning- and boring-machines in which slot-boring is used, working very much more rapidly than the reciprocating mortising-machines so much used in this country. The tool makes the bottom of the mortise flat, throwing out the shavings, and it is only necessary at the termination of the operation to square out the ends by a double chisel. In some cases, as in carriage- and cart-wheel making, etc., the round ends to the mortise are preferred. The spindle in these machines should run at the rate of at least two thousand revolutions per minute; and although a variety of borers have been tried, a simple hollow bit that can be made anywhere and is easily sharpened has been found to be the best. The frames are made either entirely of iron or of wood. In some machines the tenons are cut with spiral knives, while in others circular-saws are used. The rising spindle saw-bench previously mentioned may also be employed, but does not do the work as promptly or accurately as the special machines. Fig. 4 illustrates a Machine for Slot-Boring and Cutting Long Tenons by means of Circular-Saws. This is a very compact and convenient tool, and different wood-working operations may be accomplished by it, such as tenoning, mortising, edge-planing, and sawing, the tenons and mortises being cut of any suitable size and inclination, and the machine readily adjusted and controlled during its operations. The bed-frame consists of two main parts, one for guiding a horizontally sliding table, and the other for supporting a vertical guide-frame, and, on adjustable carriages, horizontal shafts of two vertical circular-saws. To the side of the bed-frame supporting the sliding-table is secured a vertical guide-frame having a vertically sliding carriage which supports in suitable bearings a vertical saw-

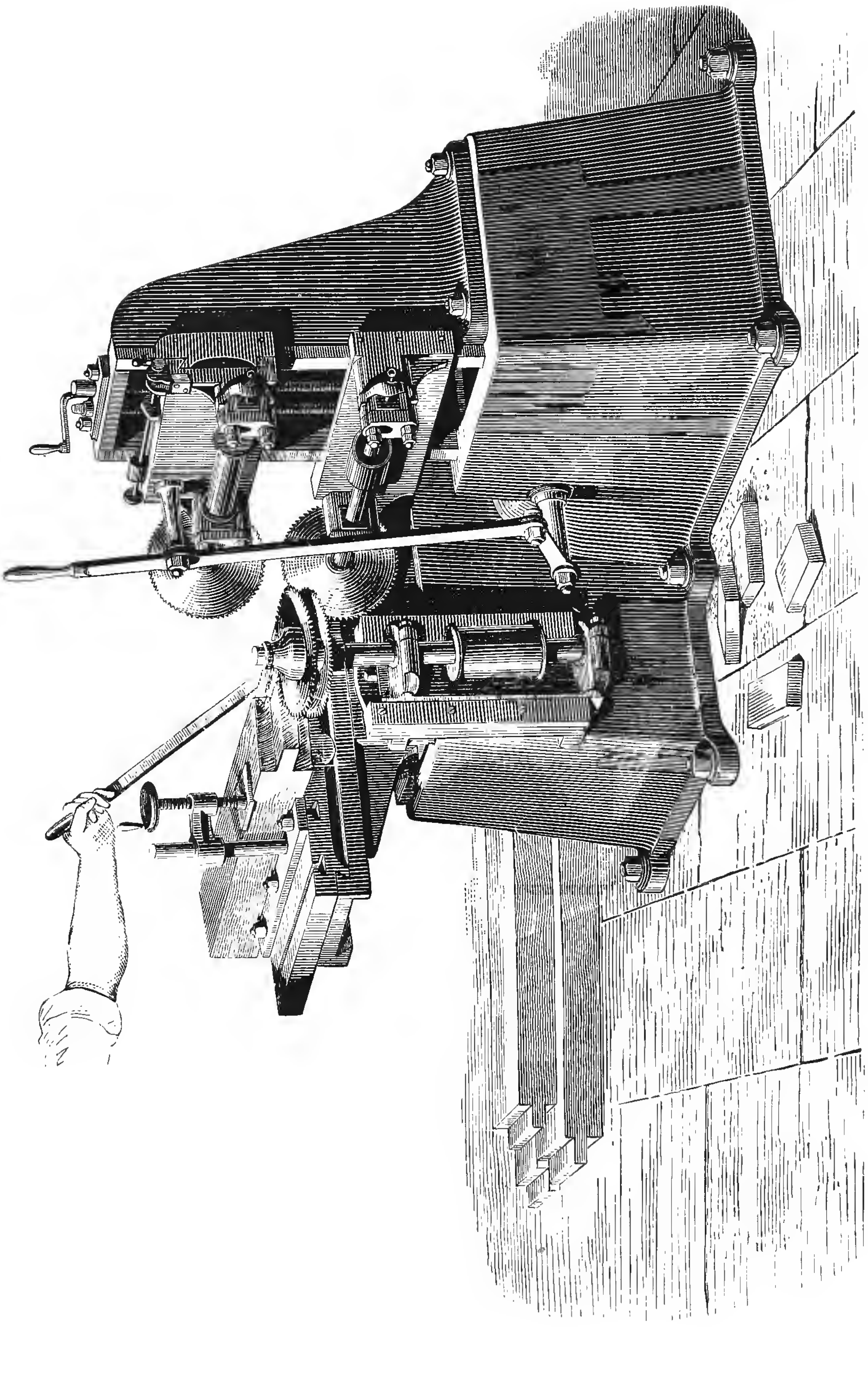


Fig. 4.—Machine for Slot-Boring and Cutting Long Single Tenons with Circular-Saws.

shaft provided at its upper end with a double set of horizontal circular-saws. The space between these saws may be readily adjusted by a suitable changing device and intermediate sleeve or collar to the thickness of the tenon to be cut. The piece of timber is first fed to the horizontally cutting saws, and then to the vertical saws, the latter cutting through the parts at both sides of the tenon, and completing the operation. The extent of the horizontal motion is controlled by stop devices, and the horizontally sliding part may be firmly secured in any position desired by a clamping-screw or otherwise, so that, by detaching the circular-saw and attaching a mortising tool, the revolving shaft may also be used for mortising and grooving, the remaining saws being placed so as to be out of the way. This machine may also be used as an ordinary circular-saw. Tenons and mortises of different angles are produced by placing the saw-bearings on swinging plates connected with the carriages, and securing the plates by clamp-screws at the requisite degree of inclination. Double tenons may also be produced with great facility by sawing them first and then mortising out

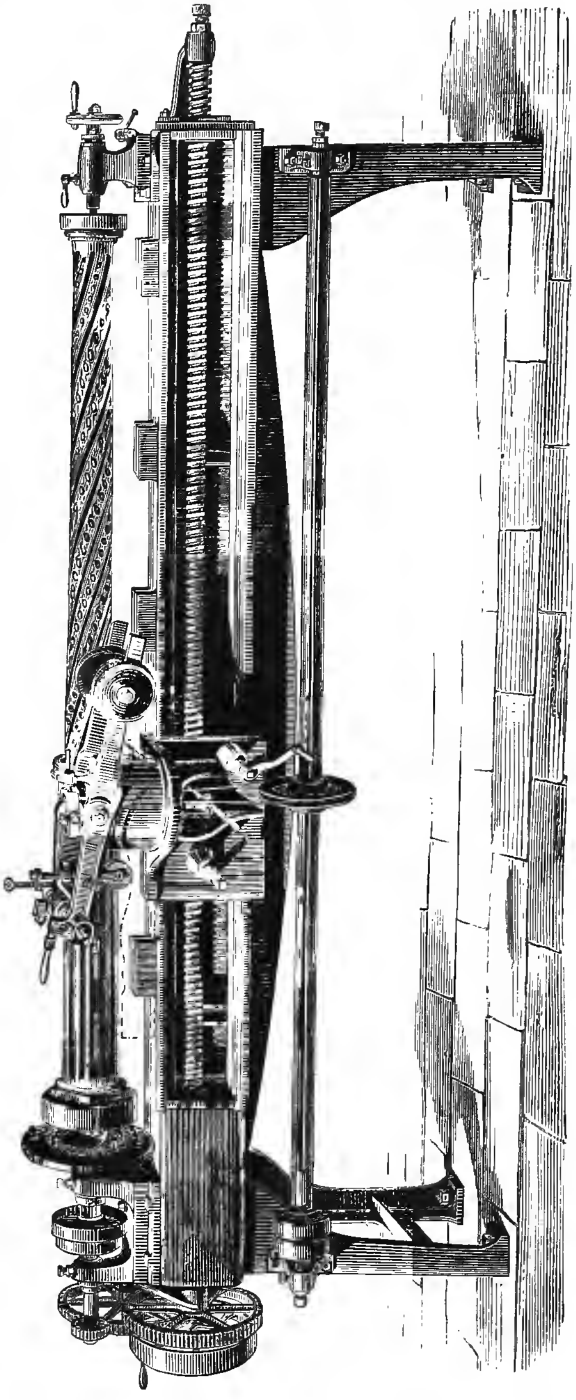


Fig. 5.—Lathe with Carving Attachment.

the intermediate grooves. The saws are revolved by belt and pulley connection with the driving-shaft; and the machine, owing to its compactness and ready adjustability, may be used very quickly and efficiently for the different purposes for which it is intended.

Very convenient machines for cutting double or triple tenons are made

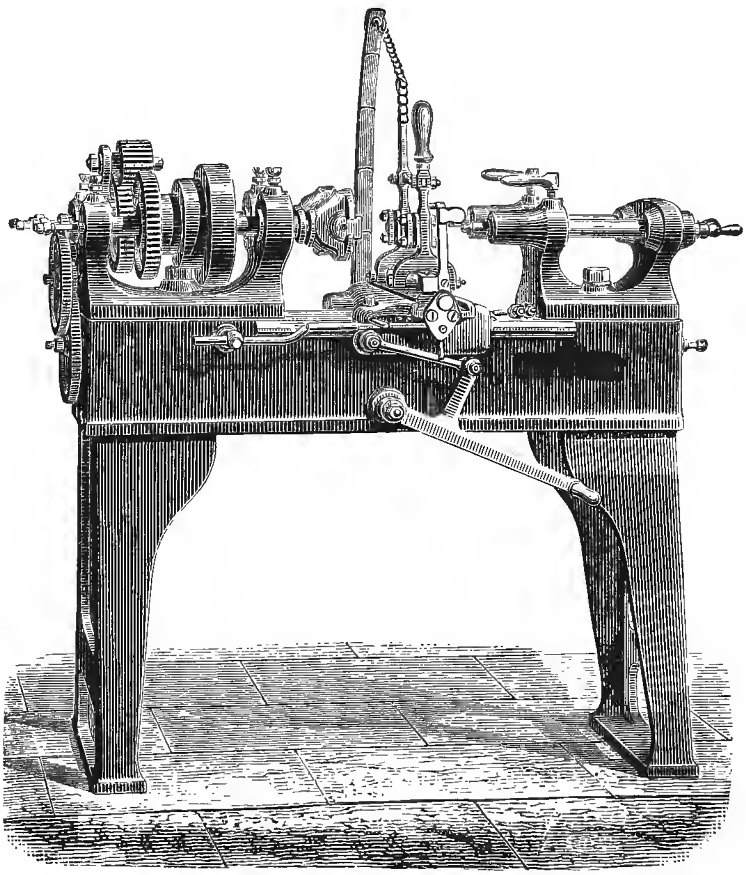


Fig. 6.—Lathe for Turning Irregular Bodies.

with rotary cutters, which work very rapidly, producing from fifty to eighty tenons per hour, depending on their size. The cutters may be shifted to make straight or taper tenons, or to alter the position of the shoulders, as may be required.

M. Arbey makes a number of special machines for carpenters, cabinet-makers and joiners to execute twisted and straight grooving and beading, for moulding in hard or soft wood, and for cutting veneers. Veneers are cut in two ways—by a sawing-machine, previously mentioned under the head of saws, and also by what is termed a slicing-machine, fitted with a sliding knife block and a thin knife and back-iron. The thin knife with back iron does away with the special sharpening-machine required. All that is needed is to unscrew the knife-rest from the saddle, taking care to always keep the three pieces, the knife-rest, knife and back iron, together. These machines cut from ten to fifteen veneers per minute, and from one hundred to one hundred and fifty to the inch of thickness, whereas the sawing-machine will not cut more than twenty to twenty-five to the inch. For very perfect veneers, sawing is better, but for work of the usual quality, these machines answer admirably, and the cut is so clean that for common purposes polishing is quite unnecessary. M. Arbey also manufactures an excellent copying-machine for making spokes, lasts, gun-stocks, etc.; a number of machines for cask-making, and one for making wooden shoes—the latter of no use in this country, but of great service in France and Belgium, where many wooden shoes are worn by the lower classes.

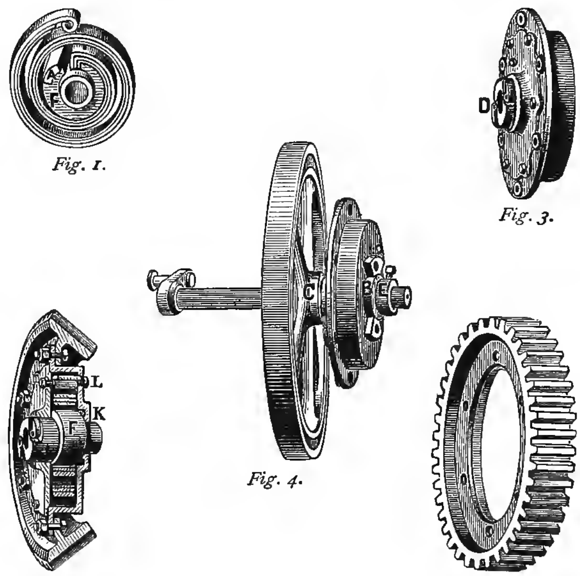
Quite a variety of turning-lathes are made by M. Arbey, and we desire to call special attention to a carving attachment, illustrated by Fig. 5, which is intended to be affixed to common lathes for the purpose of grooving, channeling and ornamenting columns, balusters, table-legs, and similar articles of irregular shape, producing perfect work with ease and rapidity. The carving attachment is placed on a traveling carriage and supported on an adjustable cylindrical standard, to which the balanced arms of the cutter-shaft are pivoted, the latter being revolved by a pulley and belt connection with a traveling pulley of the cutter-actuating shaft. The cutter-shaft is movable on its bearings by a lever-handle, while the pulley is retained by a clutch connection with a fixed brace of the weighted arms, and it is raised or lowered by means of a curved arm and guide-roller passing along the pattern of the form. When a table-leg or other object is held in position of rest in the lathe, the cutting tool passes longitudinally along the same, and works out in it a groove or channel. The dividing-disk being turned for the distance of one sub-division after each channel is completed, the next channel is then produced by the return motion of the carriage. By turning the object slowly in the lathe, simultaneously with the revolving and traversing motion of the cutter, helicoidal channels or grooves are formed. For grooving conical parts, the cutter-shaft is guided along an inclined guide-pattern, or its axis is placed at an angle to the longitudinal axis of the lathe. The cutter adjusts itself to the shape of the object, and carves, by its uniform forward motion, an ornamental groove of equal depth throughout the entire length. For the purpose of pearling or doing other ornamental carving, the cutting tool is guided to the work by a handle, while the object is turned in the regular manner by the dividing-disk, so that the pearls may be formed at uniform distances. The adjustability of the cylindrical standard, in connection with the balanced cutter-shaft and handles, admits of the convenient and accurate handling of the carving attachment, so that a large variety of ornamental work may be accomplished on this machine in a quick, economical and superior manner.

M. Arbey makes an excellent lathe for turning irregular bodies, which we illustrate by Fig. 6. By means of this lathe, sword-handles and other bodies of unsymmetrical form may be turned in a perfectly reliable and automatic manner. The supporting frame of the machine carries, in suitable standards, two rotating mandrels and fixed centres. One of the mandrels carries a set of cone-pulleys, to which the power is applied from the driving-shaft, and it is then transmitted by intermeshing gearing to the second mandrel, and by end-gearing to a screw-shaft below the table of the frame. A carriage is moved along the side guides of the table of the frame by a connection with the revolving screw-shaft, so as to travel automatically in both forward and backward direction. A suitable lever mechanism is also provided for moving the carriage back and forth to set the tools to the work. The front mandrel carries the piece of wood to be operated on, and the back mandrel carries a pattern, an exact copy of which is to be reproduced. There are two tools—a cutter which operates on the front piece of wood, and a guide tool, which moves on the finished pattern. A joint motion is given to the cutter tool longitudinally and laterally—in a longitudinal direction by the traveling carriage, and in a lateral direction by the power of a spring, seen in the engraving, that is controlled by and presses the guide tool against the pattern in the second mandrel, while it keeps the cutting tool at the same time against the wood operated on in the first mandrel. In this way the exact copying or reproduction of the shape of the pattern or finished body is accomplished by cutting out the simultaneously revolving piece of wood into a corresponding shape until finished.

Thus one piece after another may be made, all faithful copies of the original, the work being turned out accurately and rapidly.

The crank of an engine in motion acts with the greatest leverage when at right angles to the centre line of the stroke, its power gradually diminishing to zero as it approaches the dead-points. There being two dead-points and two points of greatest efficiency in each revolution, it follows that the power of the engine is communicated to the shaft and fly-wheel in a succession of impulses more or less sudden, depending on the rapidity of the stroke. The fly-wheel from its very nature cannot economically accumulate power applied to it in the usual manner, unless it attains a considerable momentum, a portion of which, more or less, is always absorbed every time the crank-pin moves over the dead-point, and restored when at the points of greatest efficiency. The result is an irregular or vibratory motion very detrimental to the machinery driven, as well as to the engine, and a loss of power much greater than would be at first supposed. The defect is partially remedied by making the fly-wheel large and heavy, and, as it were, cramping the engine into comparatively uniform motion. The advantage gained, however, is only partial, and at a further expense of loss of power. Another expedient, that of driving from the periphery of the fly-wheel, is still more objectionable, giving the machinery a leverage over the fly-wheel, and very effectively preventing it from absorbing and transmitting the full force of a stroke to the centres. The "give and take" in belts will not overcome the difficulty, as the uniform motion to the driven pulley depends upon a constant tension of the driving side of the belt, which will not obtain with the usual arrangement, the principal advantage of the belt being in its doing away with the noise of gearing. A mill-stone, for example, requiring a continuous exertion of ten horse-power, is driven by varying impulses of twenty horse-power.

Mr. John A. Hafner, of Pittsburgh, Pa., exhibits a coil spring which is intended to provide an effective, economical and easily adapted remedy for the defects of the present system, by furnishing an elastic reservoir of power between the rigid and unyielding action of the fly-wheel and the machinery to be driven, fulfilling the same duty as an air-chamber on the ascending main of a force-pump. It connects the crank shaft and fly-wheel with the driver, and allows the engine and fly-wheel to increase in speed, in the ratio of the increased leverage of the crank, as it approaches its most effective point, without increasing the speed of the machinery driven, this increased velocity acting upon and counterbalancing the increased compression of the spring, which expands in a forward direction at the time the crank is about to reach and pass its dead-points, and secures an elastic, smooth and uniform pressure. The result of this is economy, not only in working, but also in first cost, owing to the increased capability of the engine and boiler. It is stated that an engine may be employed fifteen to twenty per cent. smaller with this arrangement than without it. The whole machinery is also relieved of irregularity and vibration, and is therefore correspondingly more effective and durable, while the weight of gearing may be reduced fully one-third.



Hafner's Patent Coil Spring and Attachments.

The spring, which is represented in Fig. 1, is a spiral coil, consisting of several plates of the best cast spring steel, of varying thicknesses, and its manner of construction is its special feature, rendering its employment possible in cases where an ordinary spring would fail. It is well known in the construction of flat coil springs that, the plates being of the same thickness, the smaller the coil, the greater the stiffness, and that therefore when a spring is made of two or more plates of the same thickness, the strain upon the various plates is unequal. This difficulty is obviated by making each plate so much thicker than the one immediately within it, that all will act with the same stiffness. The plates are riveted together only at the inner or hooked end, remaining unconnected at any other point. Owing to the mode of construction, the strain upon the outer plate, which is thickest, is tensile, while that on the inner plates is compressive; and the spring being self-supporting, the grain of the steel is not affected by the strain, while the vibration being obtained merely from the natural tremor or quiver of the steel, the spring will stand and vibrate under a pressure far greater than would be the case with an ordinary single spring.

Fig. 1 represents a front view of the spring and its hub, F, while a sectional view is shown in Fig. 2, giving also the combination with a casing and a bevel-wheel. The inner end of the spring hooks into the hub, F, fitted to play freely in the casing, and the outer end is attached to the casing by a bolt, L. The connection between the hub and casing, and therefore that between the crank or fly-wheel and the driving-wheel, is consequently elastic. The rear view in Fig. 3 shows the extensions of the hub, F, and pawls, D, which fit into the clutch-box (Fig. 11), the latter being keyed fast to the crank-shaft, while the loose hub is

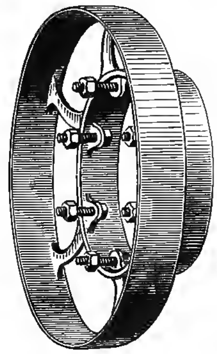


Fig. 6.

Fig. 8.

Fig. 10.

Fig. 9.

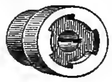


Fig. 11.

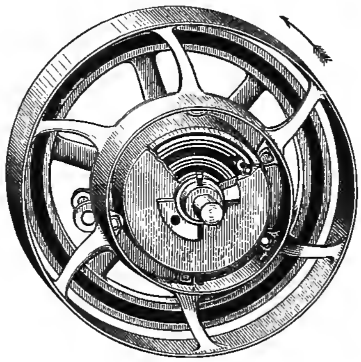


Fig. 7.

Hafner's Patent Coil Spring and Attachments.

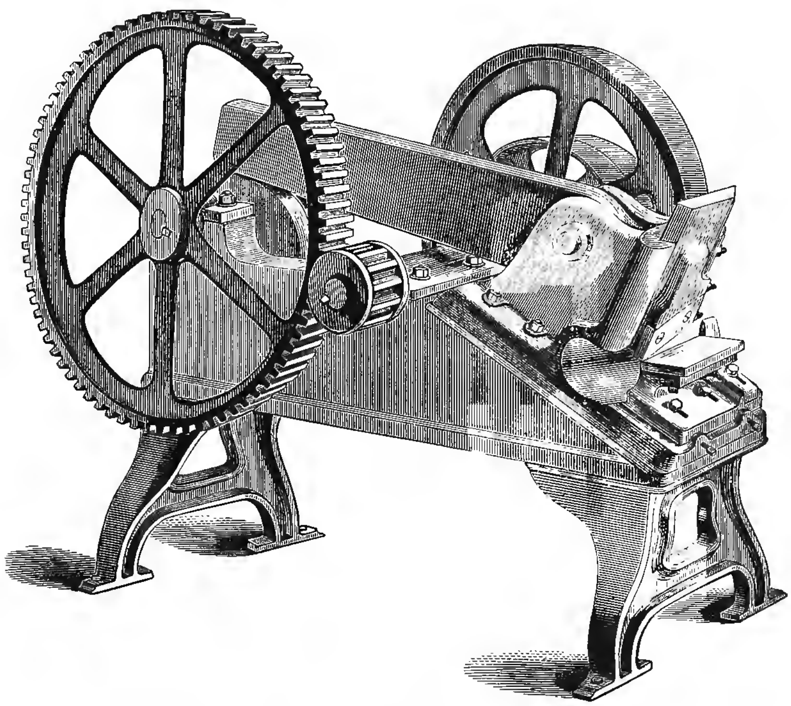
driven by the pawls in a forward direction, its position being maintained by a collar, E (Fig. 4). In case of any accident necessitating instantaneous stopping of the engine, or the slipping off of a belt, the hub rotates freely on the shaft until the acquired momentum is expended, preventing the possibility of injury to either spring or machinery. Another important feature is the facility afforded for starting an engine when on its centre, as the engine may be backed without moving the machinery. As an additional protection to the spring when backing, a groove, G, is formed in the casing (Fig. 8), and receives the lug, A (Fig. 1) of the hub, F, which rests against the stop, H (Fig. 8), effectually guarding the spring from injury.

An exterior flange on the spring casing (Figs. 3 and 4), which is turned and faced to a standard gauge different for each size of spring, admits of the adaptation, in a very short time, of either a pulley, spur or bevel-wheel (see Figs. 2, 5, 6, and 7), as may be required.

This coil spring is not confined in its application to the crank-shaft of a steam-engine, but may be used with advantage on any shaft, to control any portion of machinery where smooth regular work is required. It has been in use for a number of years with great success in flour-mills, both steam- and water-power, for regulating the speed of the burrs; also in paper- and woolen-mills. In cotton- and woolen-mills where excessively high and uniform speeds are required, its use is attended with the most satisfactory results as to economy and increased durability of machinery. Its application is of great importance and utility in the gearing of threshing-machines driven by horse-power. Any one who has seen these machines working with eight or ten horses will bear evidence as to the irregularity of the power, and the absurdity of trying to use this power economically, without the intervention of some highly elastic reservoir or accumulator such as this spring will furnish. One of these springs was tried in a threshing-machine at the Centennial Field Trial, at Schenck's Station, in July, with the most satisfactory results, and a diploma and medal were awarded the inventor. It is claimed that the use of one of these springs will save twenty per cent. in the working of a ten horse-power machine, and fifty per cent. in wear and tear.

Ira J. Fisher & Co., of Kincardine, Ontario, Canada, represented by Alexander Thomson, of Fitchburg, Mass., as sole agent in the United States, exhibit a Bevel Edge Boiler and Ship Plate Clipper, which appears to be an exceedingly efficient and complete working tool, supplying a want long felt among steam boiler-makers and iron ship-builders. This machine, which is the only one on exhibition, entirely replaces the slow and objectionable process of hand-clipping, or the expensive use of planers, doing a much greater variety of work than is possible by the old methods, and at considerably less cost. Our illustration accompanying shows very clearly the design of the tool and its mode of working. It will cut the edges of plates to any required bevel, keeping the line of direction of the cut either straight, concave or convex, as desired. This capability of doing circular-work makes it exceedingly serviceable for Iron Ship-building. The plates require no fastening while under operation, and are placed on a truck or table and passed through the shear, the depth of the cut being regulated by a guard, which is adjustable by a screw, and can be readily changed without interference while the machine is in motion and the plate being cut.

It is claimed that the capacity of one of these clippers runs from one to two hundred feet per hour, the work being done in a superior manner to that executed by planers, which will only do from two to three hundred feet per day on straight work. A hand-power machine is manufactured by the same party, provided with a concentrated power appliance under Mr. D. L. Kennedy's patent, by which it is said two to three hundred feet of clipping may be done per day on three-eighth inch plate with one man on the lever. The machine



Bevel Edge Boiler and Ship Plate Clipper: Ira J Fisher & Co., Ontario.

appears to combine great simplicity, efficiency and durability, and received an award of a medal and diploma from the Commission.

THE END.

MASTERPIECES

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EXHIBITION