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THE SCIENCE

OF

MODERN COTTON SPINNING:

EMBRACING

MILL ARCHITECTURE; MACHINERY FOR COTTON GINNING, OPENING, SCUTCHING, PREPARING, AND SPINNING, WITH ALL THE LATEST IMPROVEMENTS;

ALSO ARTICLES ON

STEAM AND WATER POWER; SHAFTING; GEARING AND AMERICAN SYSTEM OF BELTING COMPARED; GENERATION AND APPLICATION OF STEAM CRITICISED AND EXPLAINED; BOILERS, BOILER EXPLOSIONS, &c.;

ALL TENDING TO SHOW WHERE

THE OUTLAY OF CAPITAL MAY BE ECONOMISED, AND PRODUCTION CHEAPENED.

BY

EVAN LEIGH, C.E.,

MECHANICAL ENGINEER, M.S.A., ASSOC. I.N.A., ETC., OF MANCHESTER, ENGLAND;
INVENTOR OF "COUPLED MULES" WITH "PUTTING-UP MOTION," "SELF-STRIPPING CARDING ENGINE," "LOOSE-BOSS TOP ROLLER," ETC.

Third Edition.

VOLUME II.

Manchester:
PALMER & HOWE, PUBLISHERS, 1 AND 3, BOND STREET.
London:
SIMPKIN, MARSHALL & CO.

MAY ALSO BE HAD FROM

EVAN A. LEIGH & CO., MACHINERY CONTRACTORS AND SHIPPERS, TOWN HALL BUILDINGS, MANCHESTER, ENGLAND.

EVAN LEIGH & SON, MERCHANTS AND SHIPPERS, 2, BRUNSWICK BUILDINGS, LIVERPOOL.

F. A. LEIGH & CO., IMPORTERS OF MACHINERY, 103, DEVONSHIRE STREET, BOSTON, MASS., AMERICA.

1875.

CONTENTS OF VOLUME II.

LIST OF PLATES.

FIGURES AND ILLUSTRATIONS.

This machine which is represented below (*Fig.* 129), is adapted for grinding rollers, clearers, or hand-stripped flats; and only differs from an ordinary grinding machine in having a Horsfall's traversing drum in place of the usual grinding roller.

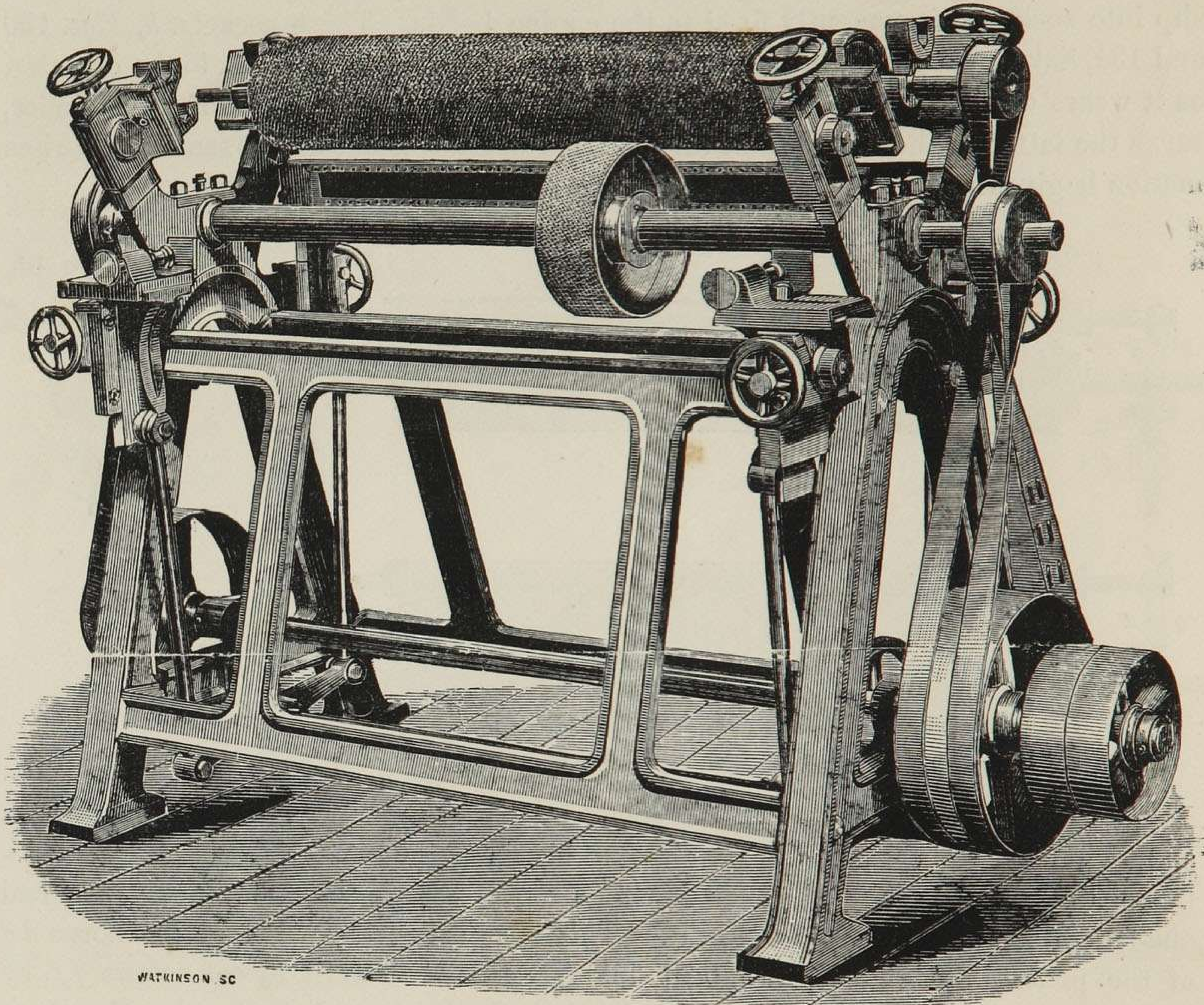


Fig. 129.—Roller Grinding Machine.

STRIPPING OUT THE MAIN CYLINDERS.

Formerly cylinders were stripped out by hand, with what is termed a hand-card, which is a board with a handle, about half the width of the cylinder, having a piece of sheet card nailed to it. This is still used to a great extent, and has a pernicious effect in loosening or bending the wire of the cylinders. Another method of doing this is by turning the cylinders slowly backward by hand, and gathering the strips upon a clearer, which is turned round at the same time in the opposite direction. The

U

latter method avoids damaging the cards upon the cylinder, but does not get out the motes which are wedged in the wire of the latter. A far better plan than either of the above is to have a circular brush, about 7 or 8 inches diameter, mounted on two light wrought-iron pedestals, as in *Figs.* 130 and 131. The legs of these pedestals slip into sockets, permanently fixed to the engine bends. These sockets, *h*, *Figs.* 130 and 131, have a set screw, with lock nut at the side, to adjust the brush to the cylinder, as it wears down; and the brush being set down a little into the wire of the cylinder, turns the latter in the direction of carding, and brushes it out at the same time, when motion is given to the brush by the handle *g*, which is turned to the right.

Fig. 130.

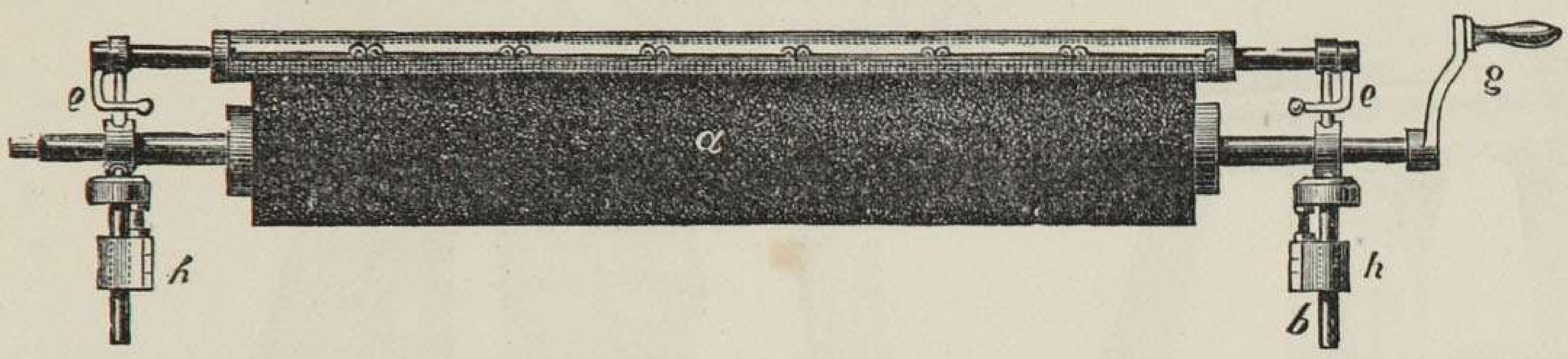
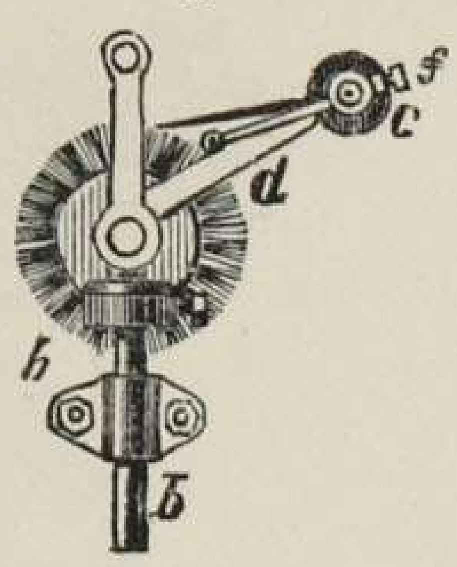


Fig. 131.



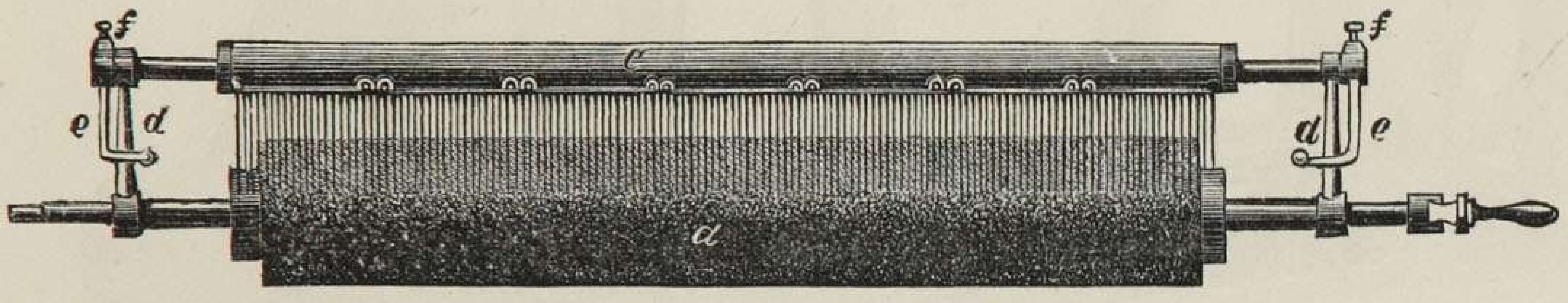


Fig. 132.

Referring to the above, *Fig.* 130 shows front elevation; *Fig.* 131, side elevation; and *Fig.* 132 plan in which *a* is the circular brush, *bb* the wrought-iron legs or pedestals, *c* a needlestick or wood roller, having a row of spikes about 4½ inches long and one-fourth of an inch apart fixed in it. This needlestick is carried by the horns *d d* of the pedestals *b*, and has two bent fingers *e e* fixed upon it by set screws *f f*, by which it is adjusted so that the comb takes into the bristles of the brush and collects the strips.

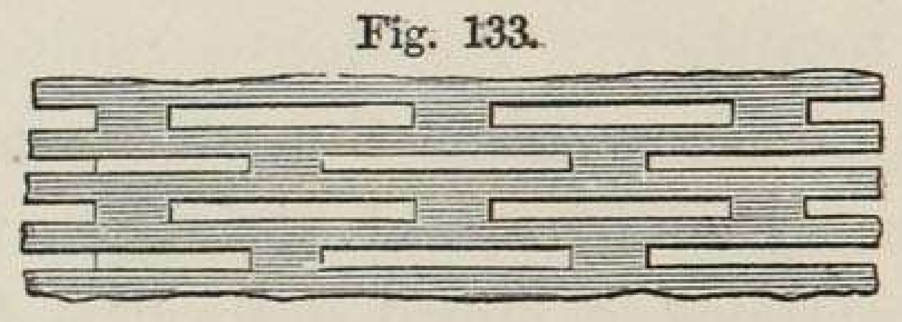
It is believed that this useful contrivance was invented by the late Mr. Smith, of Deanston, and was first used by him about the year 1832. It not only strips the cylinders effectually and without injury to the wire, but a row of engines may be stripped out by it in an incredibly short space of time after the hands get accustomed to its use, the brush being carried from one engine to another and dropped into the fixed sockets, which are all adjusted ready to receive it.

UNDER CASING OF CYLINDERS.

The casing of cylinders underneath has now become very general, and is absolutely necessary for short stapled cottons, and for the present speeds. Various opinions prevail as to the kind of casing it is best to employ. Those made of tinned flat iron soldered to three segments, whilst laid on ring gauges of the right diameter, are simple, cheap and good; but this plan does not admit of any variation on the part of the spinner when once made, therefore the following good and cheap casing is to be preferred. This is made of sheet-iron plates bent to the curve of the cylinder, and pierced all over with small oblong square holes, about one inch long and one quarter inch wide. These holes are punched in zig-zag fashion, so that the plates are of equal strength every way. If tinned after they are punched, all the better.

Casings, however made, should be set close up to the cylinder, and *ought not to be wider than the wire on the cylinder*, as they work better so than when made the width of the frame. The best and simplest way of applying them is to have the plates each about 10in. or 12in. wide. bent to the proper curve (*Figs.* 133, 134), and

Fig. 133.



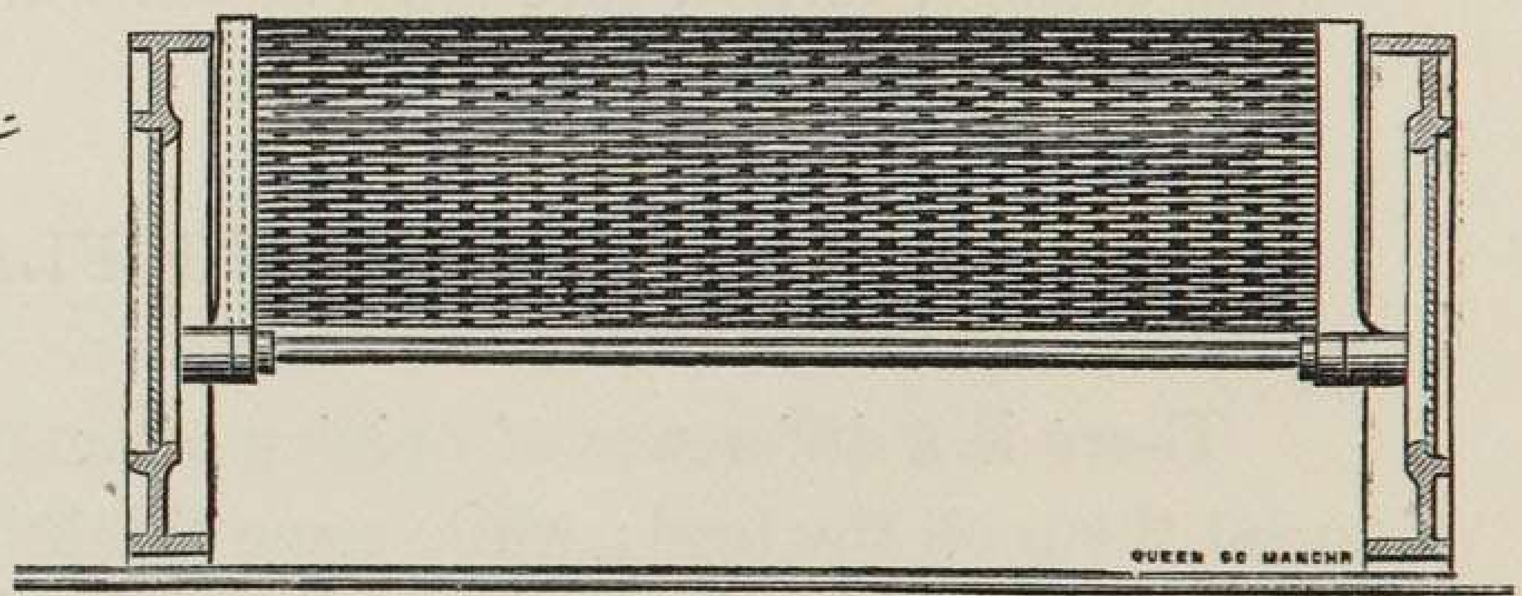


Fig. 134.

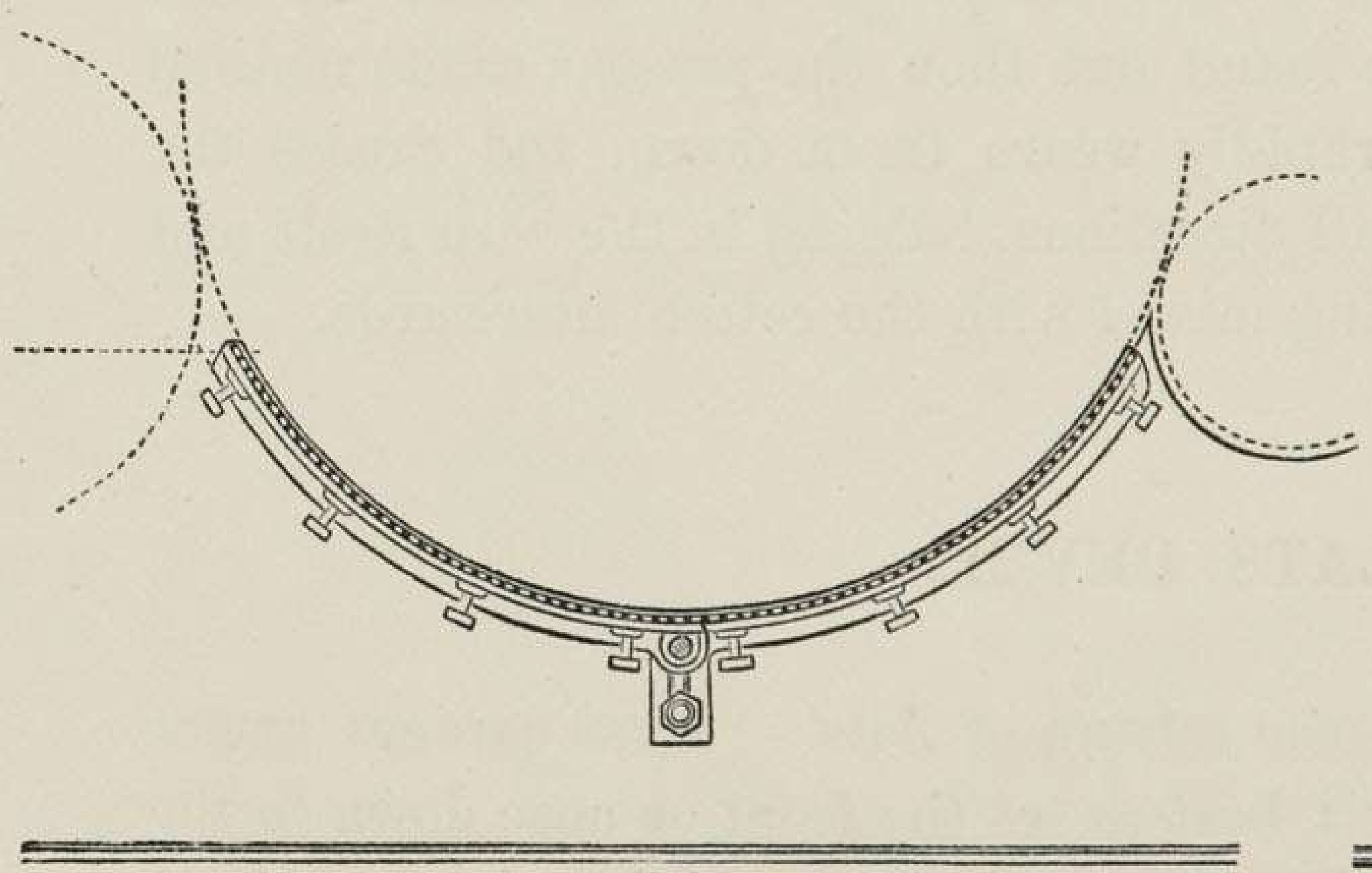


Fig. 135.

slip them in a groove, *turned* or cut in semicircular segments of wrought or cast-iron (*Fig.* 135), which may be hinged under the cylinder, and set close to it by suitable mechanism, the casing on the doffer side coming up to within about three inches of the point of contact between cylinder and doffer, and these forming a smooth straight-edge.

Some spinners have their engines only partly cased under, preferring to make a little fly to the discolouration of their yarns. In this case about two feet of the pierced sheet-iron should be placed under the centre of the cylinder, which, by preventing the catching of the fly, allows the cylinder to be set nearer the floor than would otherwise be practicable, which is desirable in many respects. In constructing carding engines the segments, accurately grooved, should never be omitted, and then the spinner can always please himself whether he uses casings or not, and to what extent. It will be found that less than half the fly will be made if only one plate be used, viz., that which is set up to the cylinder under the doffer.

Any kind of casing somewhat soils the yarn, but in other respects they are economical. The discoloring of the yarn arises in a great measure from the particles of metal which fly off when the cards are ground up with emery, particularly when the hand strickles are used. These particles of iron get deposited on the casing, and are afterwards licked up when the engine is put to work again, and they give the yarn a dirty bluish tinge. The difference is so great that if two rows of cards are working in the same room, and from the same cotton laps, one row having casings under the cylinders, and the other none, the difference in the appearance of the yarn (in the hank) is so great that it does not appear to be made from the same cotton, and if the hanks are mixed in reeling it gives striped yarn, *i.e.*, the yarn from the cards which are not cased under is brighter and lighter in colour, and that from the cased engines has a bluish tinge, and appears to be spun from cotton and waste mixed together. No doubt much of this would disappear if some more efficient method of sharpening the points could be found out than the present crude method with emery rollers and strickles, which rapidly wears them down, and causes the small particles of metal to fly like dust in all directions, lodging in the wire itself and on the casings, carried through and becoming mixed with the cotton afterwards.

SETTING FLATS BEVEL.

There is a difference of opinion about the setting of flats. Most carders prefer to set them on the heel; while some think it best to set the front or nose down to the cylinder, and leave the heel standing off. The theory for both opinions is, that if set bevel, more motes or nep will be caught by them. It is now believed that a careful and thorough examination will demonstrate that both are wrong, and that the true principle is to set them level, or with the centre of flat to the cylinder. The explanation is this:—When a flat is set on heel, a few straggling wires touch the cylinder first, arising from the wire not being in a perfectly straight line; after the top card has been stretched with the plyers and nailed on, the same may be said of the nose of the flat. In either case the flat cannot be got down close without some minute portion touching, which, as soon as heard, the setting down is discontinued. Now, this cannot happen when the flat is set down at the middle of the wire; and still the nose will be slightly elevated, so as to hook the motes, from the fact of the cylinder surface forming a circular, and the flat a plane line. There has been much unnecessary complication about self-stripping carding engines arising from this mischievous prejudice, which is a mere shadow,—having no sound argument in its favour.

ENGINE BOX.

It is a somewhat disputed point whether it is better to *draw* the cotton a little as it comes from the card, or simply to pass it through callender rollers. The latter has the merit of greater simplicity, but the former is generally preferred, and it is thought justly, as a slight and easy draught is obtained without cost in wages, which is desirable in the curly state in which the web leaves the card. A good traverse should always be insisted upon in the engine box, otherwise the top rollers will soon wear hollow.

Tatham and Cheetham's coiler is now generally adopted in this country both to carding engines and drawing frames. It is an invention which possesses considerable merit.

HOLLAND'S WEB CONDUCTOR.

The simple invention which bears this name, is one of the most useful things about a modern carding engine. It is merely a flat metal plate, *Fig.* 136, the top edge

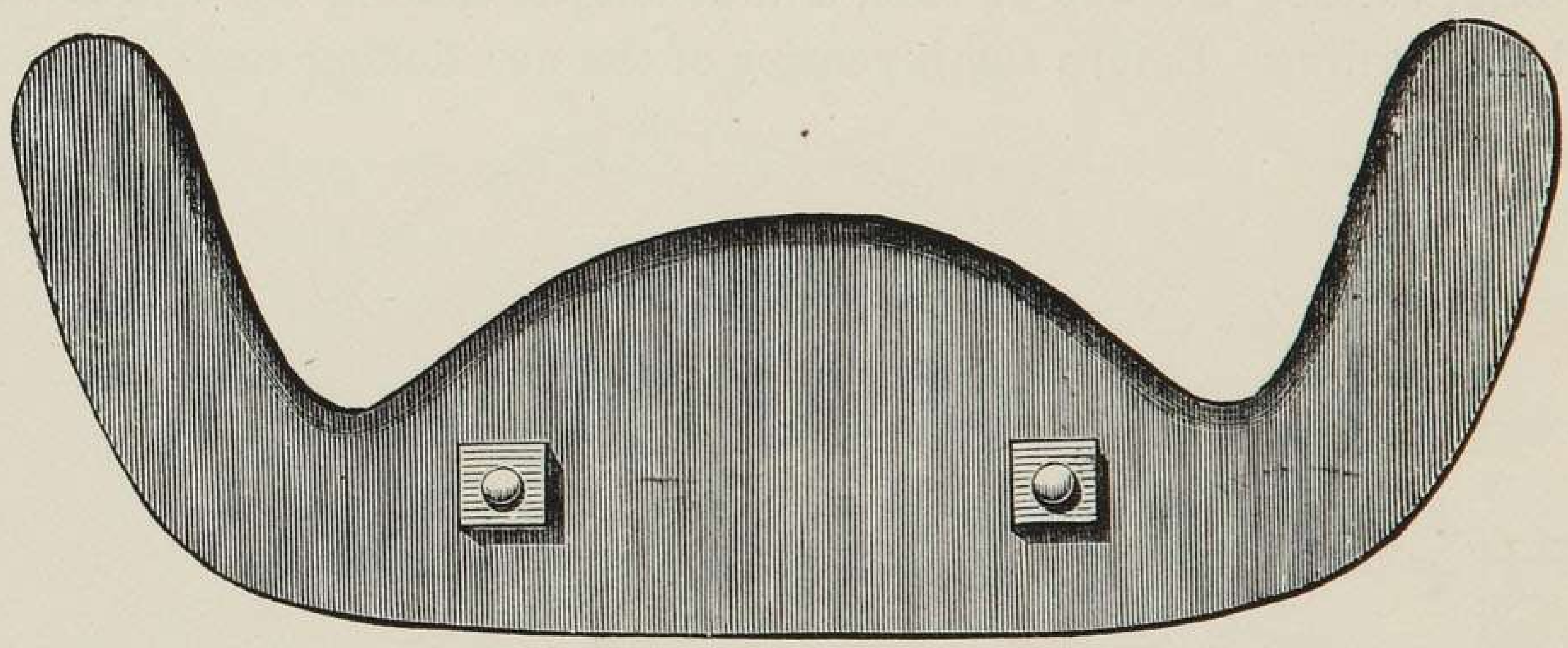


Fig. 136.—Holland's Web Conductor (Half size).

of which is in the corrugated form. It is fixed in front of the trumpet, and the card web passed over it before entering the latter. It has the singular effect of curling or doubling over the edges of the web from the doffer to the trumpet, thereby taking in or gathering up the loose fibres that were apt to drop off and be converted into waste. It is a pity, for the inventor's sake, that he did not secure it by patent, as it is far more deserving than many pretentious inventions of less worth, and no carding engine should be constructed without it.

CARDING ENGINE FRAMING.

The several examples of carding engines shown are those of different makers, none of which, however, exhibits the right style of framing as it ought to be made; and, as this is a point of considerable importance, a few observations upon the subject may be necessary.

The top flange of the frame is now generally placed outside, for the greater convenience of getting to the pedestal bolts of the cylinder, doffer, and taker-in; but this convenience, which amounts to very little, is purchased at a dear rate. In the first place, it brings the sides of the cylinder very close to the sides of the framing, and cotton frequently becomes wedged in to a dangerous extent, causing loss of power, heating, and sometimes even fires. In the next place, the engine side is greatly weakened by the want of equilibrium in the contraction when the casting is cooling, for, in addition to the flange being all on the outside, it is usually made three times the thickness of the other parts, for the convenience of planing level after the contortions produced by unequal contraction, which have made the lower part so weak and brittle that it very often splits open, sometimes before the machine is finished, but oftener with the shaking in being removed. Again, engine sides are made in all sorts of ugly forms, sometimes in steps, which are quite unnecessary and unmechanical. It is a very common thing to see the front cross rail placed just under the doffer, or so near to it that waste or fluke lodges upon it, and comes in contact with the doffer, ruffling the web at first, and at length coming up with it in patches, which spoil the carding. Before the invention of the new doffing comb it was necessary

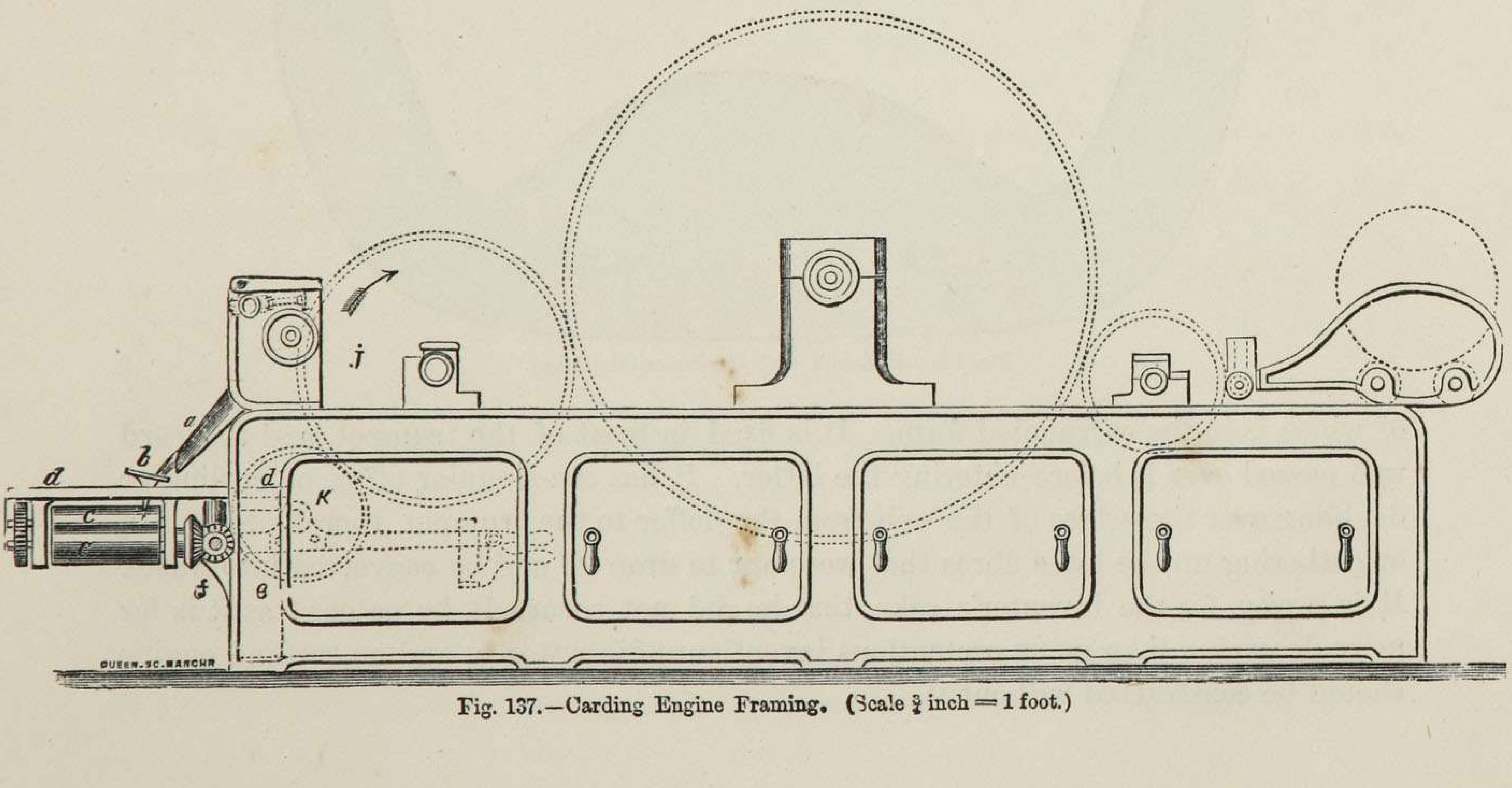


Fig. 137.—Carding Engine Framing. (Scale ⅝ inch = 1 foot.)

to have the front cross rail under the doffer, to make room for the crank shaft that worked the old comb, but, as this no longer exists, there is no reason whatever why the front rail should not be brought forward out of the way of the doffer altogether.

For a 40in. diameter cylinder, a low frame standing about 18in. high, and level all the length of the top flange, is the best and neatest, as in *Fig.* 137, on the opposite page. The cylinder pedestal should be 10 inches high, the doffer about 3 inches, and the licker-in about 2 inches high. This will leave ample carding surface, besides sufficient room in front for stripping out and grinding the main cylinder.

This frame is designed for engines connected together, in which it will be seen that the front cross rail *(e)*, seen in dotted lines (*Fig.* 137), as screwed to the frame side but better in *Fig.* 138, has a plate *(d)* screwed to it. This plate carries pedestals on its underside, to support the shaft *(f)* which gives motion to the whole of the doffers, and also the transverse callender rollers *(c c)*; it likewise supports the trumpet *(b)* on the top side, which receives the web from the doffer, and acts as a guard to the callenders and wheels which drive them. Resting on this plate is a sheet-iron fender or apron *(a)*, painted black, but polished at the (rounded) top edge. This fender fills up the space between the cross rail and doffer, to which it is set up as near as desirable. On the shaft *(f)* is a small spur wheel *(i)*, giving motion to the doffer *(j)*, through the carrier *(k)*, resting on a lever, the fulcrum of which is concentric with the shaft *(f)*; the other end of the lever being held up by a catch when the carrier wheel is geared with the doffer, and when liberated from the catch the wheel *(k)* falls out of gear with the doffer wheel, but remains in gear with the driving pinion *(i)*. When grinding the engine, it will only be necessary to take the side shaft out of gear, and the strap off the main cylinder, and drive the latter from the doffer, when both will be driven at a slow speed from the small pinion *(i)*, and in this simple manner, it is hoped, the desideratum before mentioned in the chapter on grinding may be obtained.

The connecting of cards together, before alluded to (*Page* 126), is believed to be a matter of considerable importance, when *properly* done, as it saves both machinery, power, oil, and labour. It has therefore been thought worth while to give further details, showing the latest ideas of the author upon this subject, as combined with the new system of grinding previously mentioned. Thus *Fig.* 138 shows front elevation of engines connected; and *Fig.* 139 shows plan of same, everything being reduced to the greatest possible simplicity.

It will be seen that the web of cotton from the doffer enters the trumpet, which is fixed in the plate *d*, and passes through the callender rollers *c c*, alongside the slivers, from the hind cards. The trumpets are all placed in a line at an equal distance from the doffers; and the transverse callender rollers not only take the web from each card, but they draw up the ends from the whole line of cards, and keep them tight, as the diameter of the callenders increases about 1-32nd of an inch at each succeeding card, all along the line. Thus, suppose nine engines are connected together, and the first pair of callenders are $2\frac{1}{2}$ inches diameter, the last pair next the drawing head would be $2\frac{3}{4}$ inches diameter, all going at the same speed. This progressive tightening of the ends supports the cotton from one engine to another without the necessity of either belt or trough, also makes the connection extremely simple, and prevents any breakage of the ends through sticking in the trough, which is often the case where a trough is used.

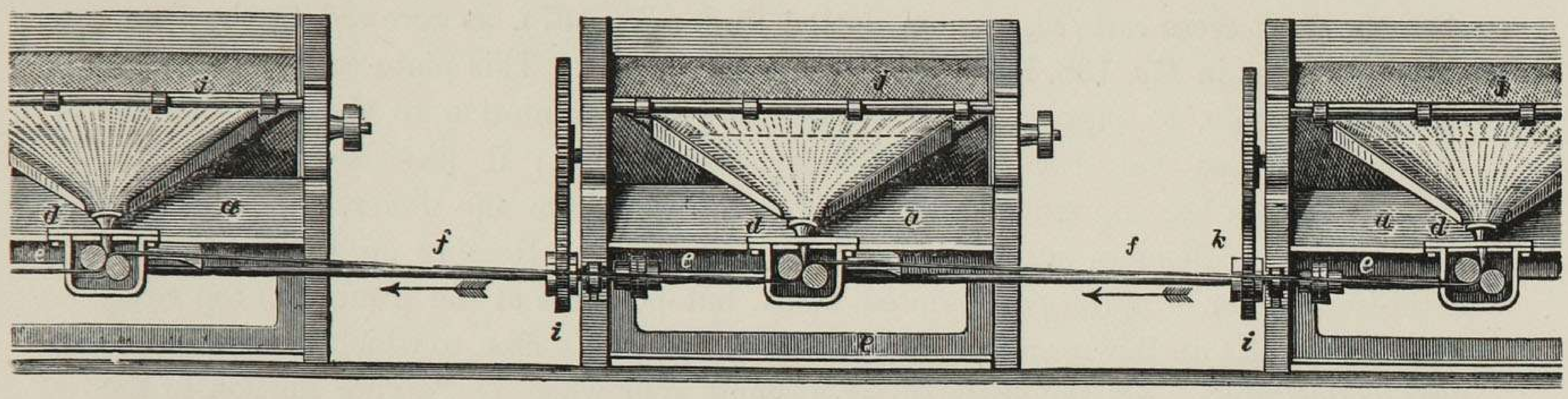


Fig. 138.—Front Elevation of Connected Cards.

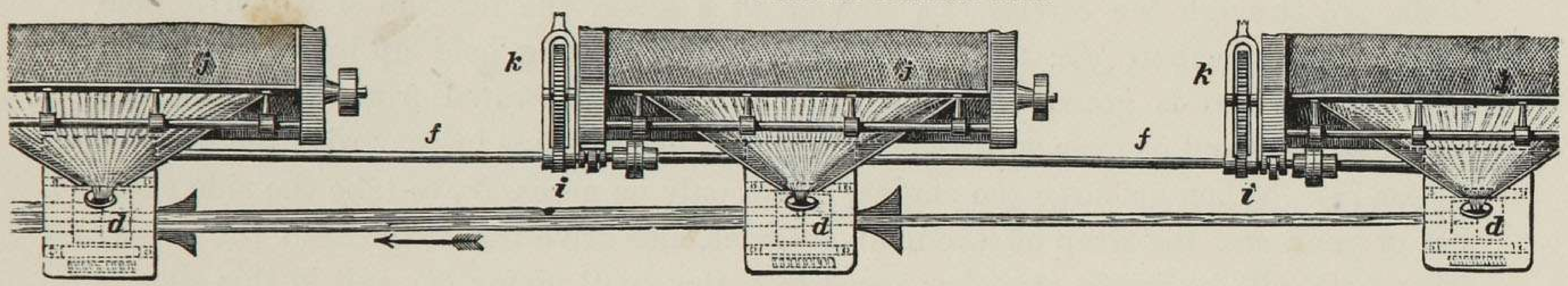


Fig. 139.—Plan of Connected Cards.

Should a cover or guard be desired for the slivers, two plates of flat iron, about 4 inches deep, may be fixed to the plates *d*, one on each side of the slivers. These plates must be glazed inside, and the back one have a cover of wood or iron hinged to it, so as to form a trough without bottom; and in cases where the cards are set too far apart, a rounded piece of iron or bar may be fixed to the bottom, about half the distance between the two cards, to support the slivers, or a roller driven from the shaft *f*.

An "*Evener*" should be used at the drawing head to coupled cards, which is an arrangement by which the front roller is driven faster or slower, as the slivers vary in weight, from an end being down when grinding or stripping out.

General Observations.—Closing the important subject of the carding engine, and taking a retrospective view of what has been accomplished during the first century of its existence, it must be admitted that considerable progress has been made, and that the whole subject seems to be thoroughly understood; but nevertheless it is still very far from approaching not only what may be desired, but to what is really practicable and within the reach of advanced mechanism.

It is not in the nature of things that any art, Minerva-like, should at once attain perfection; only by patient toiling onward, step by step, can one grasp what seems by the light of this day to be the limit of human attainment.

Ere another century pass away,—nay probably much less, for improvements are now accelerated,—and the best examples of the present carding engine will seem crude and ponderous. It requires neither the foresight of a prophet, nor the penetration of a philosopher, to discern its still existing imperfections, but only calm reflection, which whispers that hundreds of tons of coal are daily wasted in turning superfluous matter, giving motion to clumsy, complex, and unnecessary gearing. True it is that hand-stripping has been superseded, but not in that perfectly satisfactory manner which is desirable, for the best examples given in these pages are but crude and imperfect. Then, again, attention may be called to the futile attempts made to strip the cylinder running, which is not only very desirable, but believed to be quite within the reach of skill, and of easy accomplishment.

There is also, to some extent, a waste of capital in the construction of carding engines; they ought to cost less for the effect produced. Of late it has become the custom to have the main cylinder of large diameter, from 45in. to 60in., which increases the expense of a carding engine very materially, and absorbs more power in driving it.

If judiciously constructed, as much wire can be got upon a carding engine with a 40in. diameter cylinder as it will be profitable for the cotton to pass over at one operation, and, besides costing less, the low built engine has many conveniences about it that are very desirable.

Again, the setting up of the surfaces first on one side of the engine then on the other, one side of a roller or flat at a time, bit by bit, the carder often forgetting which side he set last in a room of carding engines, is very imperfect, causing both trouble and mischief. Leigh's Flexible Bend, although not absolutely exact, was nevertheless the first step in the right direction, and dispensed with very many setting screws. Ugly bolts, innumerable and unnecessary set screws, still exist in the best examples of modern carding engines, baffling and perplexing the most careful carder. A more correct and efficient system of setting is clearly indicated, by which all the working surfaces of the cards can be made to converge steadily and with mechanical precision, without derangement of parallel, towards the centre of the cylinder, when from the wear of the wire it becomes necessary to set them closer.

THE COMBING MACHINE.

SINCE the days of Arkwright, Crompton, and Kay, nothing so striking and romantically successful has been invented in cotton-spinning machinery as this most ingenious and useful machine. Before its introduction, it was impossible to spin cotton so fine as is now easily practicable, because, when carefully managed, it not only takes out the whole of the neps and dirt, but it extracts the shortest fibres also, which become mingled with the motes. True, it makes a great deal of waste, but that waste is not altogether lost. It is absolutely necessary to use the carding engine before combing, therefore the combing machine can only supersede the finisher card for fine yarns, or where first-class work is demanded.

The following interesting account of this singular machine has been contributed by Messrs. Hetherington:—

The combing machine is the invention of Mr. Heilmann, of Alsace, in France. It first made its appearance in this country at the International Exhibition of 1851, and shortly afterwards a company was formed in Manchester for the purchase of the patent as applicable to the cotton trade, and for which they paid £30,000. The company consisted of five firms, the most extensive in the trade in the spinning of the finest yarns, and the firm of Messrs. John Hetherington and Sons, of Manchester, was selected as their machine-maker. For some time the Patent Combing Company restricted the making of machines to the supply of the members, but after their wants had been provided for, and they had obtained a command of the market, they, on numerous applications from other spinners of fine yarns, consented to supply the trade generally at a price of £500 per machine, £300 of this amount being a charge for royalty. These charges were afterwards modified and gradually reduced, as the term of the patent ran out. The patent was, however, practically extended by the improvements introduced by Messrs. Hetherington, which improvements were embodied in all the machines made subsequently. and the patents for these were purchased from Mr. Hetherington by the Patent Combing Company.

Although the combing machine was at first thought applicable only to the counts of yarn finer than No. 200, it was soon found that its range was a much larger one; where quality was an object it became indispensable, and instead of No. 200 being the minimum, this was speedily reduced to No. 120; and it did not stop here, for it has since been found that superior combed single yarn will supersede with advantage the doubled yarn previously used, and this opens another wide field for the use of the combing machine. In the manufacture of sewing thread also, the advantage of yarns made from combed cotton was soon appreciated, so that now Nos. 50, 60, and 80 for such work are combed as well as some special yarns of Nos. 32 to 40.

Some idea of the advantages which have attended the introduction of combing machines can be formed from the fact that there are already more than 1,600 of them at work, each producing weekly from 120 to 200lbs. of combed cotton, spun principally into the finest counts of yarn.

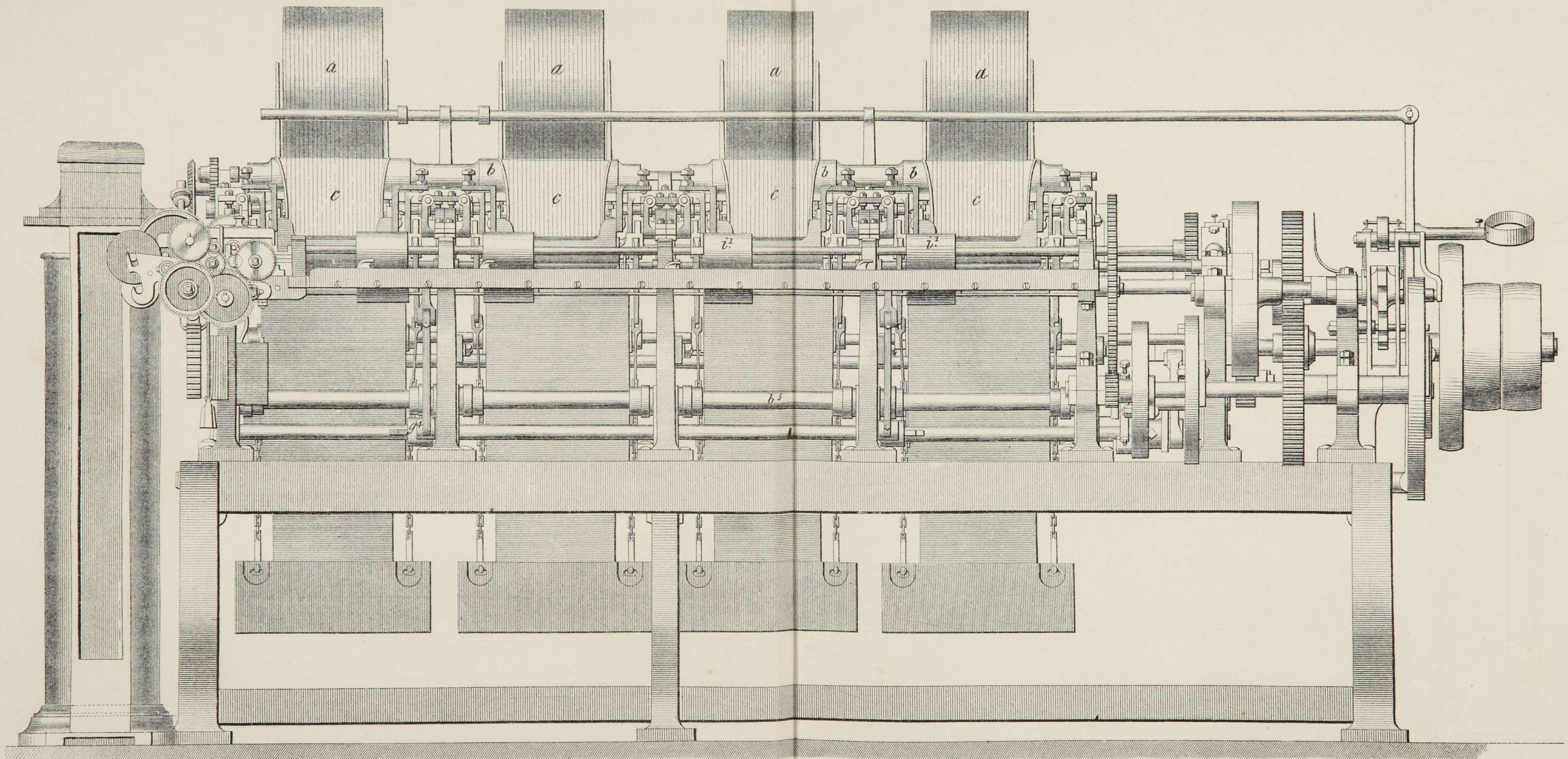
The following description and reference to the drawings in Plates XXIV. and XXV. will explain the working of the machine It is usually made of six heads; but as each of the heads works in a precisely similar way, the cross section Fig. 140, showing a view across the middle of one of these heads will serve to explain the working parts.

HEILMANN'S COMBING MACHINE OF 4 HEADS,

AS MADE BY MESSRS. JOHN HETHERINGTON & SONS.

SCALE 1 INCH TO ONE FOOT.

FIG 1. FRONT ELEVATION.



J. GALLOWAY, LITH. MANCHESTER.

HEILMANN'S COMBING MACHINE OF 4 HEADS.

SCALE 1 INCH TO ONE FOOT.

FIG 2.
END ELEVATION.

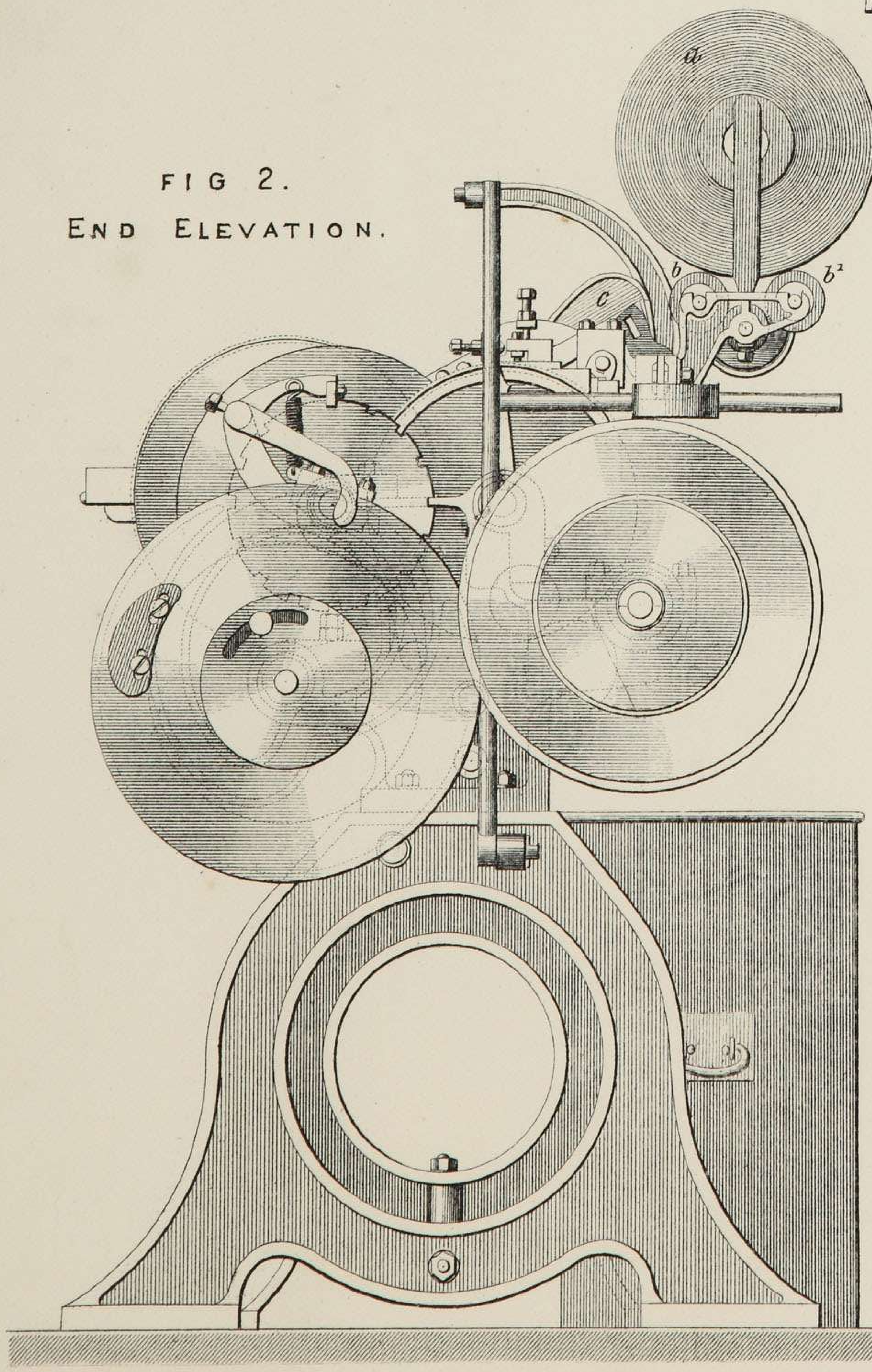
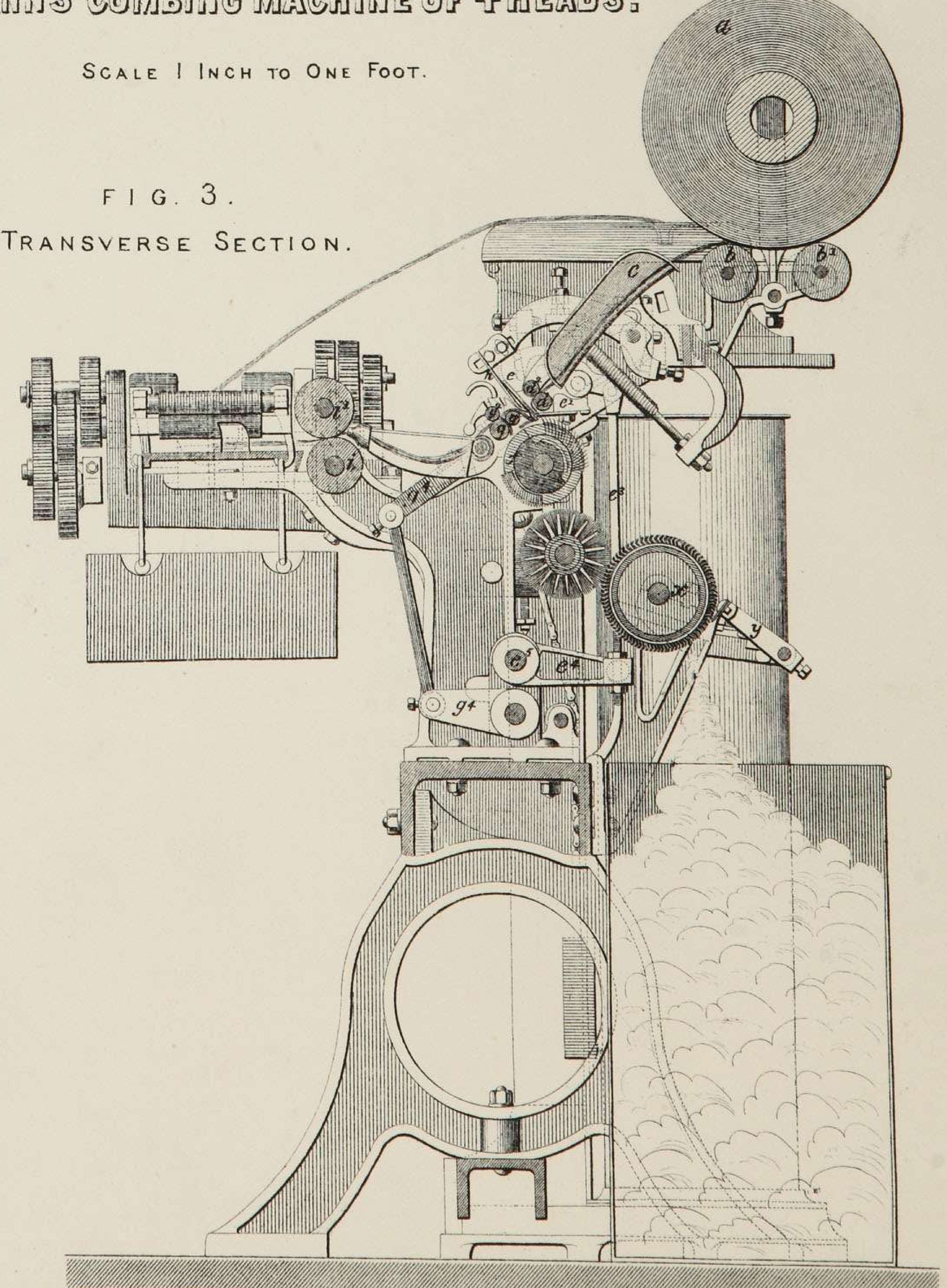


FIG. 3.
TRANSVERSE SECTION.



J. GALLOWAY, LITH: MANCHESTER.

The lap of cotton *a* is placed upon the two rollers *b* and b^1, and motion is given to these rollers to unwind the fleece of cotton from the roller or lap *a*; as it is unwound the fleece passes down the inclined guide *c*, and between the feeding rollers *d* and d^1, the under one *d* being a fluted steel roller, and the upper one covered with cloth and leather, made also of steel to resist yielding where the diameter is small. These rollers receive an intermittent motion whilst the nipper is open; each turn of the cylinder shaft through a star wheel of five teeth and other gearing moving the roller *d* $\frac{1}{10}$ to $\frac{1}{12}$ of a revolution. From the feeding rollers the fleece passes between the top and bottom jaws of the nipper; the top one is the nipper blade marked *e*, and the bottom one e^1 is usually called the cushion plate, as it is covered with cloth and leather. To the nipper blade *e* motion is given from a cam at the gearing end of the machine, transmitted through the lever e^2 and connecting rod e^3, lever e^4, and shaft e^5. More motion is given to the nipper blade *e* than is required to close it upon the cushion plate; and as the cushion plate is hung from the pivot e^6, and is held forward by a spring, it is forced backwards by the continued movement of the nipper blade into the position best suited to present the front ends of cotton fibres to the action of the combing cylinder; and the reverse movement of the cam allows the cushion plate and nipper blade to move forward, with the cotton between them, into such a position that as soon as the nipper blade rises the ends of the partially combed fibres are taken hold of by the top detaching

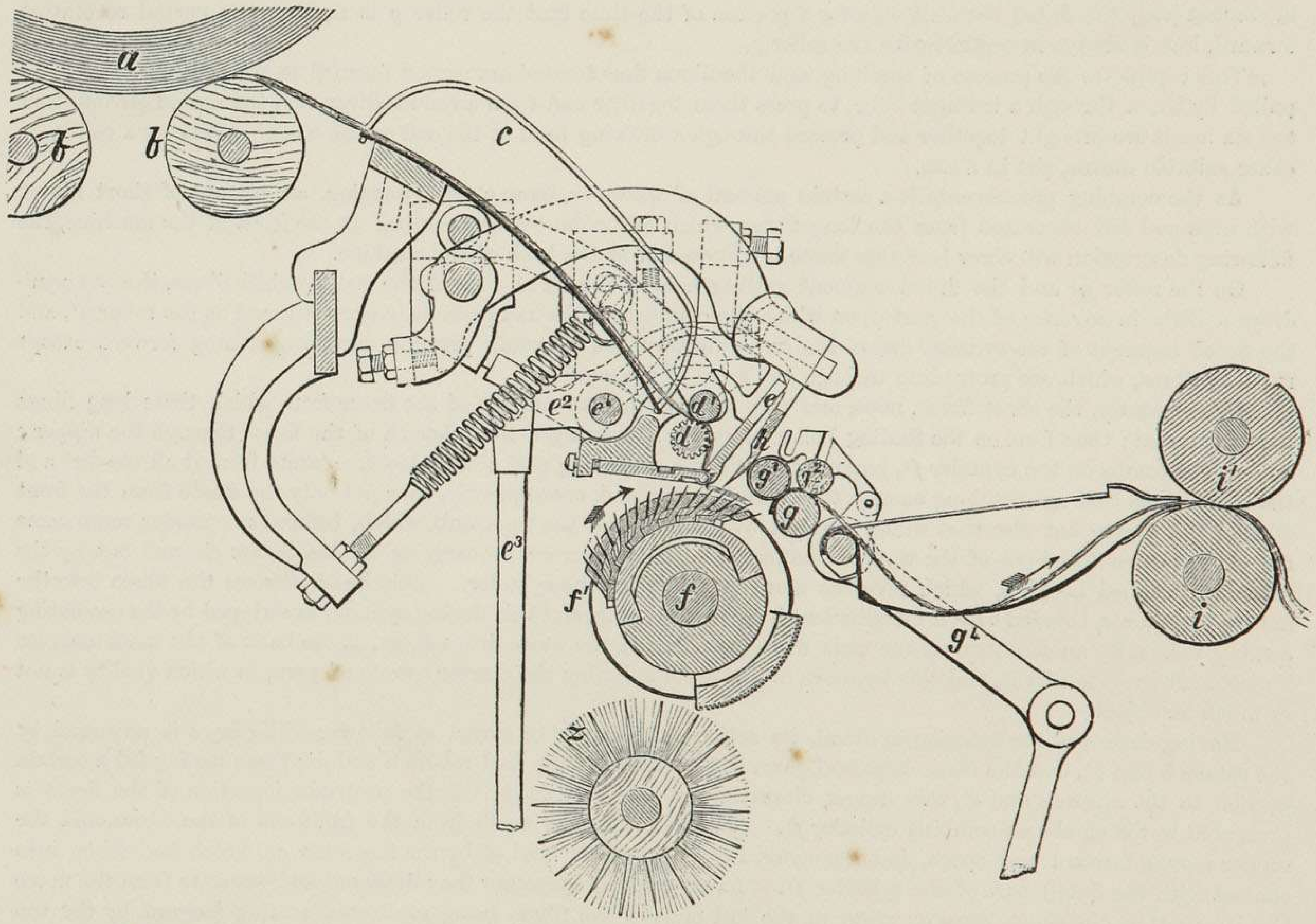


Fig. 140.—Transverse Section of Heilmann's Combing Machine.

roller g^1 and fluted segment on the cylinder f^1. The shaft *f* carries the combing cylinder f^1. This cylinder is covered on one part of its circumference by a series of seventeen combs, commencing with combs having thirty teeth in a lineal inch, and gradually getting finer to the last, which has ninety teeth in the inch. On the opposite side of the cylinder to the combs there is a fluted segment, which acts in connection with the leather roller g^1; there is a space at each side between the fluted segment and the combs, which gives time (as the cylinder has a continuous motion) to make the necessary changes between the combs ceasing to act and the fluted segment coming in action, and *vice versa*.

The top comb *h* is furnished with a row of fine teeth; its use is to comb the tail ends of the fibres, and it prevents any fibres being drawn forward except those the front ends of which have been straightened out and cleaned by the cylinder combs. The only movement the top comb has is given by a small cam, which lifts it out of the way whilst the cylinder comb passes under it, and allows it to drop into the tuft of fibres before the fluted segment and rollers draw these fibres forward.

The roller *g*, called the detaching roller, with its top leather-covered roller g^1, and accessory roller g^2, receives its motion from a cam on the end of the machine; the movement of the cam is arranged to turn the roller *g* one-third of a revolution backwards, then to reverse and move two-thirds of a revolution forwards, and there stop till the cylinder combs have prepared another length of fibre.

The reverse movement is given to the roller *g* to take back the tail ends of the previously combed fibres, so as to place them under and piece them up with the fibres coming forward from the combs, into a continuous sliver or riband; for it is necessary to detach the fibres under operation from the remainder of the fleece as fed in, and also from the fibres already combed. The piecing-up being effected, the roller *g* reverses, and removes the next length of fibres out of the way of the cylinder combs.

In order properly to catch the partially combed fibres, the top roller g^1 is allowed to move round the axis of the roller *g*, into contact with the fluted segment of cylinder f^1, thus forming a revolving nipper. The top roller g^1 is let down into contact by the lever g^4, and its connections form a cam at the gearing end of the machine; this top roller g^1 is in contact with the fluted segment only for a portion of the time that the roller *g* is making the partial revolution forward, but is always in contact with the roller *g*.

This completes the process of combing, and the fibres thus treated are passed forward to the rollers *i* and i^1, and pulled by them through a trumpet tube, to press them together and form a round sliver, and the united slivers from the six heads are brought together and pressed through a drawing head at the end of the machine, and by a coiler, or other suitable means, put in a can.

As the combing process entails a certain amount of waste, or, more correctly saying, an amount of short fibres, with neps and dirt separated from the long fibres, which are taken out as described at the front of the machine, the following description will show how this waste is disposed of at the back of the machine.

On the roller g^1 and the fluted segment getting hold of the front ends of the half-combed fibres, the top comb drops a little in advance of the part upon which the cylinder combs had previously operated, and as the roller g^1, and the fluted segment of the cylinder draws the fibres forward, the top comb prevents anything coming forward except the long fibres, which are protruding through the teeth of the comb.

Consequently, the short fibres, neps, and dirt are left in that portion of the fleece from which these long fibres have separated; therefore, on the feeding rollers *d* and d^1 delivering a fresh length of the fleece through the nipper *e* and e^1, the combs on the cylinder f^1, passing through the projecting part of this fleece, separate from it all the dirt and the short fibres that are not long enough to be firmly held; and, consequently, take not only the waste from the front ends of the fibres, but also that which was left by the action of the top comb, which, before the cylinder comb came round, had been lifted out of the way. The teeth of the cylinder combs carrying the waste, are cleaned out by the revolving bristled brush *z*, which revolves more quickly than the cylinder. This brush throws the fibres into the doffing cylinder *x*, covered with a metallic brush or card clothing, and this doffing cylinder is stripped by the oscillating comb *y*, driven by an eccentric on the main driving shaft, and the waste drops down, at the back of the machine, into a receptacle provided for it, and this becomes available for spinning the coarser counts of yarn, in which quality is not so much an object.

Having described the machine in detail, its action may shortly be stated as follows:—The lap *a* is unwound by the rollers *b* and b^1, and the fleece is passed down the conductor to the feed rollers *d* and d^1; these having fed a certain portion to the nipper *e* and e^1, this nipper closes and moves backwards till the protruding portion of the fleece is presented to the combs on combing cylinder f^1. These separate the waste from the front end of the fibres, and the nipper moves forward and opens, and the combed ends are taken hold of by the top roller g^1, which had fallen into contact with the fluted part of the cylinder f^1. As they revolve together they draw out and separate from the fleece the long cotton, the short fibres or waste in the tail ends of the fibres being prevented coming forward by the top comb, which drops amongst the fibres for this purpose. This would complete the combing of one length of fibres, but the fibres previously combed require piecing-up to the fresh ones that come forward; consequently, in anticipation of these coming forward, the motion of the roller *g* is reversed and made to return those previously combed, so that the fibres which have just been combed are placed so as to overlap those immediately before, and by this means a continuous fleece or sliver is produced. The action of each of the six heads being simultaneous, there is a sliver coming forward from each, and these are united upon the plate in front of the machine, and passed along it through a drawing head, consisting of three pairs of drawing rollers and a pair of callender rollers. These consolidate the sliver so that it may be more readily lifted out of the can or receptacle into which it is placed, either direct from these callender rollers, or, for the coarser qualities of work, through a coiling motion, which puts a larger quantity into a can, in which it is taken to the next process, and is again doubled six ends into one, and drawn down, and reunited in one sliver.

IMB'S COMBING MACHINE.

AS MADE BY MESSRS. CURTIS, PARR & MADELEY.

SCALE 1 INCH TO 1 FOOT.

FIG: 1.

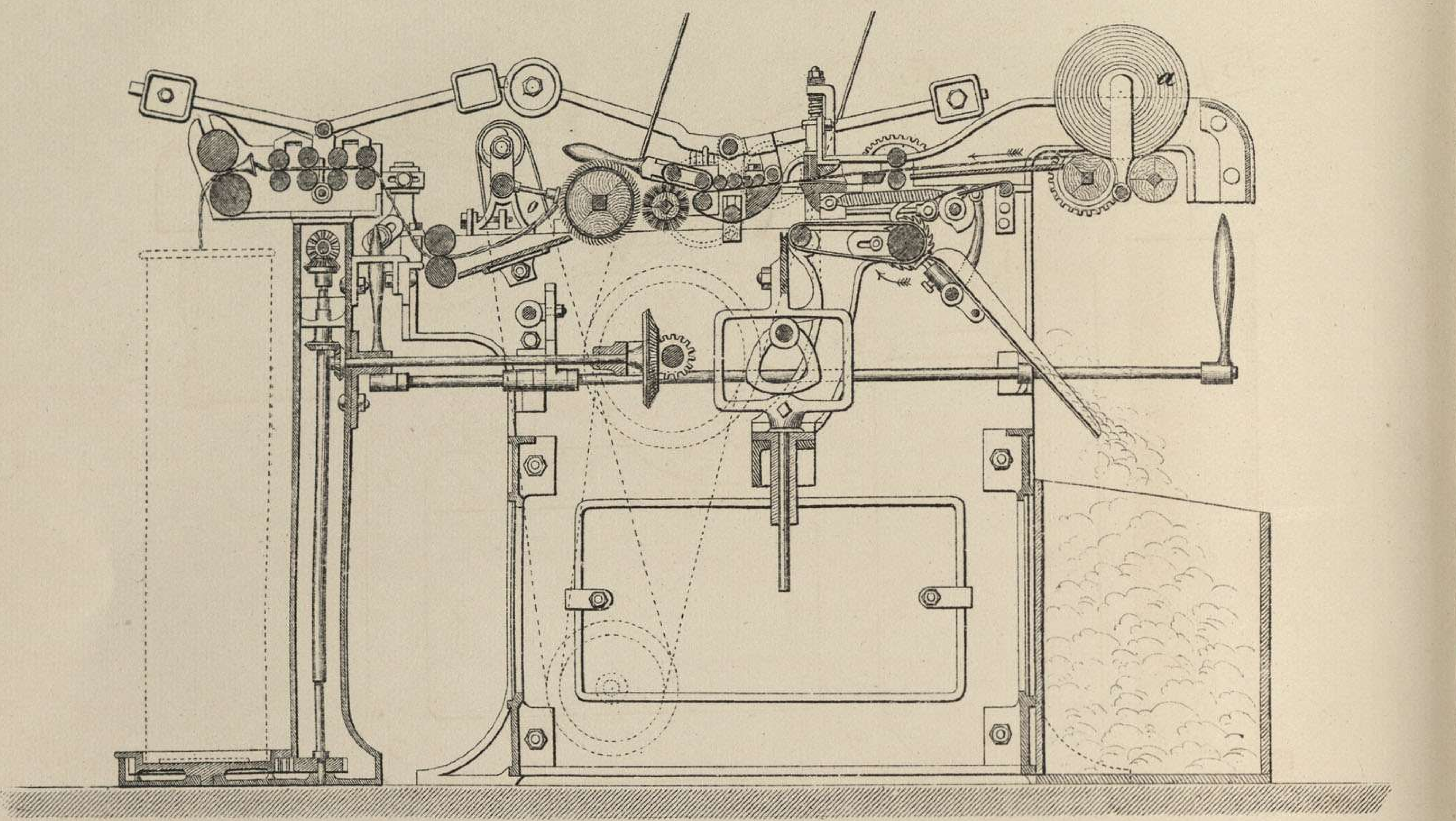


FIG: 2.

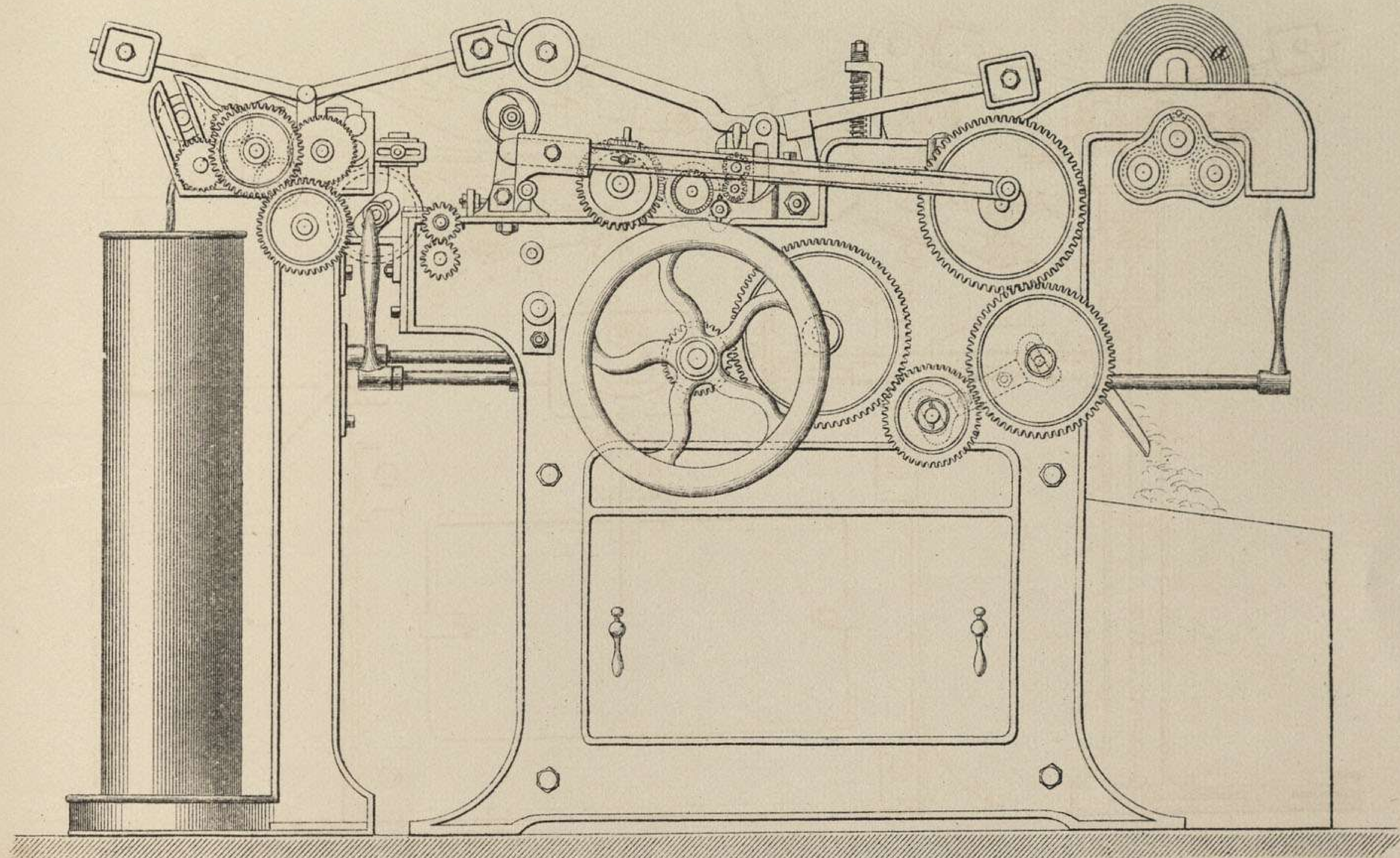


FIG: 3.

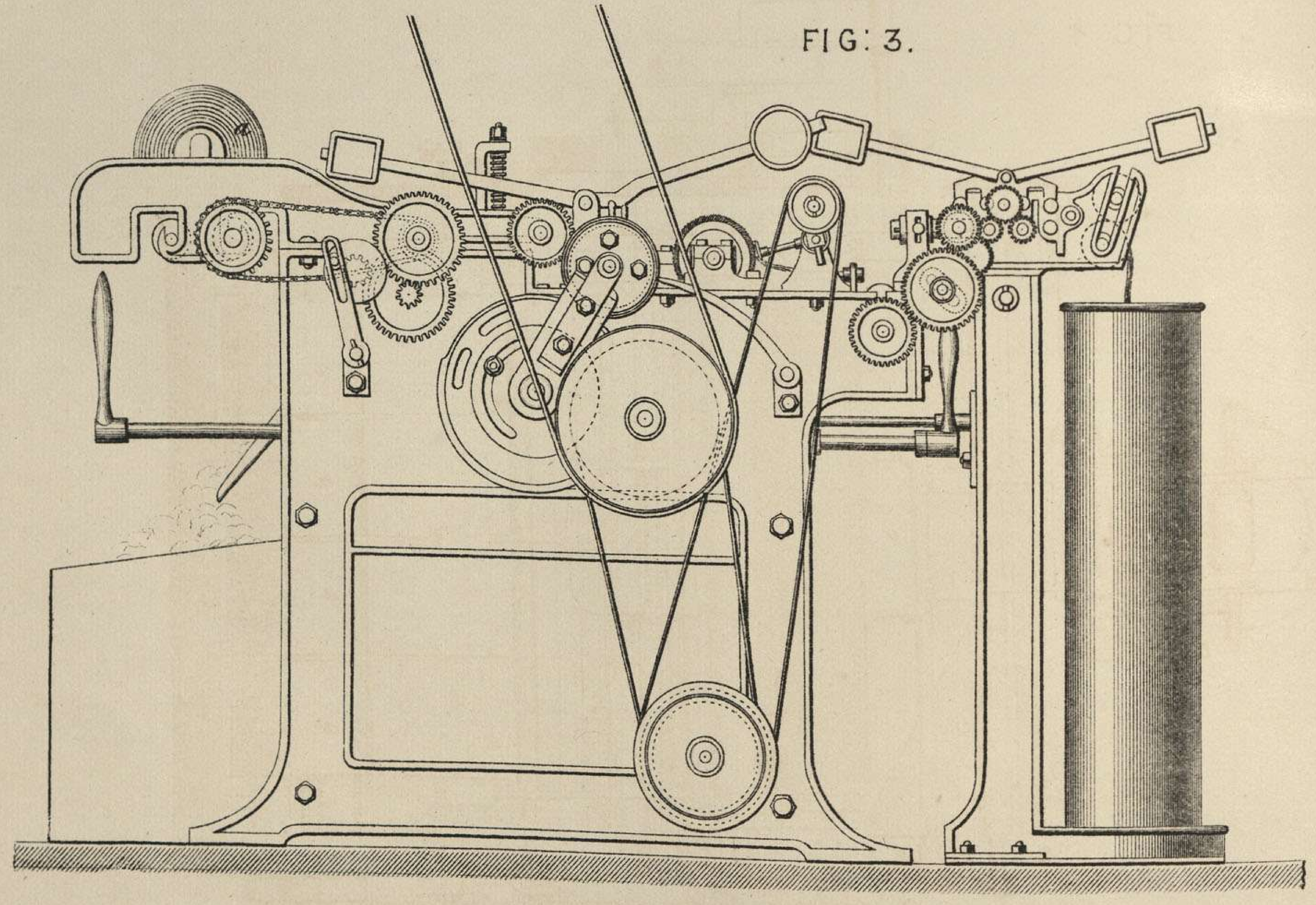
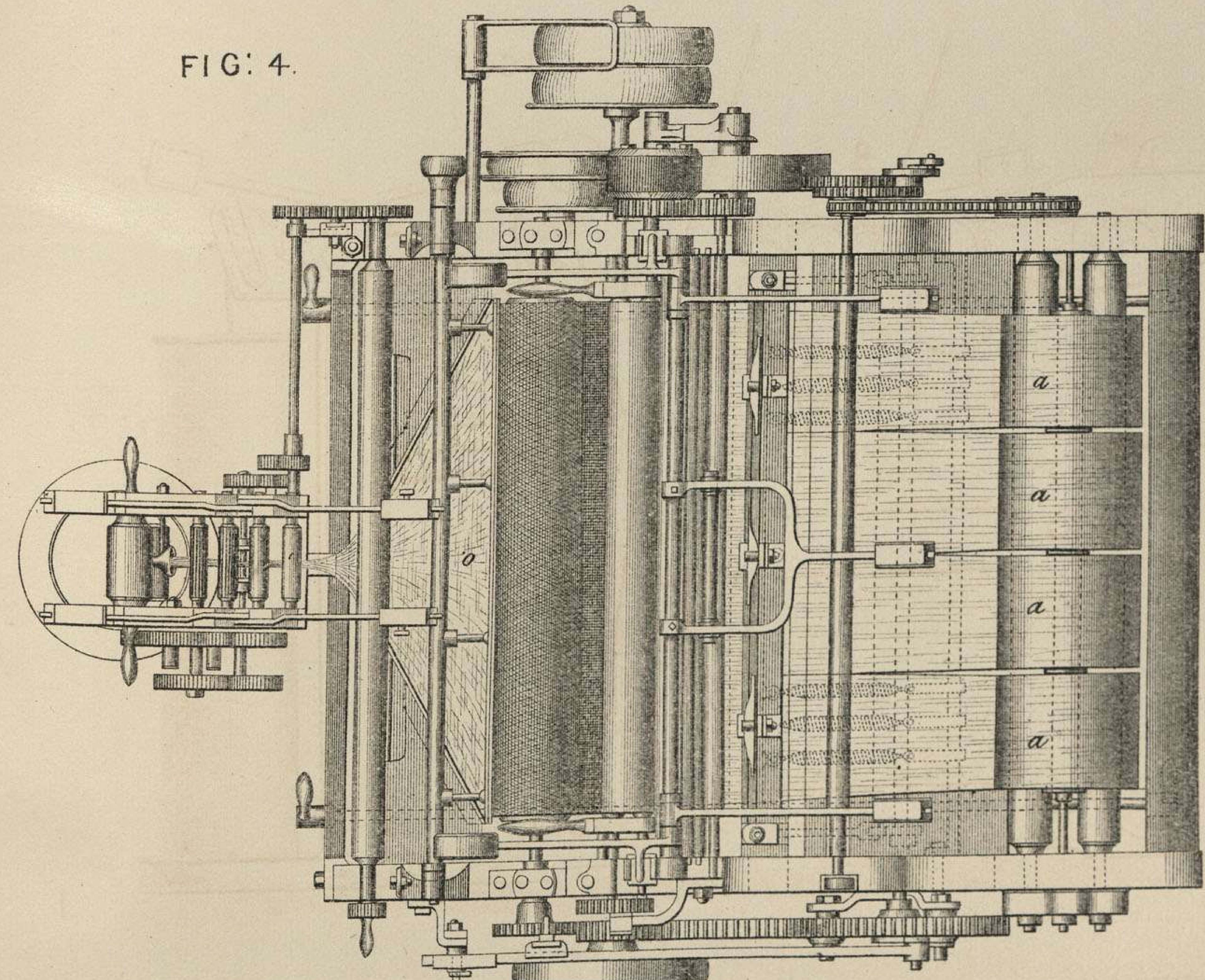


FIG: 4.



J. GALLOWAY, LITH: MANCHESTER.

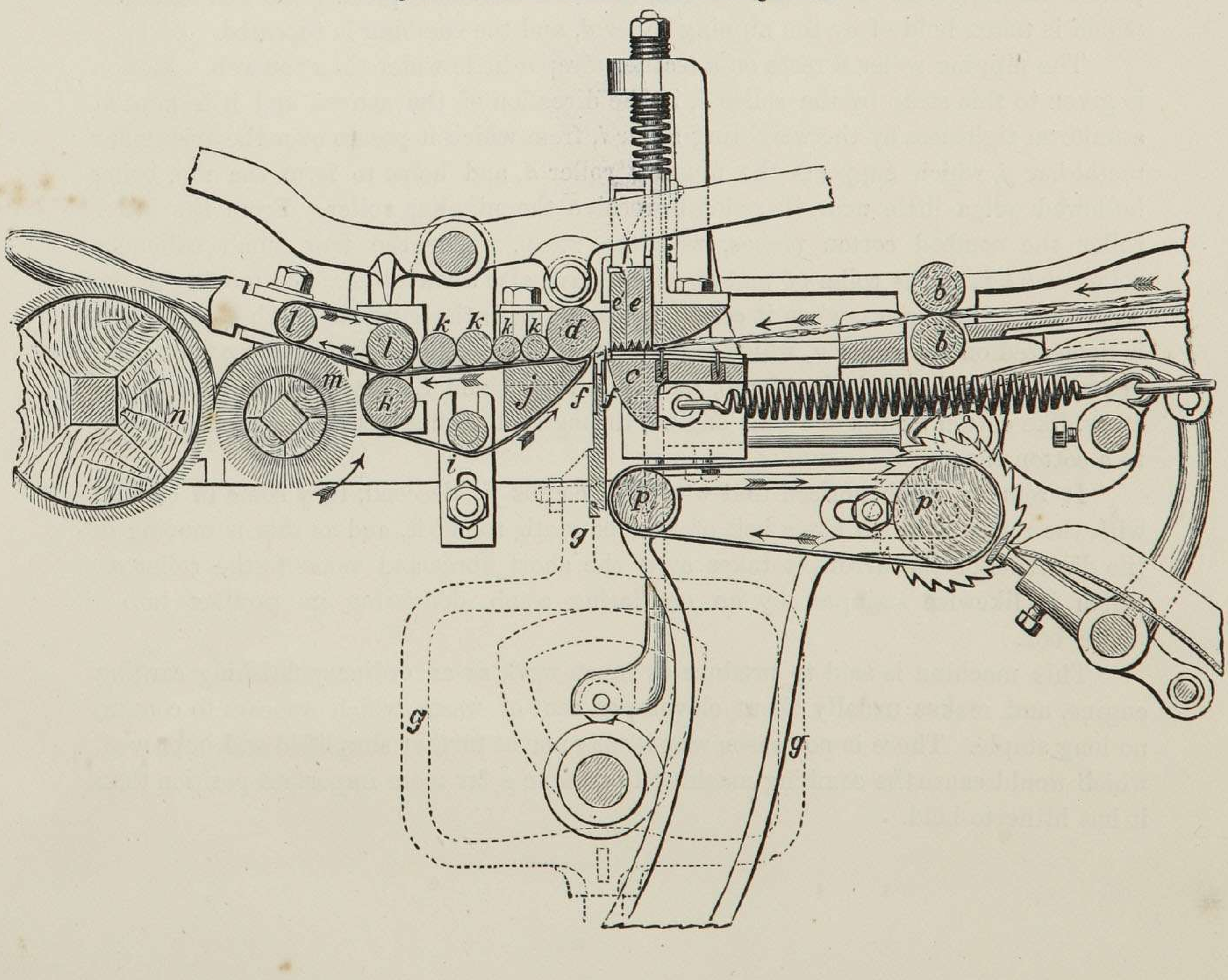
Several other patents have been taken out for combing machines, which it is unnecessary to illustrate or dwell upon, as they have not been very successful; but one which is the invention of Joseph Imbs appears to have considerable merit, and is just now being introduced by Messrs. Curtis, Parr, and Madeley.

It is proper to state that this machine has not yet been introduced into the Manchester mills, having only just started for exhibition; and the reason why it has been thought worthy of illustration is because it exhibits a new feature in combing, which, if successful after it comes into practicable operation, may have an important bearing on cotton spinning.

JOSEPH IMBS' COMBING MACHINE.

This machine was patented in England on the 1st January, 1869, by Joseph Imbs, a native of France, and has just been taken in hand by Messrs. Curtis, Parr, and Madeley, of this city, and the drawings represented on Plate XXVI. and *Fig.* 141 are

Fig. 141.—Transverse Section of Imbs' Combing Machine.



taken from the machine imported by them, under the superintendence of the inventor. *Fig.* 1, Plate XXVI., shows section of the machine: *Fig.* 2, right hand elevation; *Fig.* 3, left hand elevation; and *Fig.* 4, plan of same.

Its action will be best understood on referring to *Fig.* 141, which shows section of the principal parts on a larger scale. Cotton is fed to the machine by four laps *a a a a* (doubled from breaker cards), of about 8in. wide each, making together a feed of 32in. wide. These laps are drawn off by the rollers *b b*, which have a constant motion, and the cotton enters the machine in the direction of the arrow, over a cushioned table *c*, covered with cloth and leather, and passes on to the nipping roller *d*, which together with the other rollers, brush, and doffer, have an intermittent motion. The grooved slides $e\,e^1$, then descend upon the cushion, and hold the cotton fast, at the same time the two combs *f f*, attached to the frame *g*, ascend through the cotton, when immediately the cushioned table, together with the nippers, are drawn back, parting the web asunder; the combs then descend, and bring with them any motes or short staple contained in the length of web between the two combs. The slide then rises, the rollers having given out another length, the table advances, piecing the web together, which is taken hold of by the nipping roller *d*, and the combing is repeated.

The nipping roller *d* rests on a leather strap a little wider than the web. Motion is given to this strap by the roller *h*, in the direction of the arrows, and it is kept at a uniform tightness by the weighting roller *i*, from which it passes over the triangular metal bar *j*, which supports the nipping roller *d*, and helps to form the nip, being hollowed out a little near its point to receive the nipping roller. From the latter roller the combed cotton passes, with the strap, under the four small callender rollers *k k k k*, to the rollers *l* and l^1, which have also a travelling belt moving in the direction of the arrows, when it comes in contact with the circular brush *m*, and by it is deposited on the roller *n*, which is covered with card fillet. It is stripped from the latter by an ordinary doffing comb, seen at *o*, *Figs.* 1 and 4, Plate XXVI., and comes away, like cotton from a carding engine, through a drawing box and callender rollers to a cotton can.

It remains to be noticed that when the combs *f f* descend, they come in contact with the roller *p*, which has a belt of woollen cloth round it, and as this is moving in the direction of the arrow, it takes away the short fibres and motes to the roller p^1, which is likewise stripped by an oscillating comb, delivering its product into a waste box.

This machine is said to produce as much work as an ordinary finishing carding engine, and makes usually about eleven per cent of waste, which appears to contain no long staple. There is no reason why it may not be further simplified and improved, which would cause the combing machine to assume a far more important position than it has hitherto held.

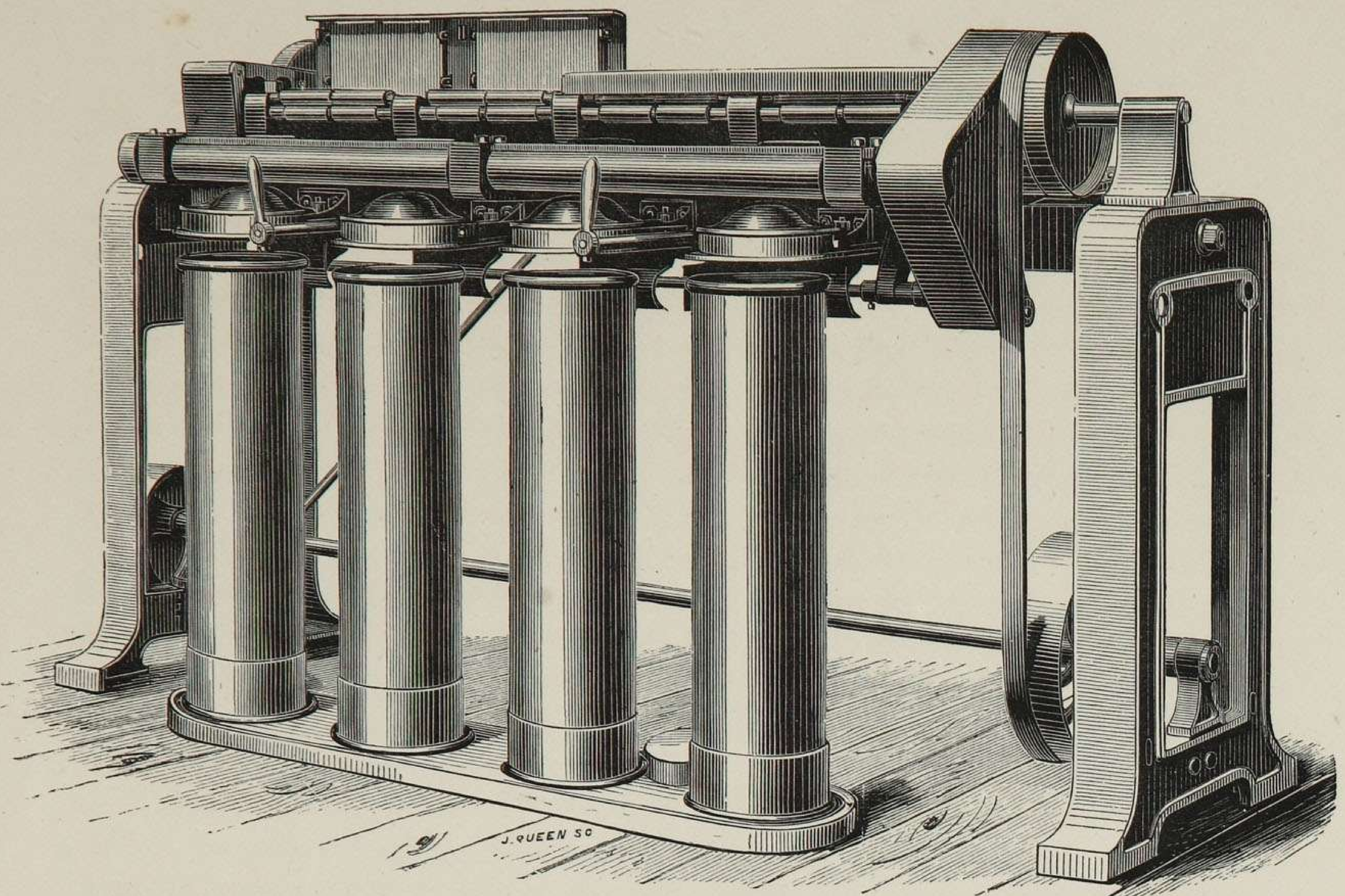


Fig. 142.—Front View of Drawing Frame.

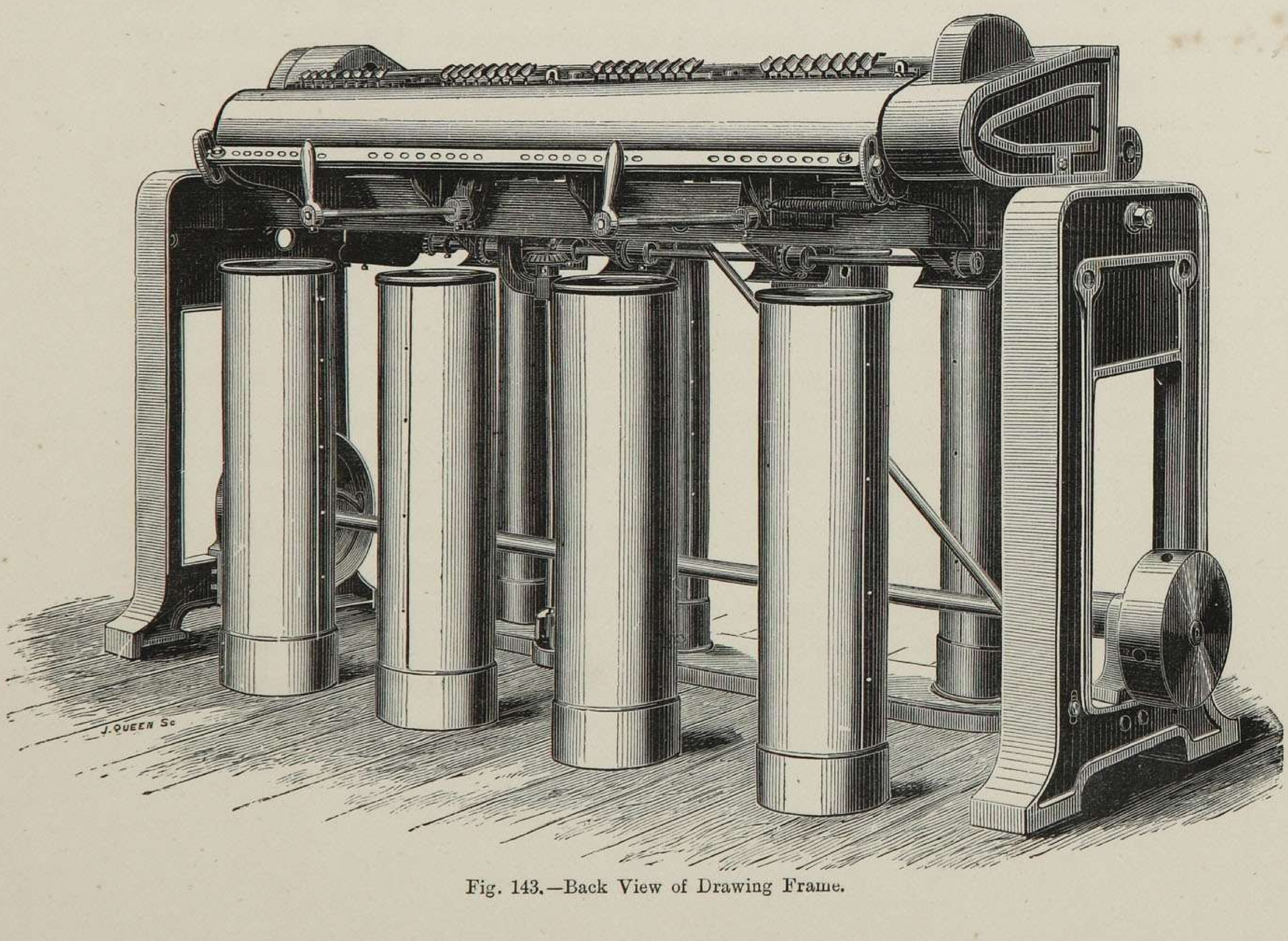


Fig. 143.—Back View of Drawing Frame.

The difference in the combing action betwixt Heilmann's machine and Imbs' is very conspicuous: the former passing, by a rotary motion, a series of combs varying in fineness from 50 to 70 teeth to the inch, through *one* end of the fibres; whilst Imbs' machine pierces the fibres close to the nip on both sides before the web is drawn asunder, when one side is combed by the drawing back of the slivers, and the other by the advance of the same through the action of the forward nip. The quantity of waste made depends in a great measure upon the fineness of the combs. It is said to be capable of using laps of 14 dwts. to the yard, whilst Heilmann's can only use laps of 9 dwts., and with such laps can turn out 320 lbs. per week, making about 11 per cent of waste, which appears to contain no long staple. If this statement proves correct, the days of the finisher card are numbered, for no carding engine can produce as good a quality of work as a well-constructed combing machine.

THE DRAWING FRAME.

The first attempt to draw cotton by a succession of pairs of rollers, each moving faster than the preceding, was made by Lewis Paul, and was named in his patent of 1738; but the Drawing Frame proper, by which the continuous slivers from carding engines were doubled again and again, drawn and redrawn, so as to lay the fibres in parallel lines, is undoubtedly due to Arkwright. Paul's idea was to reduce a single rope or sliver by rollers before twisting it into yarn; whilst Arkwright sought, by repeated drawing and doubling, to straighten, equalise, and prepare the sliver for twist. If a magnifying glass be held to cotton when it comes from the card, it will be seen that the fibres lie in all directions. The drawing process which follows carries out Arkwright's idea now in a far more perfect manner than was possible in his days, as will be seen by inspecting the elegant and substantial machinery used for this purpose.

The stop motion now so indispensable an appendage and effectively applied, was first invented by James Smith of Deanston, and patented by him in 1841.

The two perspective views, *Figs.* 142 and 143, show front and back of a Drawing Frame of the most modern construction; and *Figs.* 1, 2, 3, 4, Plate XXVII., show respectively a section, side elevation, front elevation, and plan of the same. From these its action will be understood as follows, viz.: *a a* represents the framing; *b b b b* the bottom fluted drawing rollers; *c c c c* the top drawing rollers, the two back rollers in this instance being corrugated, and the two front rollers Leigh's loose boss. The dotted lines *d d d* represent cotton slivers entering the frame from the cans. After passing through countersunk holes in the horizontal plate *e*, it goes over a semicircular conductor to another guide plate *f*, in front of which is the balanced spoon *g* which is made in the form of a compound lever, having a jointed tailpiece at the opposite end to the spoon, and a fulcrum pivot at *h*. When cotton is going through the frame, the lever is held in the position shown by the cotton sliver passing over the spoon, but when an end breaks the spoon rises, because the other end of the lever is slightly heavier, and the pendant piece g^1 drops down and stops the notched shaft *i*, which being driven through a catch-box, the sliding half is forced aside, and thereby stops the frame. A similar contrivance is placed in front of the frame over the callender rollers *j j*, by a trumpet fixed on the end of the long compound lever *k*. This lever is nicely balanced by the weight *l*, which has slightly the preponderance, but is held up by the pressure of the cotton going through the trumpet; but should the end break, the weighted end of the lever immediately falls, and coming in contact with the notched shaft stops the frame, as before explained.

The spoon lever *g* and the long lever *k* would be more sensitive if their fulcrums were like those of a weigh beam.

After the end has passed through the front horizontal callender rollers *j j*, it enters the can through a slanting pap in the revolving disc *m*, which being set eccentric, with the can underneath, deposits the cotton in circular layers from the side to about two-thirds the diameter of the can; and the latter moving slowly round, causes the web to be equally and neatly laid in circles which cross each other, so that, when drawn out of the can again it leaves freely, without sticking in lumps. This very ingenious contrivance is the celebrated "coiling motion," patented about thirty years ago by Messrs. Tatham and Cheetham, of Rochdale, and is now almost universally adopted to drawing frames and carding engines, where the latter are not connected together. It is scarcely necessary to go further into the details of thisdrawing frame, which is a simple machine and easily understood; the example here given, as far as neatness and solidity of workmanship go, can hardly be exceeded. Attention must, however, be called to the arrangement of the gearing, which shows that the front roller has nearly all the work to do, as usual, but to which exception is taken for reasons already explained.

There is much difference of opinion amongst practical men as to the number of doublings which ought to be given in the drawing process; it is however certain that the more it is doubled and drawn out the straighter the cotton fibres lie, but by carrying this process too far other evils are produced, viz., expense is incurred and the material is somewhat weakened.

American cotton, as a rule, requires less doubling and drawing in this operation than most other varieties, whether long or short, and where Orleans, &c., is exclusively used it is recommended that it should be put through two heads only, having eight ends each into one, giving 64 doublings for yarns up to No. 34. In other cottons of more stubborn character three heads of drawings are necessary, giving altogether 512

DETAILS TO DRAWING FRAME.

AS MADE BY MESSRS. WARD & BULLOUGH.

SCALE 3 INCHES TO ONE FOOT.

FIG. 1.
SECTION ON LINE A.B.C.D.

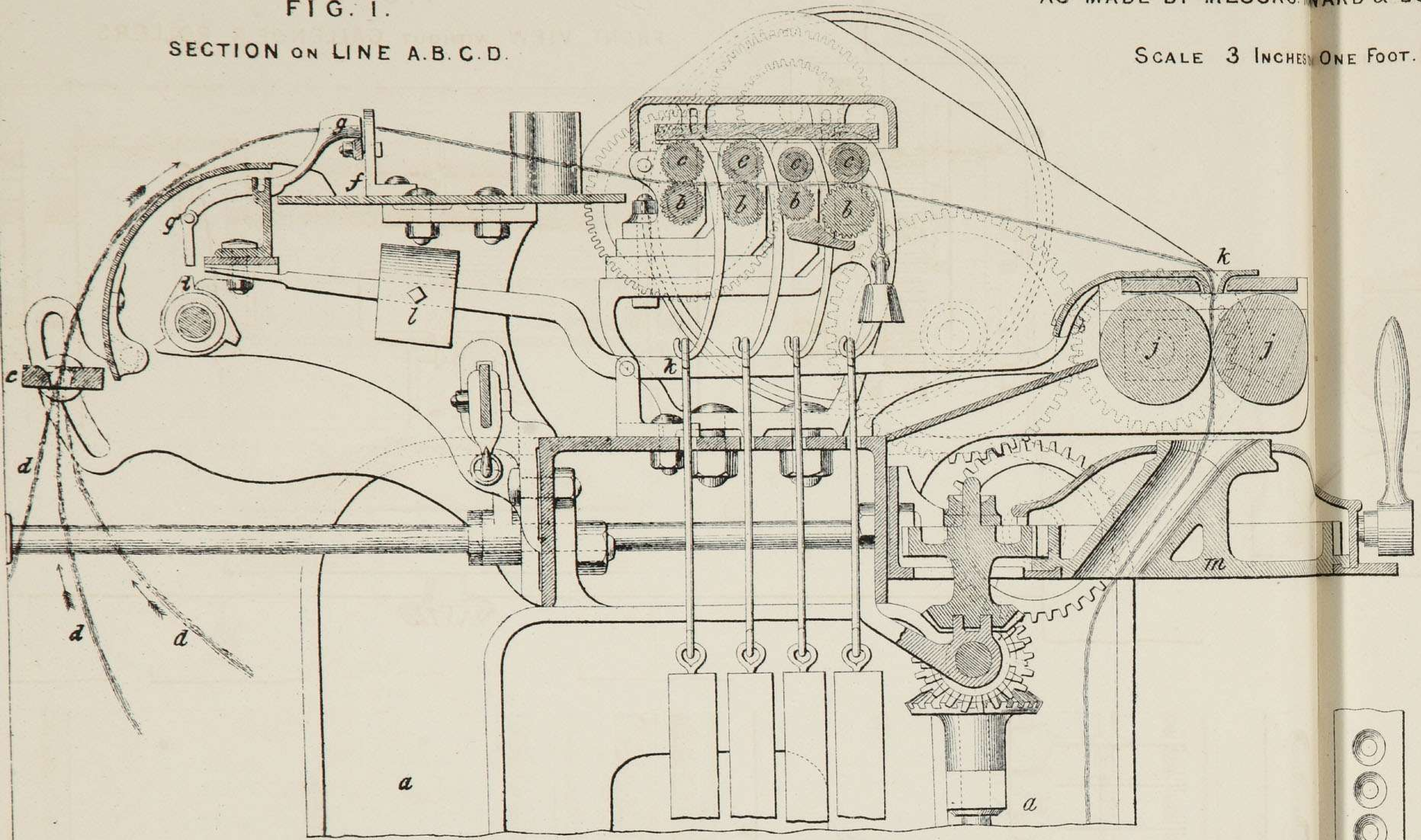


FIG. 2.
SECTION ON LINE E.F.

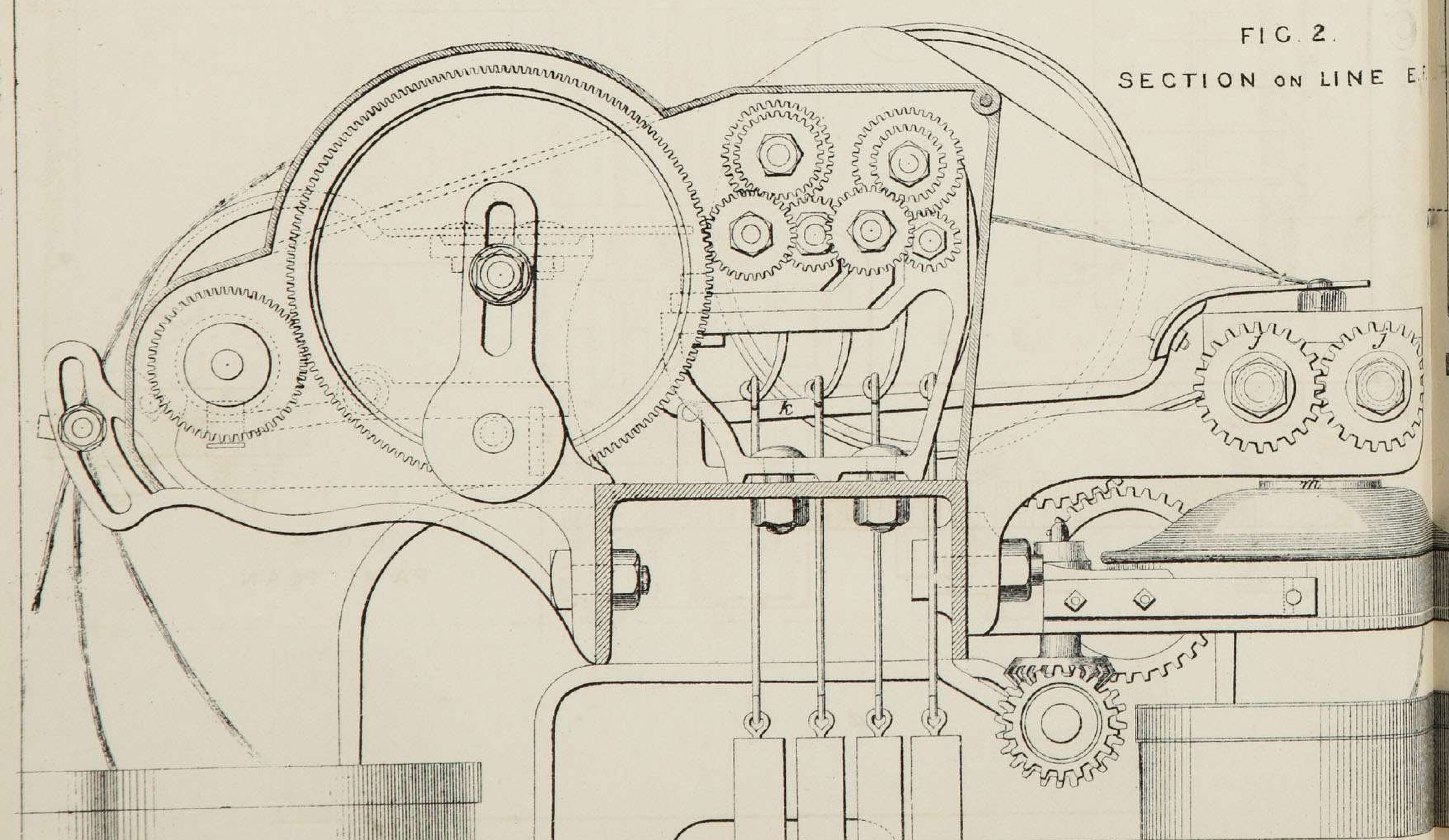
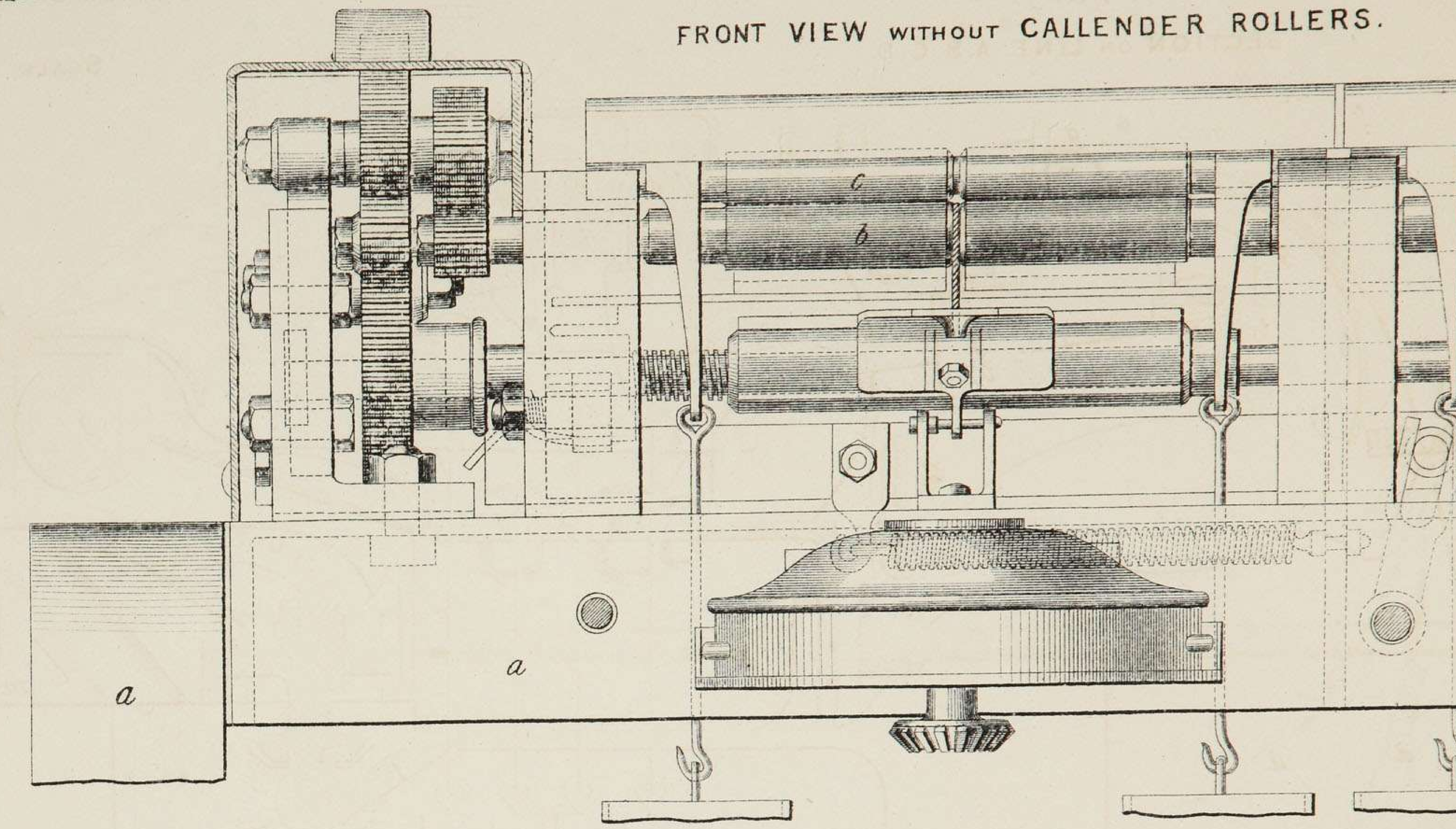


FIG. 3.
FRONT VIEW WITHOUT CALLENDER ROLLERS.



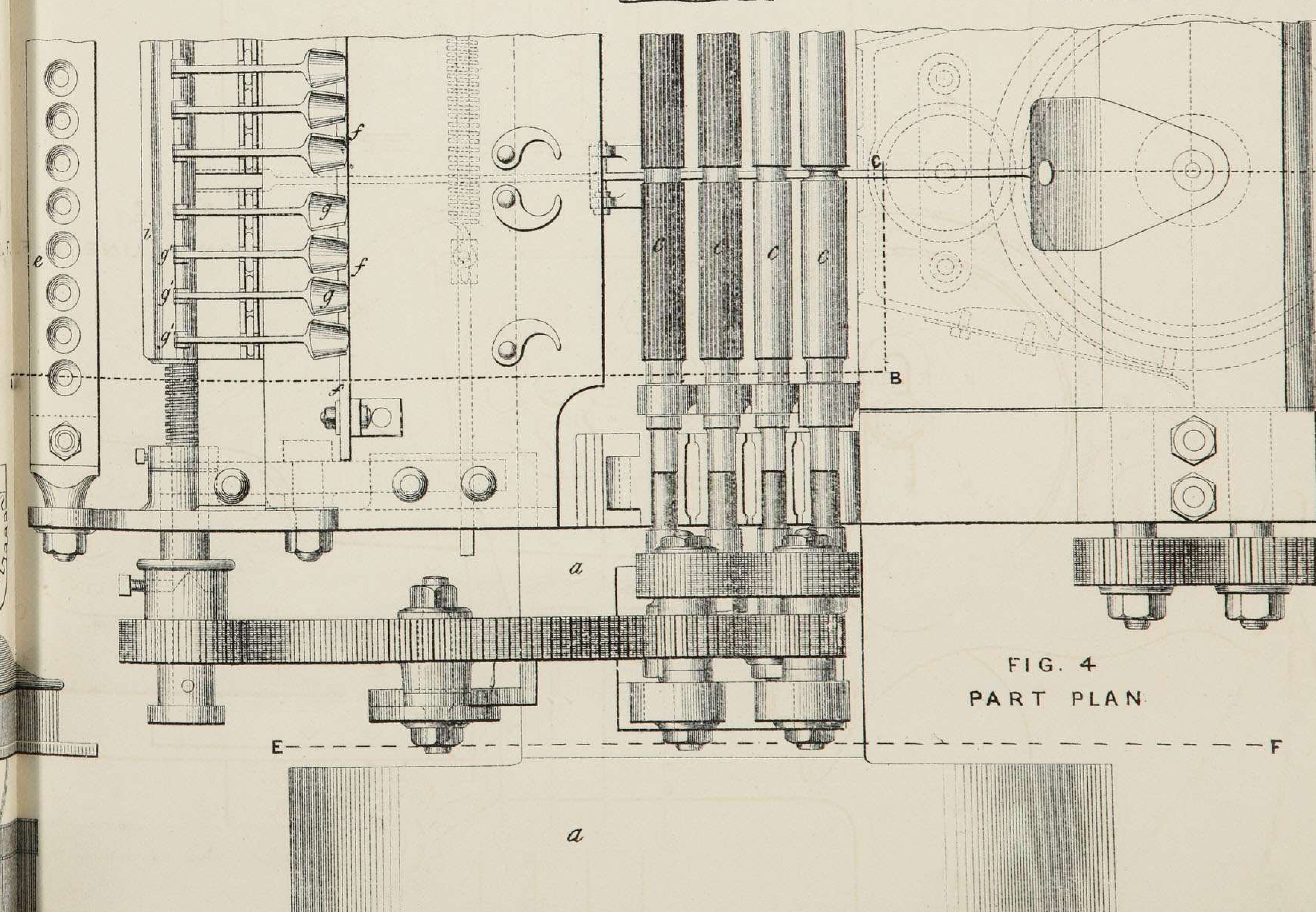


FIG. 4
PART PLAN

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doublings for the same numbers. Some spinners put up three ends to each boss, making six into one, which three times over gives 216. Where frames have only three rows of rollers, less drawing power and shorter bosses, this is better for this reason: that when too thick it is apt to spring the top rollers, and never becomes so well drawn, as the fibres are held tight in the centre of the sliver and loose at the edges; it ought, therefore, to be spread out on the bosses as much as possible, to make sound yarn, care being especially taken that one end never rides upon another.

Drawing frames should never be placed in damp situations, as under sheds, on a ground floor, more especially when there is a clayey subsoil. Spinners often, in such a case, find their rollers licking and making flat waste where the subsoil is clay. This is very troublesome, occasioning much loss. In such a situation there should be thorough and deep drainage. Varnishes and roller pastes are often resorted to, and have a pernicious effect, injuring the nature and elasticity of the leather. Again, to avoid licking, the ends or slivers are brought so close together that the drawing is spoiled. An excellent remedy for this is as follows, viz.:—Let the drawing frames have *two* front rollers, going at nearly the same speed. Let the *back* front roller carry nearly all the weight, and draw the cotton as before, leaving what is termed the *new* front roller nothing to do but simply revolve, and take hold of the delicate web as it comes through, merely gaining a tooth or two at the other, and passing it on.

This arrangement may be best explained by observing that the front roller of a drawing frame, as at present constructed, has nearly all the work to do; is the most heavily weighted; goes the greatest speed; and gets abrased and cut up by the sand, grit, and shells coming through with the cotton, with which it comes in violent contact. It has two bosses, one of which is invariably somewhat larger in diameter than the other, after being covered with cloth and leather, so the smaller is predisposed to revolve faster than the larger, which the latter resists, therefore abrasion constantly takes place from this cause, as well as the others above named. Now the extra front roller has none of this heavy work to do, and therefore the leather keeps smooth; it merely takes hold of the delicate fibres, which have a tendency to curl up and lap round the damaged hard working roller, and passes them on.

Perhaps the most practical method of carrying this out will be found in making the second front roller of an ordinary drawing frame, which has four rows of rollers, do the work by throwing the principal weight upon and speeding it nearly as fast as the extreme front, leaving the latter to be merely a conductor.

The drawing frame is a very important machine, on account of the large quantity of cotton passed through it daily. It ought to be kept in perfect order, well cleaned and oiled; great care being taken that the saddles or weight hooks do not clip or bind the rollers, either back or front, otherwise in a short time a large amount of irregularity is produced.

RAILWAY DRAWING FRAMES.

This term is given to those drawing frames which have two heads or sets of rollers, set transversely to each other, thus:

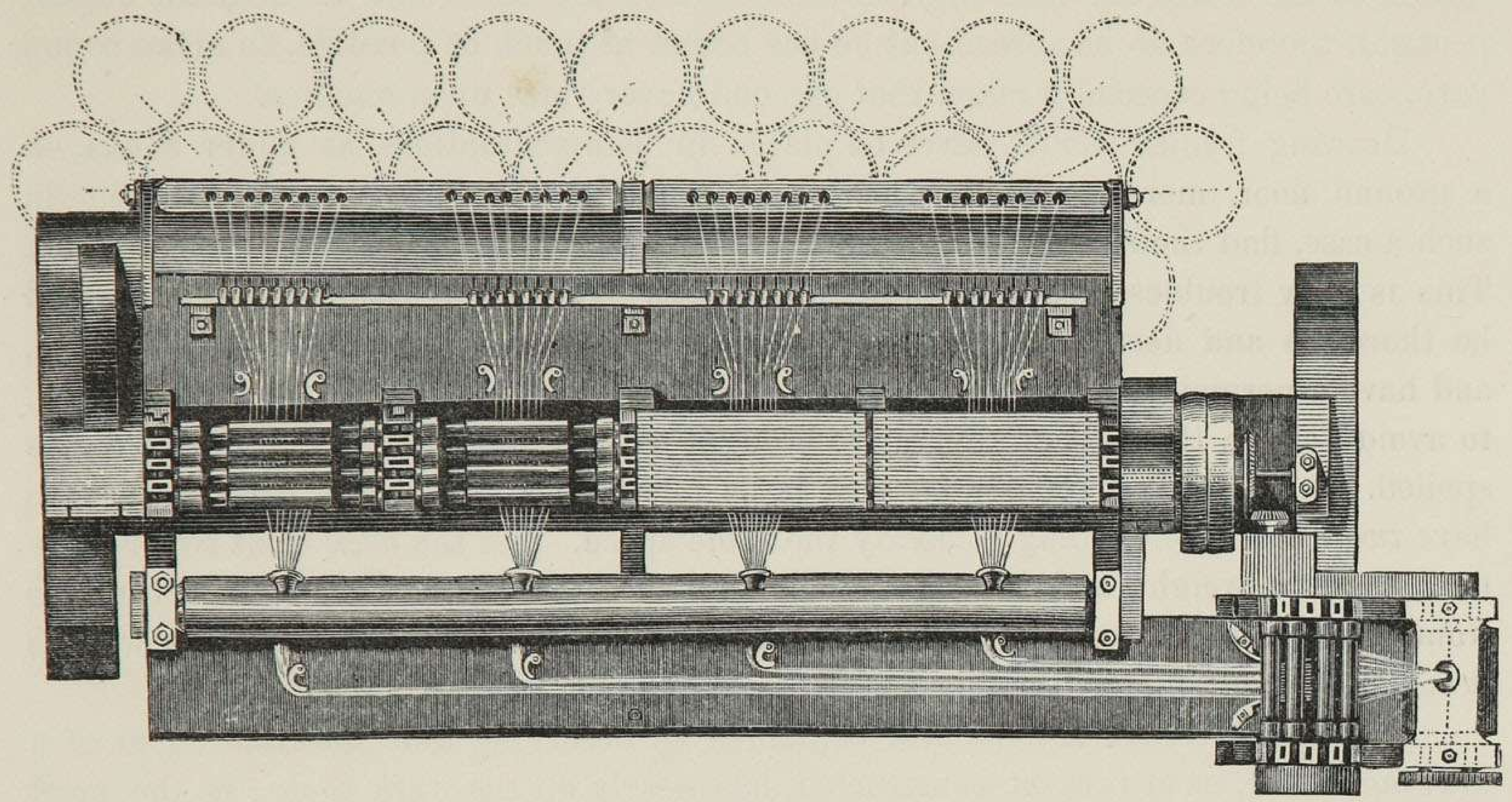


Fig. 144.—Railway Drawing Frame.

It will be seen that the first roller beam may either be like that of a slubbing frame, with a long row of rollers, delivering their slivers upon a polished table, over which they are drawn to the second set, or as shown in *Fig.* 144, with long single boss rollers, which are preferable. This makes a neat arrangement where little doubling is required. It was once in great favour, but has now almost gone out, not because of its lack of merit, but simply from abuse. Having generally been made with only one delivery at the finishing head, it was found impracticable to get a large amount of work through it without running the latter at a very great speed. This necessity was not provided for by the machine maker, who merely put in ordinary rollers, instead of steel ones, and made no provision to prevent licking and flat waste: thus, from the urgency of the spinner and the ignorance of the machinist, a valuable principle and neat arrangement was condemned. The term *valuable principle* is used advisedly; because in this arrangement the ends or slivers go straight through the frame without being drawn the reverse way, as is the case with the ordinary drawing frame. This reversing has a tendency to double over those fibres of cotton which lie on the outside of the slivers. Again, the first set of rollers in the long beam *(a)* go at a slow speed; there is therefore no crowding or riding of one end upon another, and the best facilities being given for correct weighting, the work has every chance in this beam or first head of being done correctly; and if any mistake is made from bad rollers or cutting, the imperfections do not come together to the second box. Taking this kind of frame then as a whole, there is a decided advantage in this principle, if the frames be properly constructed. *Singles*, arising from breakages in drawing frames, are very effectually prevented by the ingenious contrivance of the *stopping motion*, which is now made in great perfection.

Clouded Drawings.—It frequently happens that the drawing seems uneven, cut, and lumpy, notwithstanding that great care has been observed in setting the rollers a proper distance apart from each other to suit the staple of the cotton passing through them; and as cotton is apt to vary, from different mixings, it is difficult to hit upon the right thing in distance one from another, of the three or four rows of rollers, as the case may be, when all the top rollers are weighted heavily, and the mischief produced is allowed to go on. Clouded drawing is not only produced from heavily-weighted rollers being set at improper distances to suit the staple of the cotton, but from long and short stapled cottons being mixed together, which it is sometimes desirable to do on account of their relative cheapness in certain states of the cotton market. The best remedy for clouded drawing is to take the weight off the middle rollers.

General Remarks.—Although the examples of the drawing frames illustrated and described do not embrace all the varieties which might have been shown of this important machine, they are nevertheless sufficient to give the reader a thorough idea of the principles of its action in straightening out and laying parallel the fibres of cotton after carding. Hitherto there has been no disturbing element to unsettle the *principle* as shown by Arkwright. From year to year, however, improvements have gone on in the construction and details of the machine, especially by the additions of the stop motion and coiler. Spinners appear to have settled down generally to the kind of frame, with three or four lines of rollers, exhibited on Plate XXVIII., which, as a piece of workmanship, is admirable. A refinement in mechanism has, in this frame, caused a simple but sound principle to be overlooked, if not trodden down. Half a century ago it was shown in the throstle that only one top roller, covered with leather, was necessary. Later on, Sleddon, of Preston, successfully applied the same principle to intermediate and roving frames, as well as to mules having one-thread bosses, which are still preferred in the Bolton and Preston districts to all others.

There is a charming simplicity and decided economy in this principle of drawing cotton. It saves power, oil, cloth, and leather, besides giving irregular stapled cotton a better chance of equal drawing. On this system, even fixed cap bars and fixed roller stands can be used, because the longest fibres of the cotton are held so slightly by the middle top roller that they can be drawn from under it without being broken.

This system of drawing has only been employed by those spinners who use it *after* twist has been given to the sliver. It appears not to have been generally thought of for the untwisted sliver in drawing and slubbing frames; yet it is sound in principle, has been tried, and proved to work very well.

The greatest perfection in drawing will probably be found in the arrangement of rollers and relative speeds, shown in *Fig.* 145, in which a is the bottom back roller

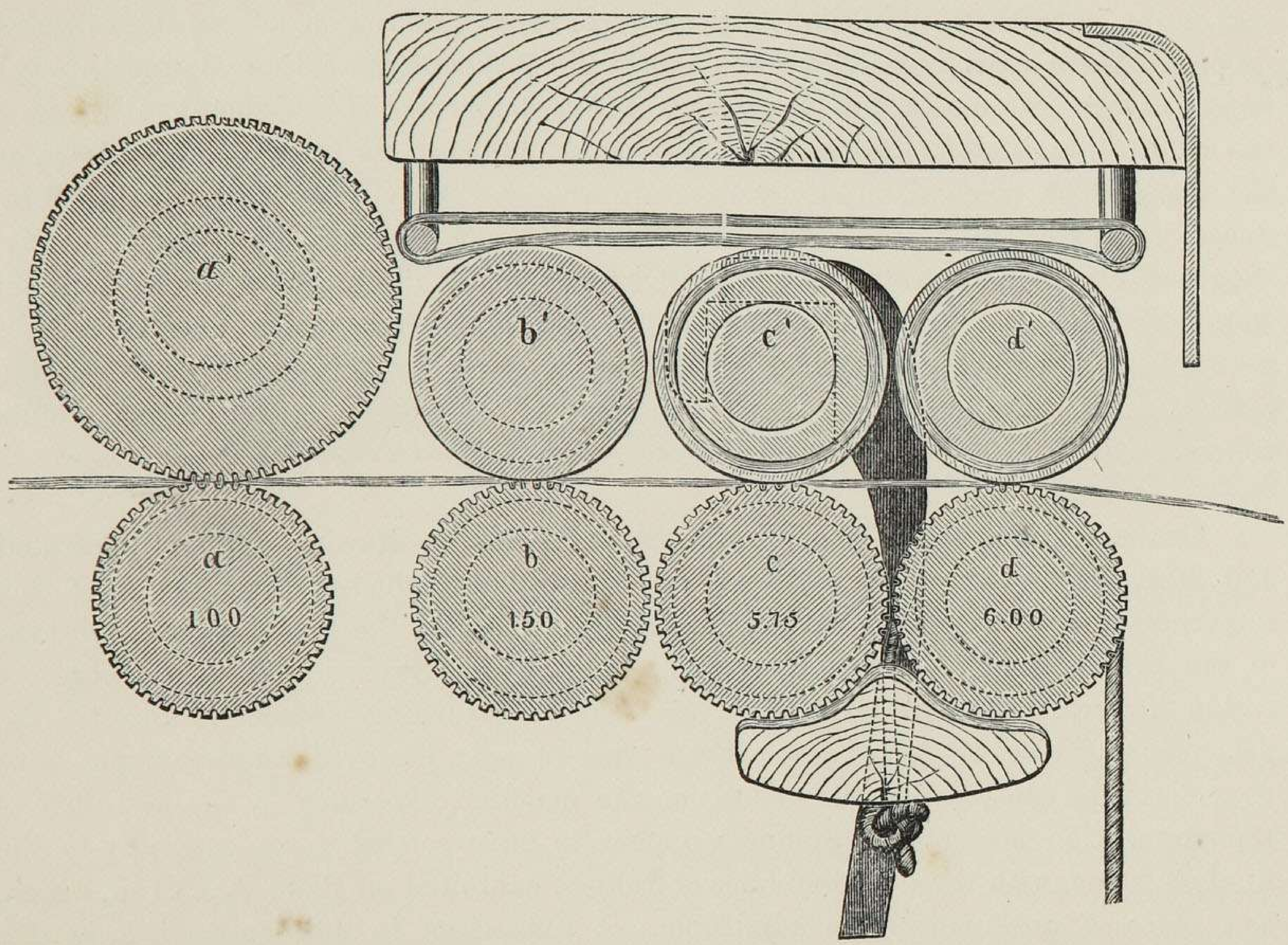


Fig. 145.—Improved Drawing.

and a^1 the self-weighted top roller which takes in the cotton; b and b^1 are the next pair; c and c^1 the third pair; and d and d^1 the fourth or extreme front rollers. Suppose the draught to be six out of one, let a=1·00, b=1·50, c=5·75, d=6·00, or in similar proportion for more or less draught; let c^1 only be weighted; let a^1 be a large plain roller, as shown, which will be sufficient weight of itself to take the cotton in with regularity,—if corrugated, all the better; but if a small roller be used, only the same size as the other tops, it must be weighted and corrugated as well. The next top roller, b^1 must be a plain iron roller of the same diameter as c^1 and d^1 are when covered, the latter being loose boss rollers. The same arrangement may be used in the slubbing frame, after which three rows of rollers are sufficient, the extreme front being dispensed with because after the cotton becomes twisted there is not the same tendency for the fibres to curl up and make flat waste. The corrugating of the back top roller may likewise be dispensed with after the cotton has passed the drawing and slubbing frames, but it must still retain its larger diameter.

If the above named system be adopted throughout, not only will a large amount of power, oil, wear and tear, &c., be saved, but considerably better work and less waste will result.

ERRATA.—*Card Feed Rollers:* On page 139 an improvement is mentioned as having been effected by Mr. John Tatham in Feed Rollers (*Fig.* 119). This kind of Feed Roller is claimed by Mr. Edward Lord, of Todmorden, who writes :—"I patented this same thing on the 28th December, 1861, No. 3,249. You will see that it is identically the same thing, only that, being divided into sections, it is more efficacious than being all in one piece."

Holland's Web Conductor: Referring to this invention (page 157), it is spoken of as not being patented. It appears, however, that the author was mistaken; for Mr. William Holland, of Victoria Mill, Manchester, writes :— "I obtained a patent for this, dated 11th June, 1862, No. 1,738; all the duties on which I have duly paid, and it is now in full force."

SLUBBING.

THE LANTERN OR CAN SLUBBING FRAME.

AFTER laying the fibres straight with the Drawing Frame, Arkwright's idea of further reducing the cotton sliver and twisting it at the same time, was by giving a rotary motion to the can, which received it after passing through another set of rollers. The first clumsy experiments to accomplish this ultimately terminated in the "Lantern Frame" (*Fig.* 146), so called because it had a sort of skeleton can,

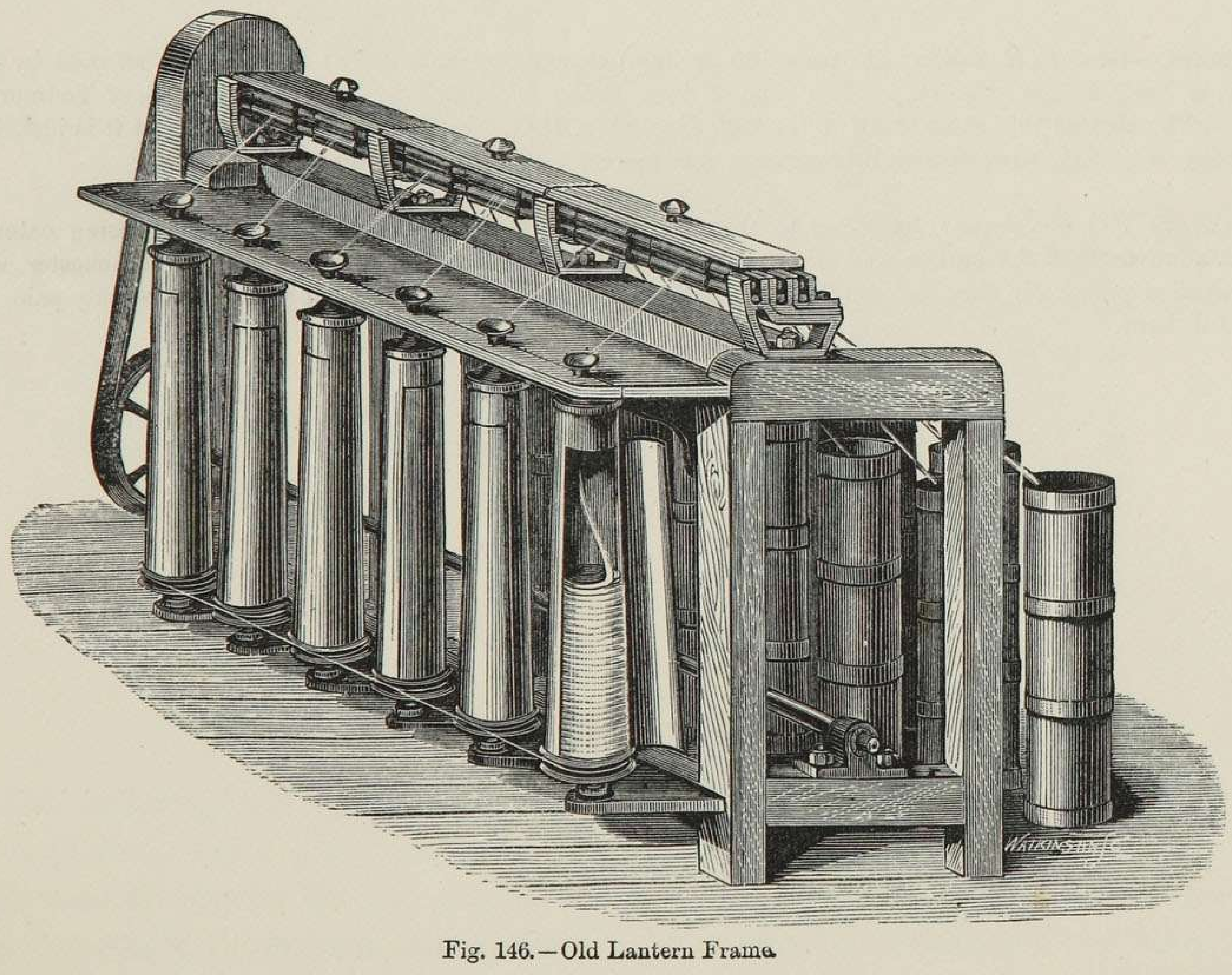


Fig. 146.—Old Lantern Frame.

which worked on a pivot, and had a semicircular door closed by tin hoops. This can was furnished with a large warve, or pulley, at the bottom, over the pivot, and had a brass tube attached to the top that passed through a bearing. The frame was of sufficient length to admit of ten or a dozen of these cans in a line; and motion was given by a cord which wrapped round the pulleys, and received its own motion from a twitch-nick pulley, conveniently placed on the driving shaft of the frame. As the tender slivers came from the rollers, each sliver passed through the tube or hollow neck of the can opposite to it, when it was immediately twisted up to the boss of the roller, and entering the can became coiled round its inner surface until filled; the tenter would stop the frame, open the doors of the cans one by one, and push down the coil, and set the frame on until again filled up; the frame was then stopped, and each coil taken out carefully. The coils were then deposited in a skip. and removed to the winder, who wound them one at a time upon bobbins.

The *Winding Wheel* consisted of a wood wheel about three feet diameter, mounted on a stand or frame, and a horizontal spindle, which was driven by a band from the rim of the wheel (as shown in *Fig.* 147), the cotton sliver passing between the finger

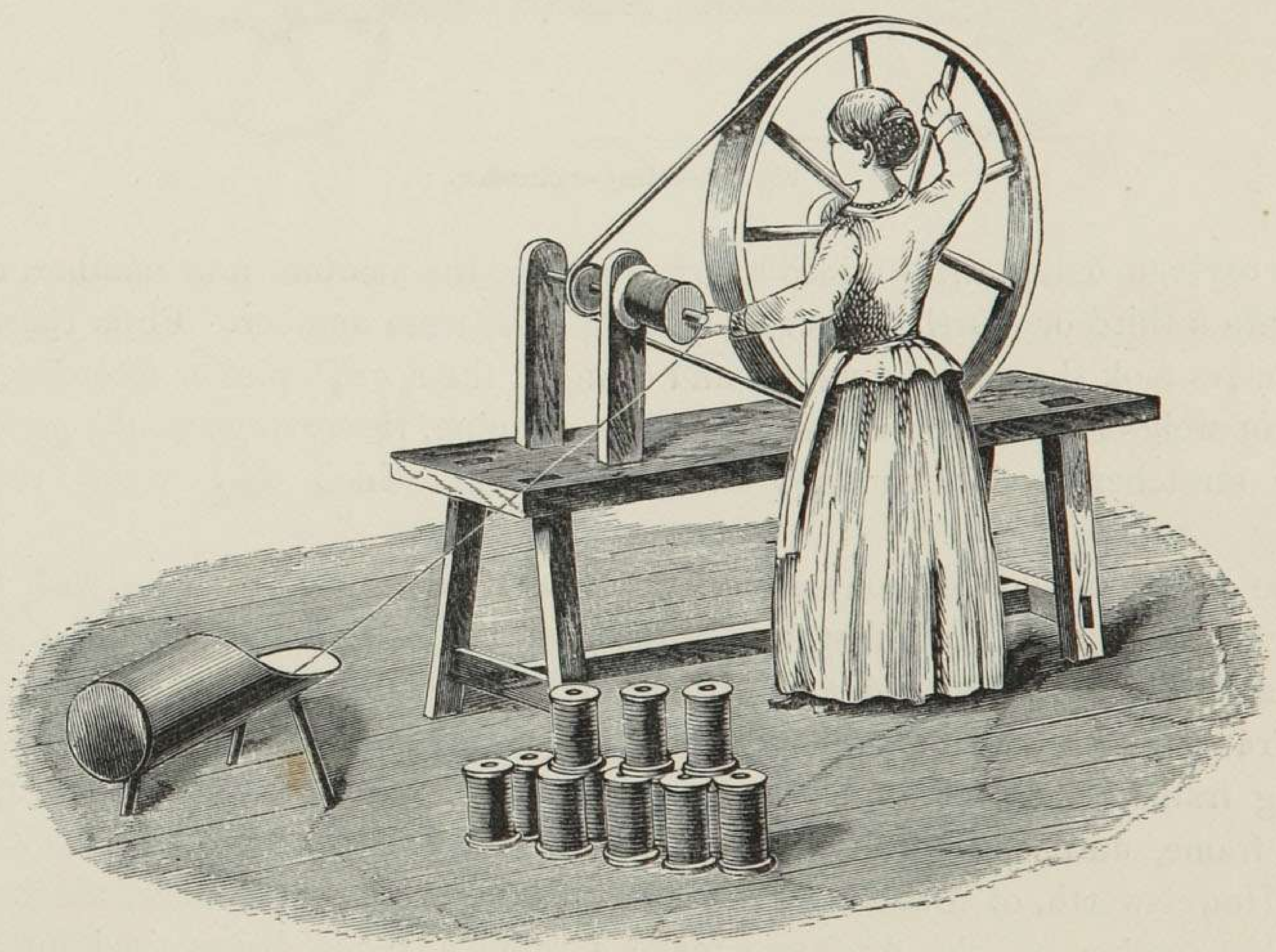


Fig. 147.—Bobbin Winding Wheel.

and thumb, was guided by the hand moving to and fro until the bobbin was filled. These bobbins were then put in a creel behind a billey or stretcher, a machine with about 120 thick spindles, as shown in section (*Fig.* 148), which is similar to a *mule* in appearance. The cotton from the bobbins being drawn through a series of three pairs of rollers, was reduced to the desired thickness, slightly twisted and built upon the spindles to about three inches diameter, parallel in the middle and conical at the ends, being so crossed in the building that when doffed off the spindles it would hold together with sufficient tenacity to admit of being carried about, first to the *sorting room,* where each roving was tested by a roving sorter on a small pair of scales, the

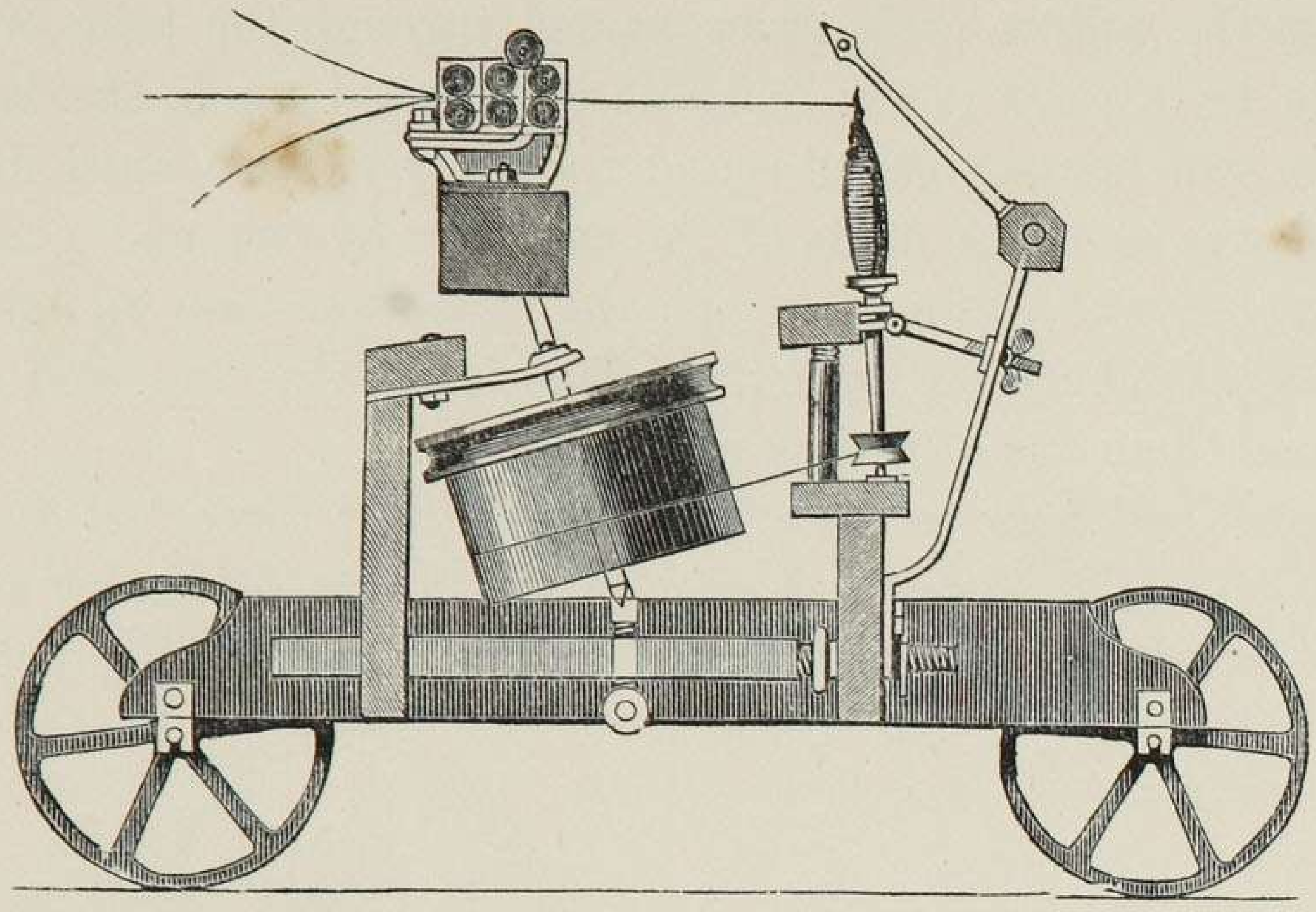


Fig. 148.—Billey or Stretcher.

lightest rovings being thrown into a box together, the medium into another, and the heavy into a third or fourth box, each bearing a separate number. From these boxes the spinners took the *sets* of rovings, and changed their grist pinion according to the *number* or weight of their rovings. For fine spinning, the rovings would go through another stretcher, and sometimes two, in each of which they would receive a doubling.

The above process of converting cotton into yarn became, along with the old breaker and finisher, a settled system, which held its place for about half a century, but became at first disturbed, and ultimately broken down, by the invention of the "Fly Frame." Prejudice fought for years against carrying the latter further than the slubbing frame, which, as at first constructed, was no great improvement upon the lantern frame, until the "differential motion" was invented and applied to it by Mr. Henry Houldsworth, of Manchester. After this beautiful contrivance, which will be illustrated further on, the fly frame made a rapid advance, being used for "intermediate," or middle, as well as coarse slubbing frames; the stretcher being, however, still retained for the final operation until about thirty years ago, when it was gradually pushed out by the fly frame.

THE BOBBIN AND FLY FRAME.

Under this head is now included the Slubbing, Intermediate, Roving, and Fine Jack Frames.

As the invention of the bobbin and fly frame, with *differential motion*, marks a very important era in the cotton manufacture, its origin has become a matter of interest. It appears from the Patent Records that the "differential motion" was first invented and brought out by Joseph Raynor, a cotton spinner of Sheffield, whose patent bears date the 21st April, 1813. It will be seen from the sketch of Raynor's frame, given in *Figs.* 149 and 150, that although his "differential motion" was a very different

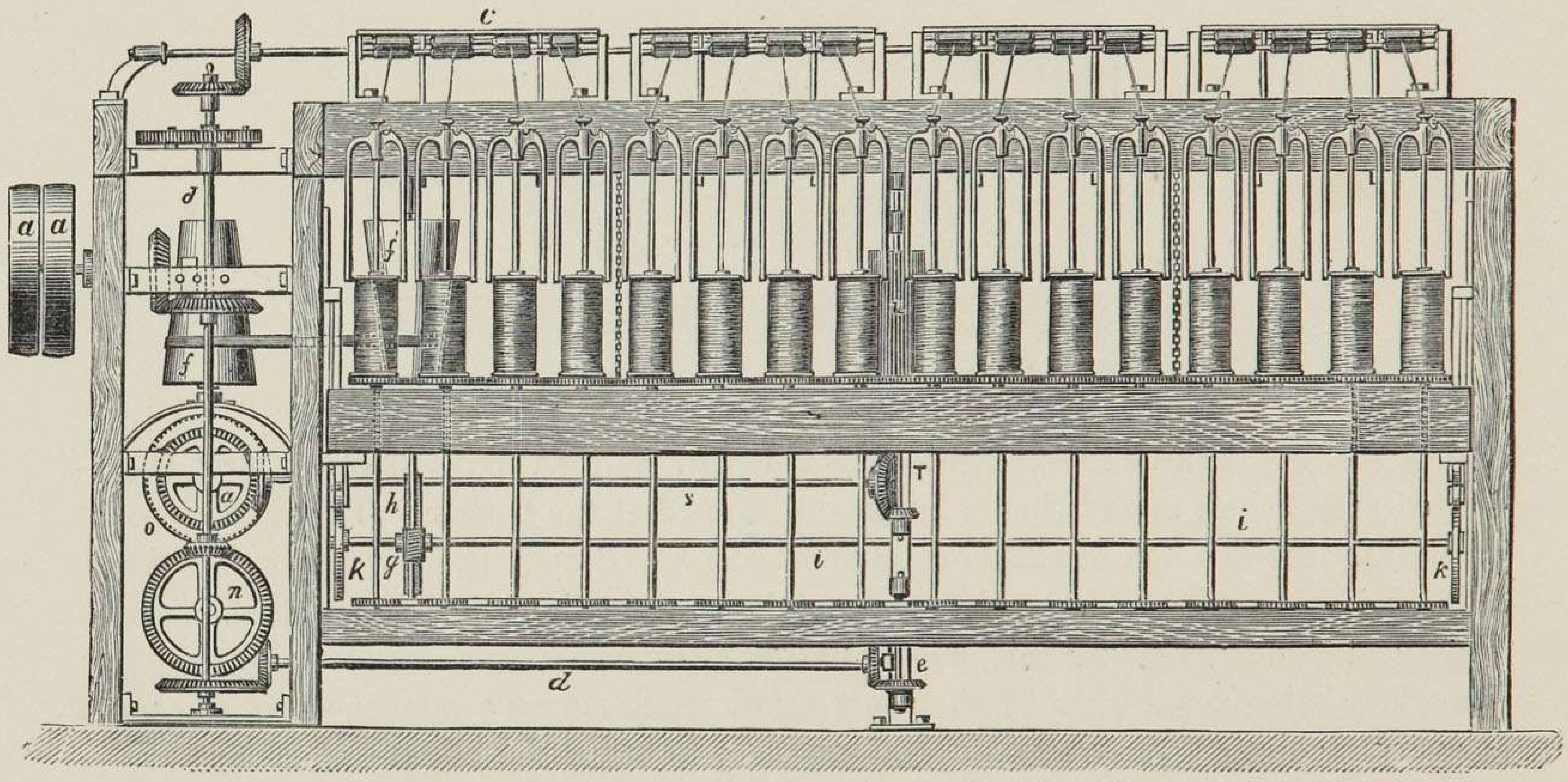


Fig. 149.—Bobbin and Fly Frame (Raynor's Patent, 1813) Front Elevation.

thing from the scientific production of Mr. Houldsworth in 1826, and although his frame seems clumsy and unmechanical, compared with the substantial and elegant productions of the present day, nevertheless it displays great ingenuity, and is both interesting and instructive.

Fig. 149 shows front elevation, in which *a a* are fast and loose driving pulleys attached to a short horizontal shaft, which drives the vertical shaft *b* by a pair of bevel wheels. The vertical shaft *b* drives the rollers *c* at the top by bevel, and a cone drum *f* by spur wheels (*Fig.* 150). A strap from cone *f* drives cone f^1, the vertical shaft of which has a worm at the bottom which drives the heart wheel shaft *i*. The heart wheel shaft has a heart at each end which lift the bobbin beam through two levers *e*, that work upon studs at one end, and the heart wheels act upon the middle of the levers, each of which has a friction bowl.

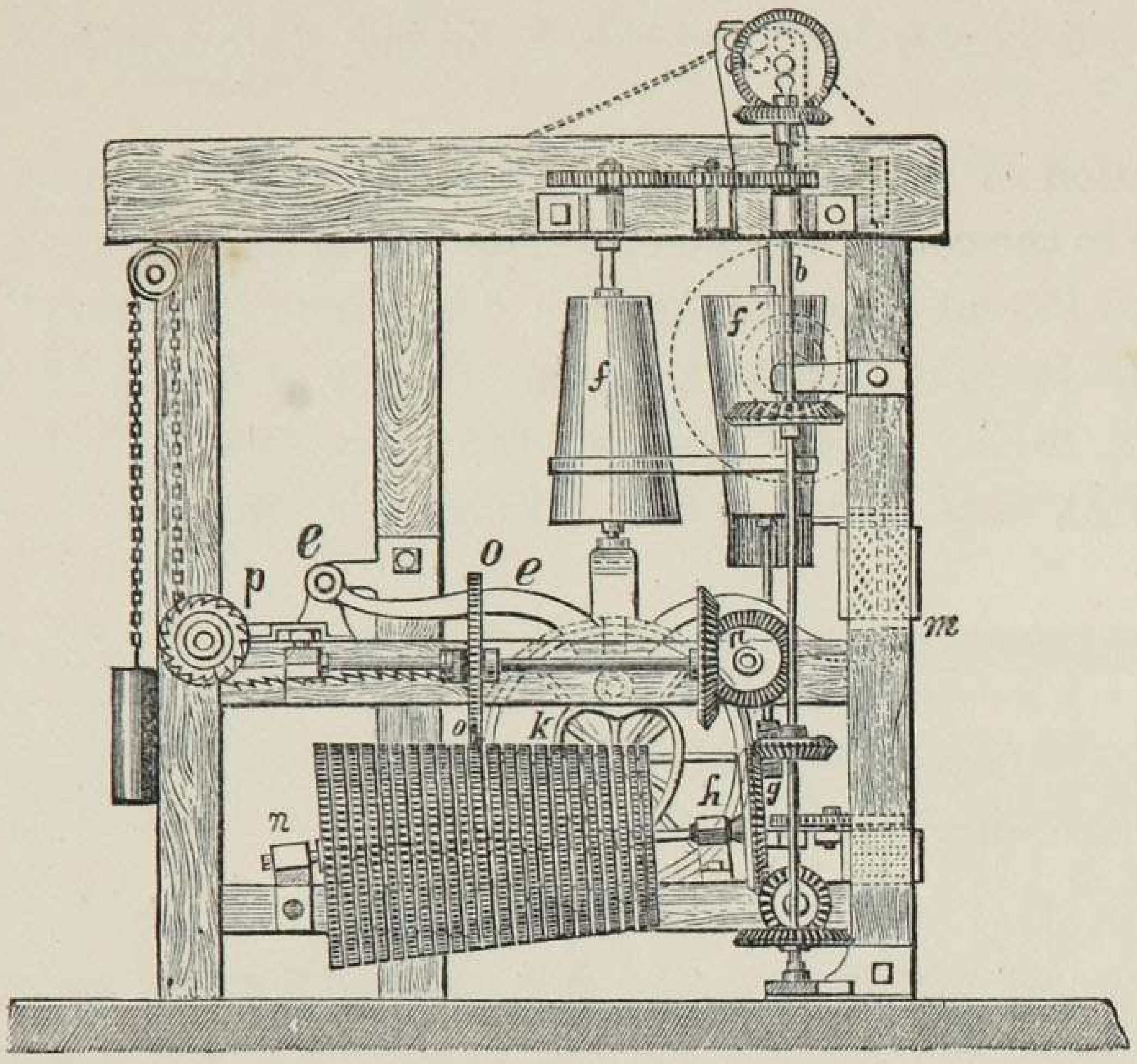


Fig. 150.—Raynor's Frame (End Elevation).

Referring back to the upright shaft *b*, it will be seen to drive below, first, a graduated wheel shaft *n*, and then a horizontal shaft *d* at the bottom. The shaft *n* works on a slight incline, and has 22 brass spur wheels keyed upon it, of which the largest is 11in. and the smallest 9in. in diameter. A brass travelling wheel *o*, which slides upon a grooved shaft, takes into this, and is moved at intervals from one of these wheels to the other, being acted upon by the heart shaft, which moves a ratchet wheel *p* a tooth at every revolution, thus allowing the weight *q* to bring the sliding wheel forward to the next series of graduated wheels. The grooved shaft transmits its motion to the bobbins, which it drives through the shaft *s*, giving motion by bevels to a short upright shaft fixed about the middle of the frame. This upright has a long spur wheel upon it the full length of the lift, and drives the bobbins by spur wheels and carriers, one being placed on a vertical stud between each spindle. The shaft *d*, before mentioned, goes also to the middle of the frame, and drives a small upright by bevels at *e*, which has a spur at the top that gives motion to the spindles through spur wheels similar to those which drive the bobbins. The roller beam, lifting rail, and all the framing, are of wood; also the driving pulleys.

The problem to be satisfactorily solved was both intricate and difficult; for not only had the bobbin to vary its speed at every layer as it filled, running all the while at a rapid rate after the flyer, but that speed must be increased at every layer in a constantly accelerating ratio, so that the difference between the flyer and the bobbin would be maintained with precision at the acting circumference of the front roller. The mechanism in this frame had also to be arranged so that the twist of the slubbing or roving might be varied at pleasure, which increased the difficulties to be surmounted; therefore it is no wonder that the first frame had so many cones and other complications about it, which were gradually removed as the machine got into different makers' hands. Messrs. Cocker & Higgins, of Salford, Manchester, were for a long time the principal makers of the fly frame, in which they effected many improvements. Formerly this frame was of very small dimensions, having only about twenty or thirty spindles, which were driven by bands, as an improvement upon the spur wheels; but, since the introduction of skew gearing, and greater perfection of the differential and changing motions, effected by the late Mr. Henry Houldsworth, of Manchester, they are now made of much larger size.

THE MODERN SLUBBING FRAME.

This frame is now made to contain from 40 to 80 spindles, and has a lift of from 10 to 12 inches. Instead of winding the cotton on a bobbin with flanges, in a soft state, it is wound on a plain barrel or spool, and gradually tapered off at the ends. One leg of the flyer is furnished with a finger, or presser, around which the cotton sliver laps as it passes on to the bobbin, whereby it becomes tightly wound on. Plate XXVIII. shows a front elevation, back elevation, and two sectional views of this frame, as constructed with all the latest improvements.

It will be noticed that Twist* is first given to the cotton in this frame, the small modicum it receives in the coiler being excepted. Here also commences the complicated and beautiful machinery, which is a marvel of ingenuity, for winding the twisted slubbing on a bobbin—that increases in diameter with every layer—with the greatest

**Query: What is Twist?* A learned friend, in answering this question, said: "Without twist there could be no cotton manufacture, no cotton lords, no cotton millionaires, no Cottonopolis. Manchester would sink in ruins like Babylon of old, and perhaps the very site of it be sought for, or its ruins sketched by Macaulay's New Zealander, 'in some succeeding year, when Britain's May is in the sere.'" What, then, is *Twist?* It is not the yarn, nor the fibre which composes it; it is not matter, nor is it spirit—What then? Twist is an accidental property, or quality, of the material of cotton, flax, wool, silk, or any other fibre capable of being converted into a fabric. It is the application of the screw power in mechanics, and the spiral convolution of Nature to the fibre, which previously existed in a *straight line*, and whose strength is increased by giving one or more strands a spiral direction to a certain extent, and rendering it capable of conversion into cloth, by the process of weaving. Nature is prodigal of spirals—in the celestial nebulæ, in the motions of the heavenly bodies, in the earth, in the vegetable kingdom, and even in the human system. The spinner only takes a leaf out of Nature's volume, and applies her spiral or screw principle to his cotton fibre, and lo!

"A new world rises, and new manners reign."—*Dr. Young.*

Cottonopolis springs like a new creation into being, and the merchant princes exclaim, "Is not this great Manchester which *we* have built? quite forgetful that they are mere imitators of Nature, and that "by this craft [twist] they have their wealth."

regularity and exactitude, although the length given out by the acting circumference of the front roller is always the same. Most people have heard the observation that "There are wheels within wheels;" verily they may be seen here.

The introduction of twist to the sliver is very important, as the whole character of the doubling and drawing out is afterwards changed. It is said that *one* doubling after the sliver has received twist is worth a hundred previously. The reason is obvious; namely, when the fibres of cotton are twisted together and then drawn asunder, they get more thoroughly stretched and laid side by side than previously. This may be seen by taking a sliver of untwisted cotton from the drawing frame, and observing how easily it is pulled asunder *without twist*, but how different and more stubborn it is to separate after being twisted.

It is common to make this frame with three rows of rollers, but four rows are as clearly required here as in the drawing frame, leaving the extreme front row little or nothing to do but pass the tender fibres on. When the delicate fibres of cotton come through the rollers of the slubbing frame and receive their first twist, they are so attenuated that the extreme edges are apt to curl and be licked up by the front roller, gathering under the flat, or clearer, for a time, until it forms a lump, when, if not picked off in time by the tenter, it is carried through the rollers again and twisted in the slubbing. This makes a bad end and a thick streak in the cloth.

There is a difference of opinion also as to whether two ends, or one only, should be put up behind the slubbing frame. Two ends are undoubtedly better than one, if there is sufficient power in the drawing frames to bring them out fine; but if that is not the case, by no means should the rollers of the slubbing frame be crowded by having too much cotton under them; rather have a single end with a lighter draught. Where two ends are put up behind a slubbing frame, it should only have a single row of spindles. Whether one end or two be put up, the *stop motion* should be applied. The presser on the flyer leg is also very advantageous in the slubbing frame; indeed it is now pretty generally used in all the frames.

THE INTERMEDIATE FRAME

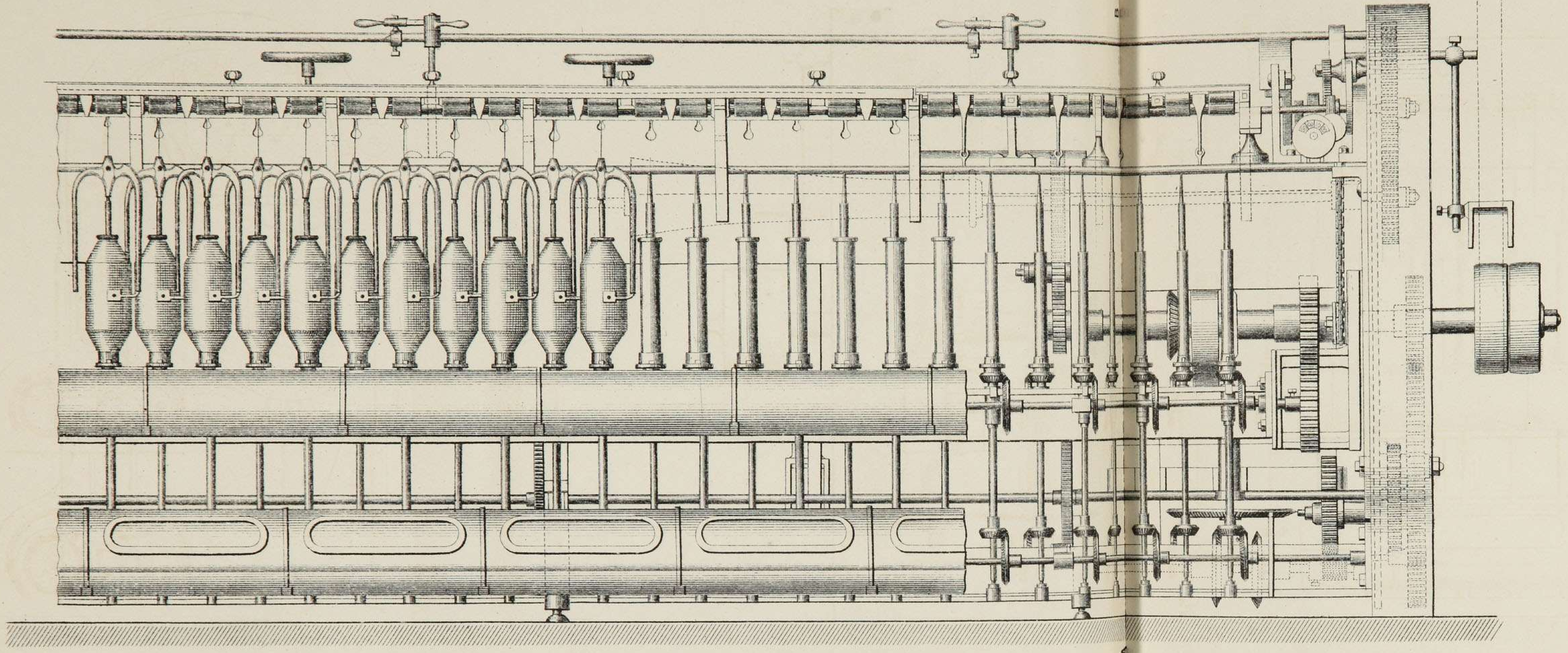
follows the slubbing frame in all well-regulated mills. This, as its name implies, comes between the slubbing and roving frames, whenever the numbers spun exceed 20's. Attempts have often been made to dispense with its use up to No. 30's and higher, but the inferior quality of yarn and greater breakage in spinning, which follow, more than counterbalance the apparent saving by leaving it out. It is generally made to contain about 80 to 120 spindles, with an 8-inch lift for the medium counts, and a 9-inch lift for lower numbers.

SLUBBING FRAME.

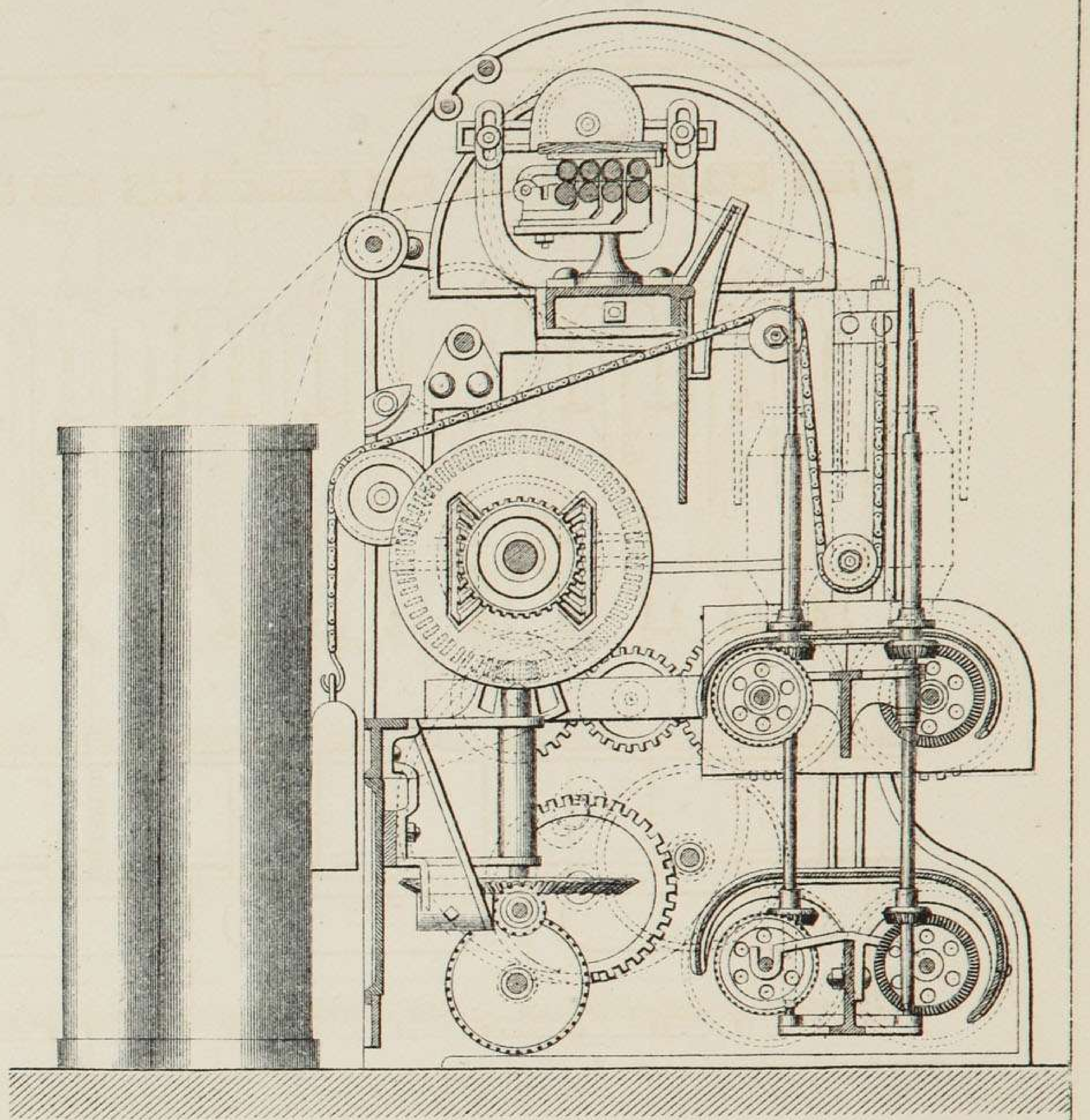
WITH LATEST IMPROVEMENTS.

SCALE 1 INCH TO 1 FOOT.

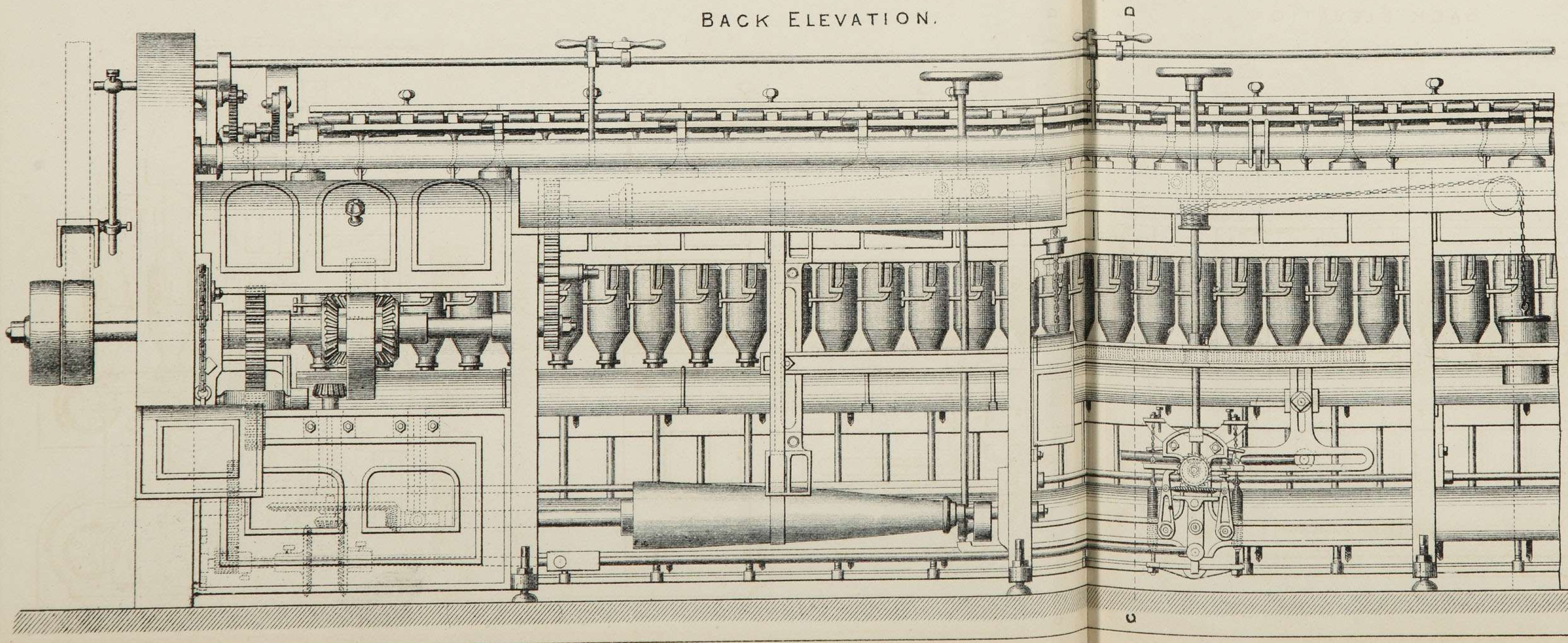
FRONT ELEVATION.



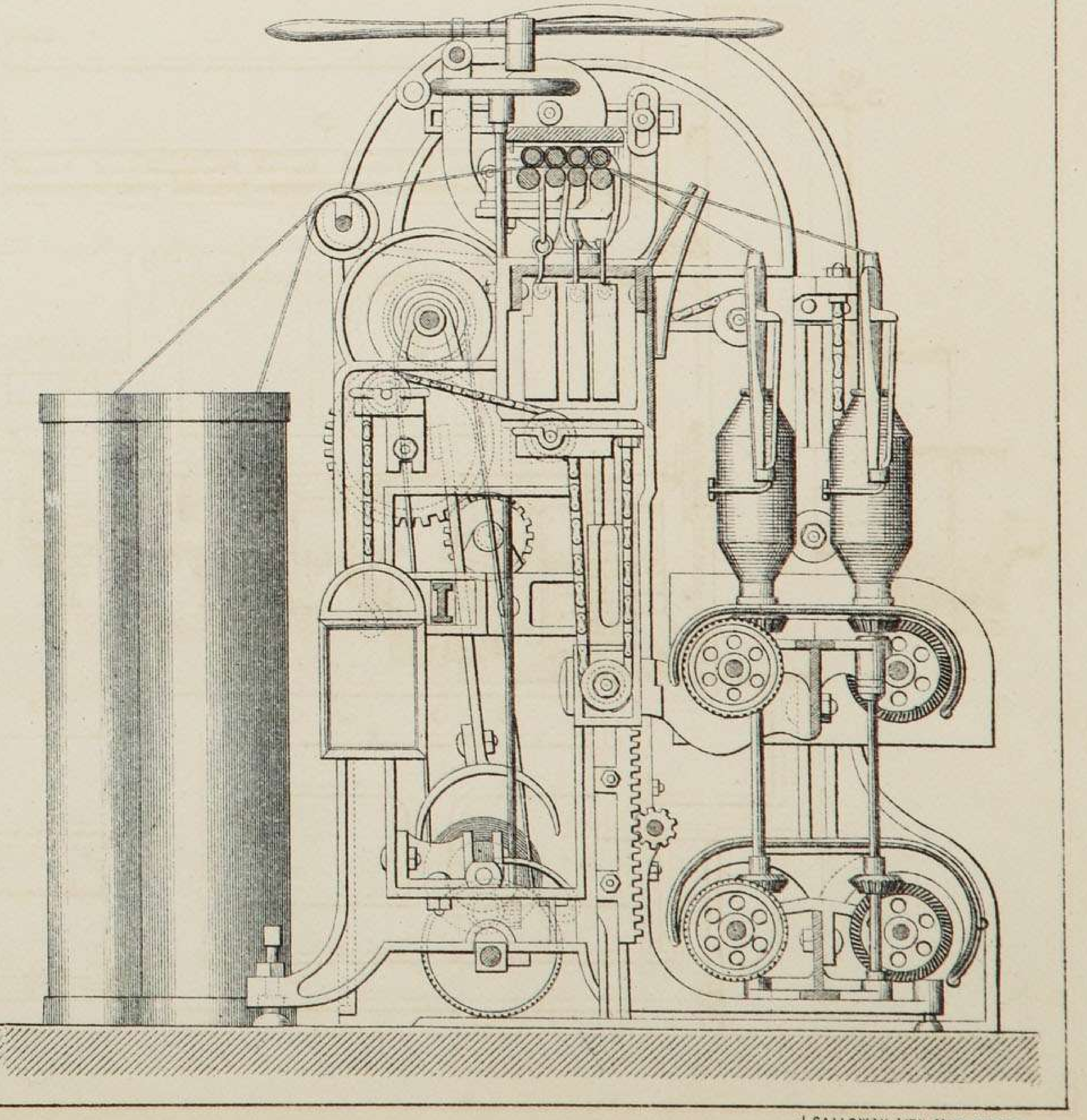
SECTION ON LINE A. B.



BACK ELEVATION.

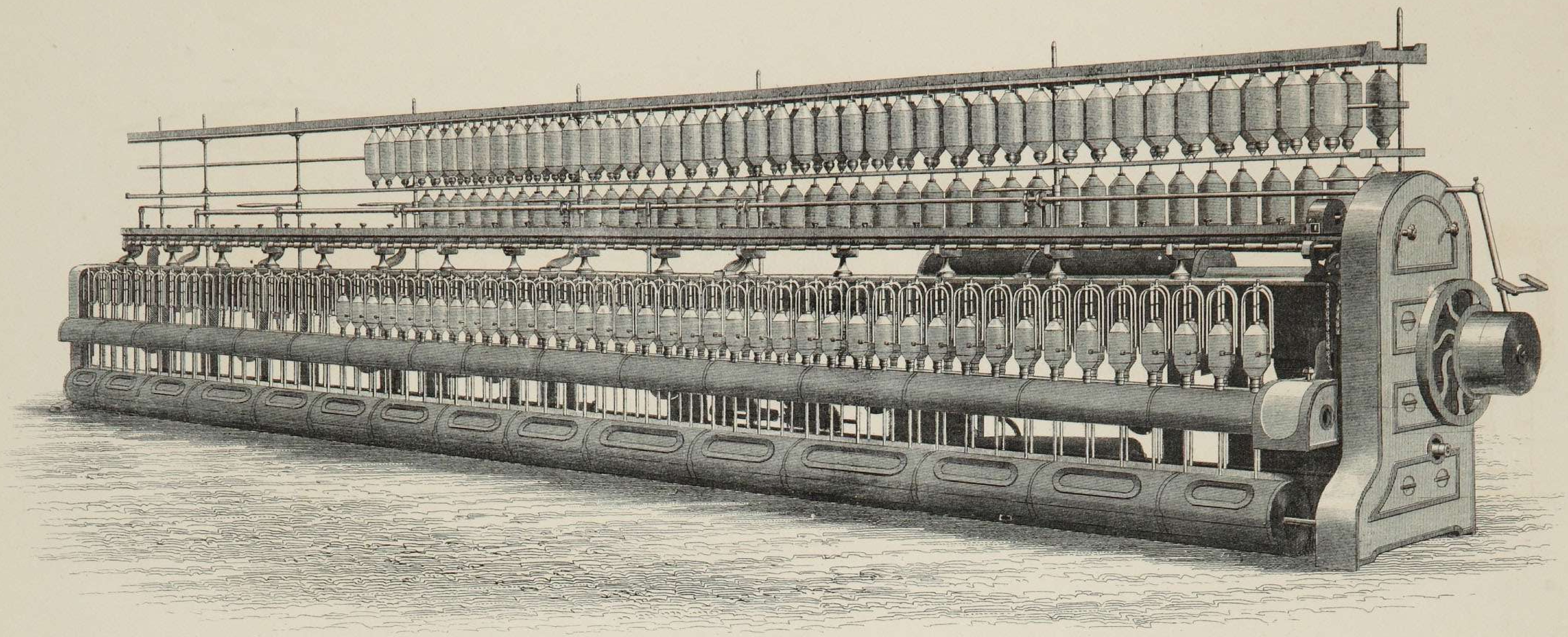


SECTION ON LINE C. D.



J. GALLOWAY, LITH MANCHESTER.

PLATE, XXIX.



ROVING OR INTERMEDIATE FRAME.

WITH LATEST IMPROVEMENTS.

FRONT VIEW.

J. GALLOWAY, LITH: MANCHESTER.

THE ROVING FRAME

follows next in succession, and is the same in principle as the two preceding, differing only in having a shorter lift, with more spindles set closer together. This frame contains seldom less than 100 and sometimes over 200 spindles, according to the numbers required to be spun; and has a lift of about 7 inches for the coarser counts, and of 5 or 6 inches for the finer numbers. It may be said to have now entirely superseded the old stretcher before mentioned. (*Vide* Plates.)

THE FINE ROVING OR "JACK" FRAME

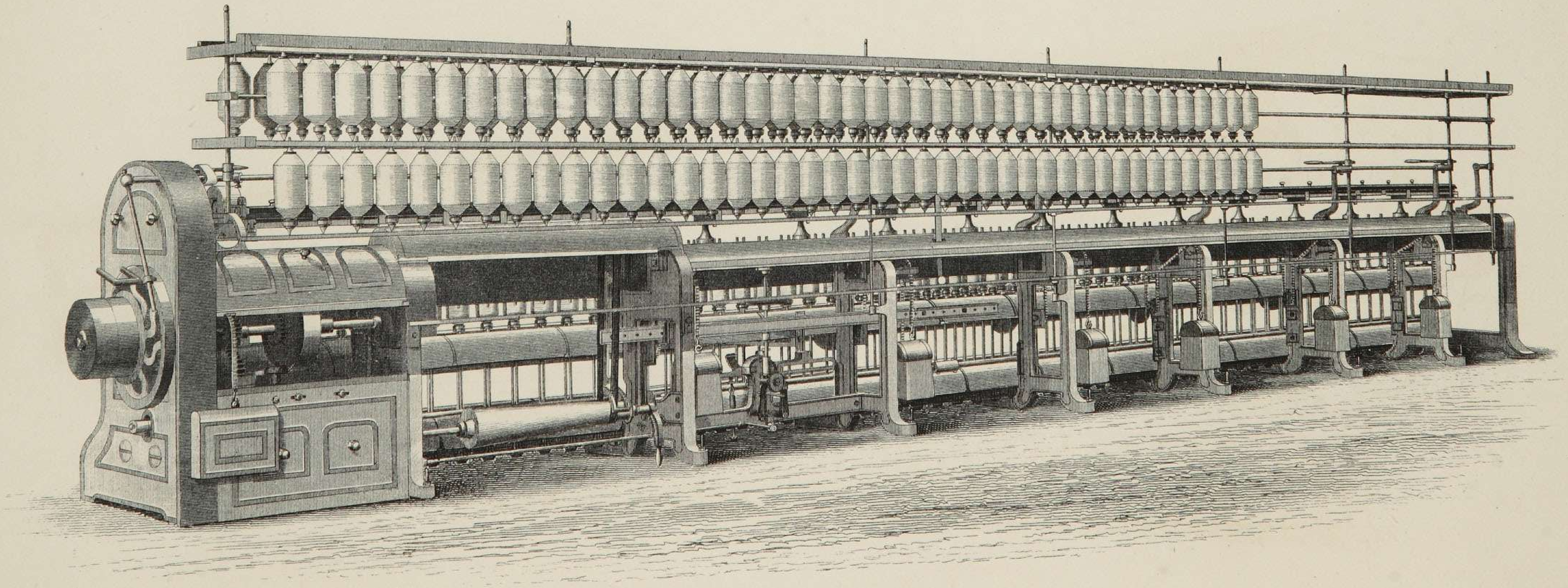
differs only in the length of lift from the preceding. It is generally used where fine counts are spun, making sometimes a 30 or 40 hank roving from the bobbins of the first roving frame. It is usually made without presser, the bobbins having a small flange from which the roving tapers off. These frames are frequently made to stand end to end, so as to present the appearance of a large frame of 240 to 300 spindles or more, driven from each end; but the rollers and other working parts are severed in the middle, so that one-half can stop for piecing or doffing, whilst the other goes on.

REMARKS.

The manufacture of the important frames above enumerated appears to have settled down to the type of frame shown in the two perspective illustrations, Plates XXIX. and XXX.; also more minutely in Plate XXVIII., showing details of slubbing frame, which have been selected from the workshop of Messrs. Howard & Bullough, of Accrington.

It will be noticed that all the illustrations exhibit frames having two rows of spindles. Some spinners prefer to have their slubbing frames with one row of spindles only; and there are, at least, one or two firms of great note who will not have a double row of spindles to any of their frames. Excellent reasons are given for what appears a prejudice on their part. It is alleged that where there are two rows of spindles it is not possible to make the slubbing or roving of the back and front spindle the same thickness because of the extra vibration on the front thread. Again, where there are two rows of spindles, there is necessarily more crowding under the rollers, and consequently the cotton has not so good a chance of being well drawn. From the same cause, inconvenience is experienced at the back with crowded cans or creels. There are also, they say, numbers of other little conveniences with single-row

PLATE, XXX.



ROVING OR INTERMEDIATE FRAME.

BACK VIEW.

frames in the doffing, cleaning, oiling, lighter weighting, &c., all of which are advantages that, in their opinion, outbalance the extra cost and room occupied by the single-row frames.

There is no doubt about the truth of the above reasoning; but it would be a difficult matter to persuade the trade to adopt the single-row system nevertheless, as it nearly doubles the price per spindle of the various frames. In the general desire to keep down outlay when a mill is established, small matters of that kind are thoughtlessly overlooked.

About forty years ago the ingenious Mr. Francis Sleddon, of Preston, was forcibly impressed with the advantage to be derived from single-row frames; and to neutralise the extra cost, he made his intermediate and roving frames with a single row of spindles on each side, like a throstle. They worked very well, having small steel shafts, of about half an inch diameter, to drive the bobbins and spindles, but at that time there was much greater complication about the changing differential and tapering motions than there is now, and although his frames were extensively adopted, they had not the same chance that such a frame would have at the present time. It is thought that if any good machinist would now bring out a neat frame of that class, made to stand very low, with all modern improvements, he would do a service to the trade, and probably meet with a large demand, especially for new mills.

Mason's Long Collar.—A decided opinion expressed *pro* or *con*, upon this invention, would be sure to evoke dissent, because many spinners strenuously support it, whilst others as strenuously reject it. The benefit to be derived from it is greatest when made so that the spindle bears only at the *top* part of the collar. When made to bear on both the top and bottom of the collar, the power required for driving the frame is greatly increased, not because of the extra bearing as such, but from the fact that the spindle is being held in three places. Unless the two upper bearings comprised in the collar be accurately bored out, and the latter be so fixed in the lifting rail that the holes are exactly perpendicular over the spindle step, the spindle is sure to be more or less bound, when the power required to drive it is increased amazingly. Now, there is considerable difficulty in the accurate manufacture of these tubes, on account of the holes being cast in; hence arises indifferent workmanship, and the binding, with waste of power complained of; therefore, by taking away the middle bearing, much of this is obviated. There is, however, another reason why the Mason Long Collar requires extra power, and this is one which cannot be removed—namely, the necessarily large diameter of the dead tube upon which the warve and bobbin work.

The question to be considered in regard to this principle resolves itself to this; viz., Is it worth while to incur the extra cost and extra power, continually required, for the sake of a *little* greater durability and steadiness at high speeds? Many doubt the advantage of high speeds at all; but very high speeds are condemned by all practical spinners.

Should the Bobbin lead or follow?—Something can be said on both sides of this question. The advocates for the *bobbin leading* the flyer, and over-running it just so much as will take up exactly what the front roller delivers, assert that, when an end breaks there is a chance of less waste being made than when the flyer leads. To a certain extent this is so, but ends ought not to break; and in well-regulated mills the advantage claimed in that respect is exceedingly small, whilst there is a constant disadvantage and loss of power incurred by the bobbin leading. When the bobbin leads in presser frames, the spindle *is dragged after it*, and both spindle and bobbin are driven through the moving gear of the lifting rail, the power for which is communicated through the radial arm and train of wheels upon it, which being a variable motion, regulated through the "jack box" or differential motion of Houldsworth, is unfavourable for transmitting nearly the whole power required by the frame. On the contrary, when the *flyer leads*, it drags the bobbin after it; consequently the gearing of the lifting rail, and all its connections, has nothing to do but slightly to hold back and regulate the motion. It is far more favourable and far more natural to transmit the bulk of the power through the fixed gearing of the spindle step rail; besides, in the latter case, the bobbin goes through considerably less space in following the flyer than in leading it, which, of itself is a direct saving of power.

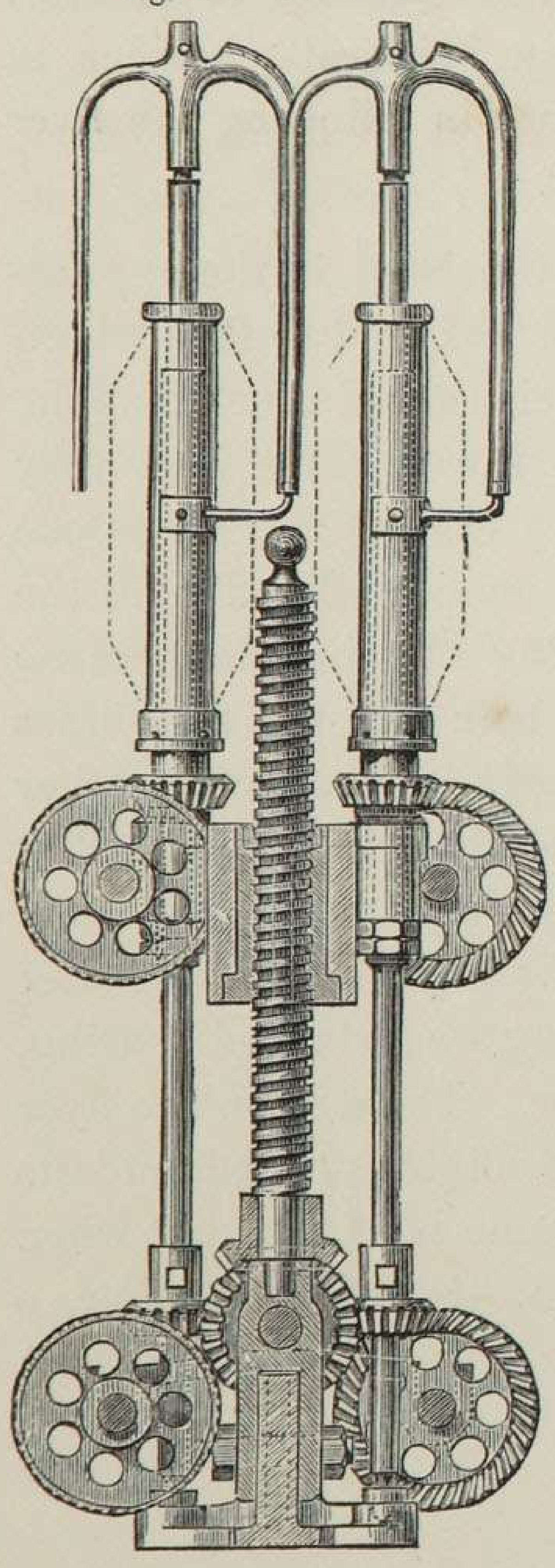
Pressers.—When this invention was first brought out it consisted in the application of a small brass finger to the tube leg of each flyer, which was held to the bobbin by a spring. These springs were constantly giving way, which caused much trouble. In 1843, Mr. Joseph Lamb, of Manchester, dispensed with the springs in a very ingenious manner by centrifugal action, which was effected by casting a lump on one side of the presser. When in motion, the tendency of this lump to fly off held the presser to the bobbin, which was a great improvement, unerring in principle, because founded upon a natural law; but there was much wear and tear with the soft brass pressers from breakage and cutting until steel was substituted. Subsequently other improvements were made, so as to give a better hold of the flyer leg, &c., until at length the force of gravitation was added to a still slight centrifugal action, the lump being dispensed with; and in lieu of it a steel wire, which is a part of the presser itself, extends up the flyer leg, clips it at top and bottom, giving a substantial bearing, and then extending to the bobbin with the usual shaped finger. The clip on the flyer leg is so arranged that when the presser is drawn back it is slightly raised, and its own weight gives a gentle pressure on the bobbin when the frame is at rest, but when in motion this pressure is increased by centrifugal action,—being, altogether, a beautiful adaptation of natural laws to mechanics.

Management of Frames.—All slubbing, intermediate, and roving frames should have their rollers taken out, the bottom rollers scoured, the squares oiled, and the other working parts of the frames taken to pieces and thoroughly cleaned, once every six weeks; drawing frames once a month or oftener. This is called scouring through, and should on no account be neglected.

Draughts must be apportioned in these different frames according to circumstances, ever bearing in mind that a better quality of work is produced with a fine roving than with a thick one; but a fine roving cannot be produced for any definite object without a sufficient number of spindles, or, what is equivalent, good work, so that the frames can be kept constantly running.

A good manager will, by keeping his cards in order and his frames clean, produce a sufficient quantity of a 5-hank roving to keep his spinning going from a given number of frames, whilst a slovenly manager could not get more than a 4-hank roving in the same quantity, the cotton, mixing, &c., being alike. Now the difference in the spinning and quality of yarn produced would be so great, that where the slovenly manager only made ends meet, the good manager would make a handsome profit.

Fig. 151.—Screw Lift.



It is a bad thing to keep constantly changing draught pinions, or ratchet wheels in frames. Alterations, when required, should be made before the cotton enters the frames.

All the slubbing frames, doing the same kind of work, when first started should be adjusted to knock off at the same length, have the same ratchet wheel and change pinions, so that the bobbins, if mixed, will come off at the same time. If this is properly attended to, half bobbins and whole bobbins can work together in the intermediate frames, which should, in their turn, be similarly adjusted to allow of both running through together in the roving frames. By careful attention to this point the work will be much more regular.

A great improvement was made in the lift-gear of slubbing and roving frames about thirty-eight years ago, by the application of screws (*Fig.* 151), to the lifting rails, instead of the racks and pinions, which cause the rails to dwell a little at each change, by reason of the backlash in changing with so slow a motion. However perfect the rack and pinion gear may be made, the motion is so slow that a little dwelling of the rail takes place at every reverse of motion, which is fraught with great evil, as it stretches the work by winding on tighter at the moment, and increasing the diameter of the bobbin a little at the ends. By the application of screws, the rail rests with a portion of its weight on the threads, and the instant the reverse or change takes place, down or up (as the case may be) goes the rail. This improvement was hailed by the trade as a very beneficial one, and for a short period it was very popular; but alas, for human foresight and prejudice! Unfortunately these lifting screws were made of wrought iron, and the bushes of brass, which soon wore out, and consequently got cried down; therefore this beautiful improvement was at once thoughtlessly abandoned.

The author had at this time one of his slubbing frames lifted by screws, and noticed his tenters frequently quarrelling about the bobbins. Whenever a set was doffed there was a rush to get hold of them, simply because they worked so much better than the others. This he distinctly ascertained arose from the fact that they were not stretched at the ends, like the others. Subsequently, having a new mill to fill, he was determined to have all his frames with screws, very much against the advice of the eminent machine-making firm, who had abandoned the principle on account of its excessive wear and tear. The writer nevertheless persisted, but had both the screws and the bushes made of *cast iron;* and instead of allowing the whole weight of the lifting rail to rest upon the thread of the screws, he had it partially balanced, leaving only a preponderance of weight upon them. For twenty-five years these frames were worked, and the screws seemed to be quite as good at the last as they were at first, never having cost a penny in repair during the whole time! This added another to the many previous proofs a long experience had given him of the value of cast-iron surfaces working together, care being taken to oil them well at first until the metal is saturated with oil, which, from its uniformly porous nature, it takes in like a sponge, and afterwards attains a high polish like glass, becoming almost as hard and durable.

Many good inventions get unthinkingly condemned through some little blunder or oversight having been made on their introduction. It has been thus with this valuable invention of the screw lift: it is hoped, however, that this really good thing may some day be revived.

A Secret worth Knowing.—It is a common thing to turn the spindles of slubbing, intermediate, and roving frames all to the *right* or *twist* way. The effect of this may be best illustrated by endeavouring to make a rope of many strands twisted all one way. The tendency of such a rope would be to curl up and untwist itself; but if the strands are twisted one way when single, and the contrary way when doubled together, the rope will lie straight with the twist in it.

Suppose it is required then to spin *Twist* from double rovings, and there are slubbing, intermediate, and roving frames, with the ends or bobbins doubled behind the intermediate and roving frames, as well as in the mules, the proper thing to do is to twist the slubbing to the *left*, the intermediate to the *right*, the roving to the *left*, and the mule to the *right*. The effect of this is, to a certain extent, to make the yarn like a cable, the fibres of the cotton being interwoven together. Both the intermediate and roving frames would work better, the mules would spin better, and the yarn would be sounder and freer from *crackers* or weak places. More twist may also be got into it, and there will be less disposition to curl.

Suppose it is required to spin weftwise also in the mules with double roving, then the order must be reversed all through, by commencing twistwise in the slubbing. If it be required to spin *twist* from the mule, but with *single* roving, then the slubbing spindles must turn to the right, the intermediate to the left, and the roving to the right, the same way as the mule. It must be distinctly understood that it is of no use to reverse the spindles, except *where a doubling takes place at the back*, otherwise it is *twofold loss* of the twist in the roving.

It is thought by many that the twist in rovings is *taken out* in the rollers as it passes through and gets broken or elongated. This is a mistake, as both ends are held fast. Although small in amount compared with the twist in yarn, it nevertheless is there, and contributes its quota to the yarn, helping to curl it up if the spindles go the same way; but becoming, as it were, latent or fixed as it is thrown over, if the spindles go in the opposite direction and there are two ends or rovings.

Attention to the above cannot be too strongly impressed upon spinners, as the advantage to be derived from it is very great.

Adjusting the Lift.—It is of considerable importance to adjust the lift of frames in such a manner that the roving or slubbing comes as near the end of the spool or bobbin as possible, and to make all the frames of each class exactly alike in that respect. By doing this carefully two good points are secured, viz., greater length is got upon the bobbins, which saves doffing and setting-in, and greater uniformity in the bobbins coming off, which saves trouble in setting-in and prevents singles running on, together with the stoppages occasioned thereby.

The advantages to be derived from a strict attention to small matters of this kind are greater than might be supposed, yet it is a very common thing to see some frames lifting half an inch more than others, in mills where there is a slovenly manager, and sometimes the lift will come nearer to one end of the bobbin than the other. The advantage of setting-in full bobbins to half bobbins behind the intermediate and roving frames, has been already pointed out; but it is impossible to maintain that order of working when the bobbins come off irregularly, unless it is done by making a great deal of unnecessary waste. If the spools have small flanges at the ends so as to prevent the cotton slipping off, a longer lift may be got than when made quite plain.

TATHAM AND CHEETHAM'S CAN SLUBBING FRAME.

Thirty years ago, slubbing and roving frames were not so perfect and substantial as they are now; and shortly after the invention of the coiler Messrs. Tatham and Cheetham conceived the idea of adapting it as a slubbing frame, as shown in *Figs.* 152,

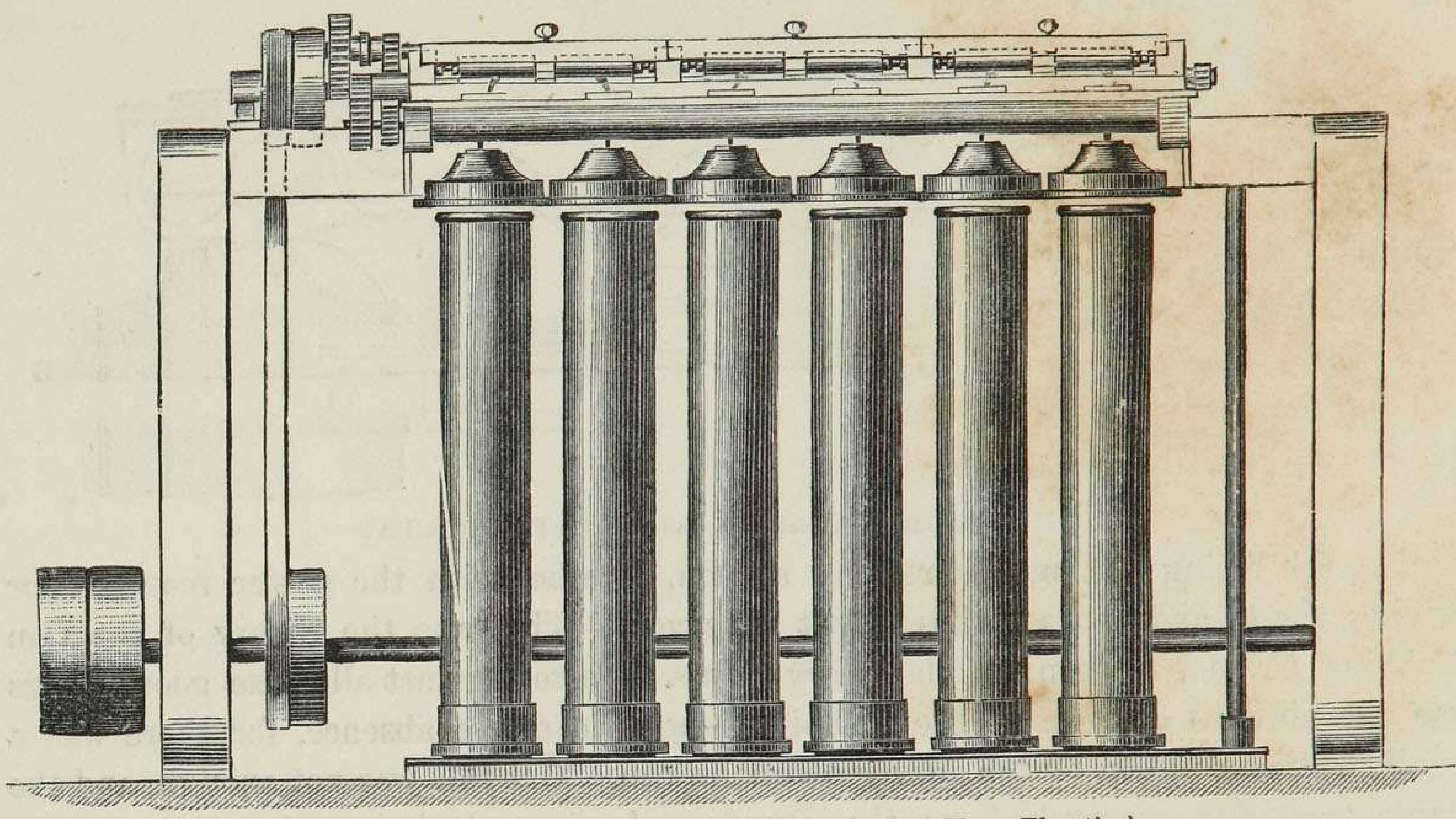


Fig. 152.—Tatham and Cheetham's Can Slubbing Frame (Front Elevation).

153, and 154, where, instead of spindles and flyers, a row of coilers were substituted for cans of about six inches diameter. This made a very neat and elegant-looking frame, and it worked exceedingly well, having stop motions both front and back in the latest build. True, it could not have as many cans working in the same length as there

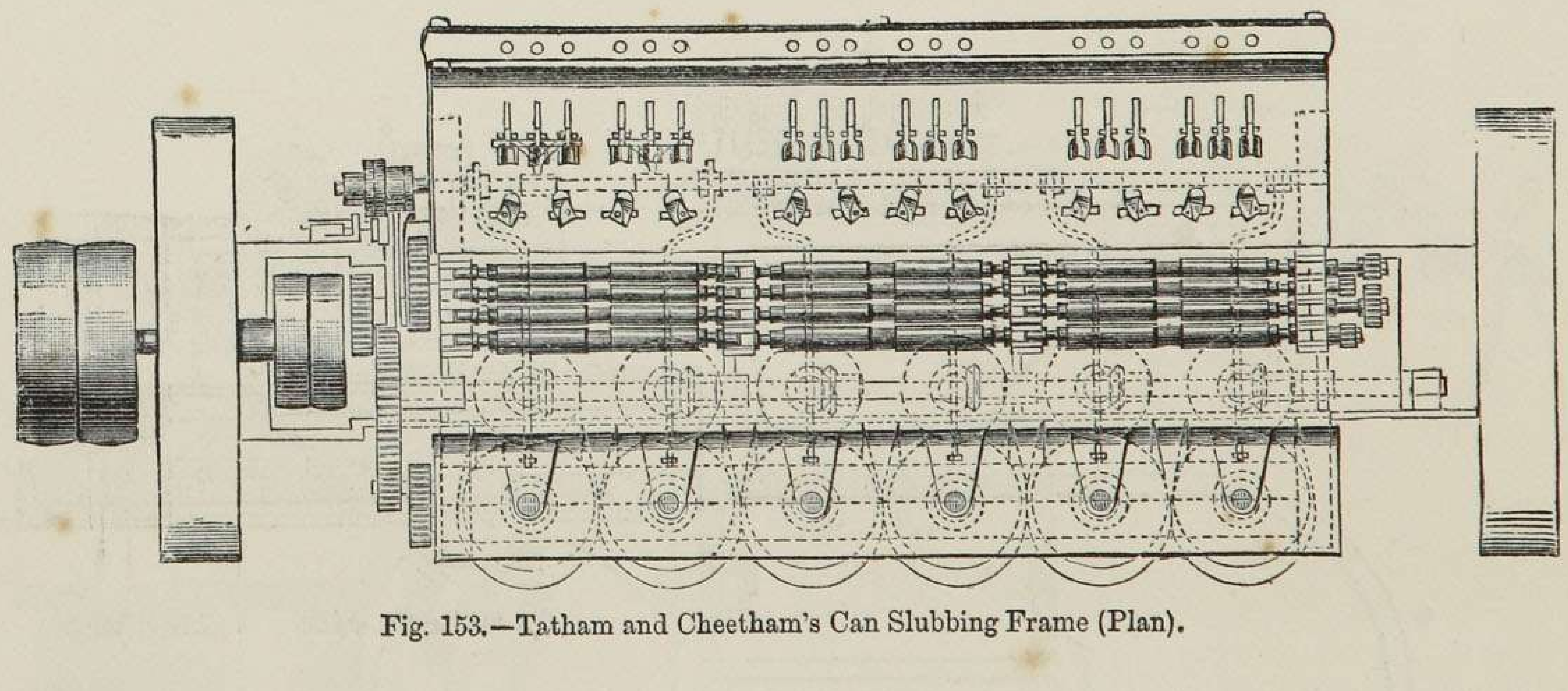


Fig. 153.—Tatham and Cheetham's Can Slubbing Frame (Plan).

were spindles in a slubbing frame ; but then the rollers could be run at much quicker speed, and one can would be equal to at least two slubbing spindles, and all the complicated machinery necessary in the latter to effect the winding on, the differential

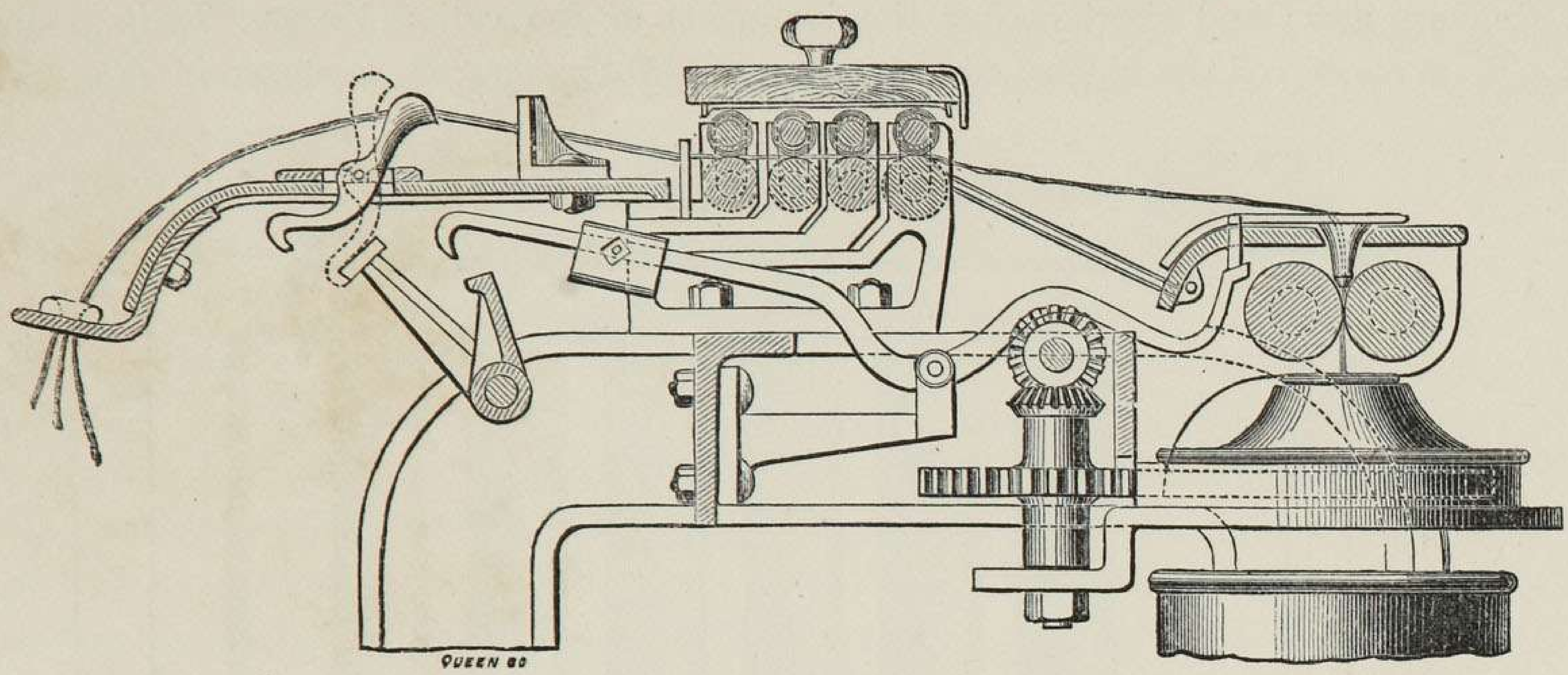


Fig. 154.—Tatham and Cheetham's Can Slubbing Frame (Section).

motion, the lifting rail and shortening motion, together with the power required for driving these, and the spindles might be saved. This was the theory of the Can Slubbing Frame, and a plausible theory it was. To set against all these good things was the absence of *twist* in the slubbing,—not the entire absence, for there was a small modicum put in by the slowly revolving can. But this was not enough, and the frame gradually succumbed, as the Dyer's and others had done before it, to the improved manufacture of fly frames—another proof of the great value of twist.

BARLOW AND TAYLOR'S PATENT DUPLEX SLUBBING FRAME.

This is an invention recently patented, differing from the frame last described in having a Dyer's tube *a* (*Fig.* 155) placed in front of the delivering rollers, and a top

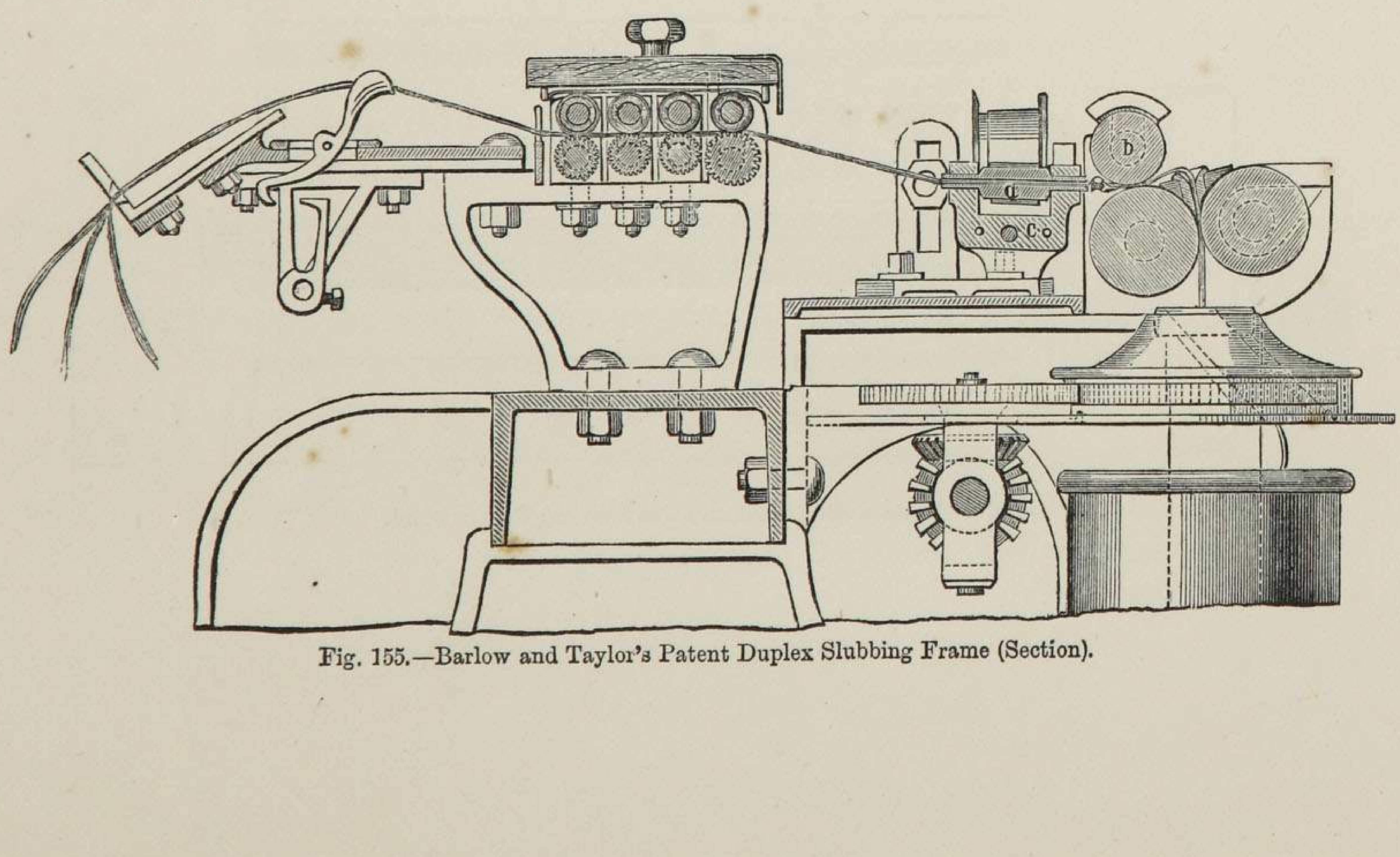


Fig. 155.—Barlow and Taylor's Patent Duplex Slubbing Frame (Section).

EVAN LEIGH'S LOOSE BOSS TOP ROLLERS,

FULL SIZE.

FIG. 1.

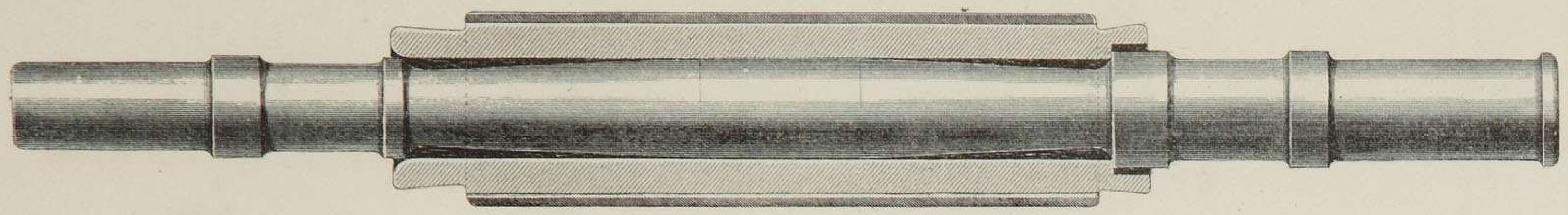


FIG. 2.

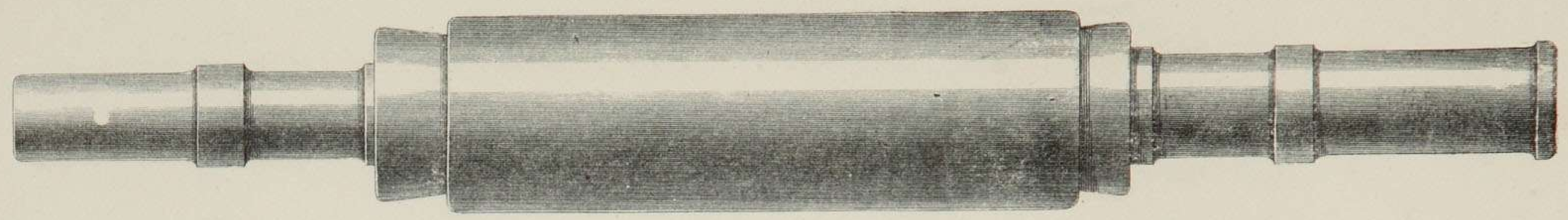


FIG. 3.

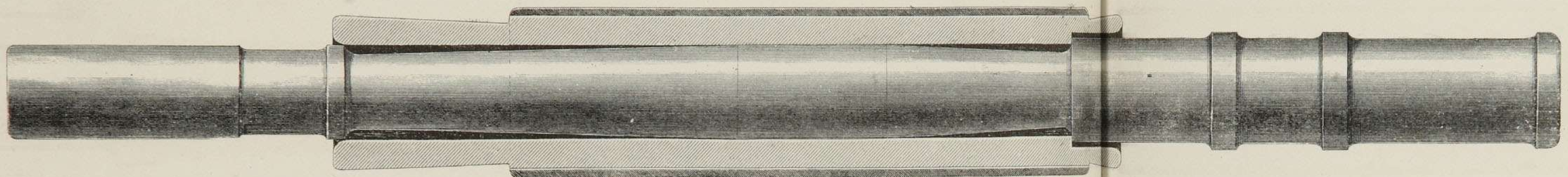


FIG. 4.

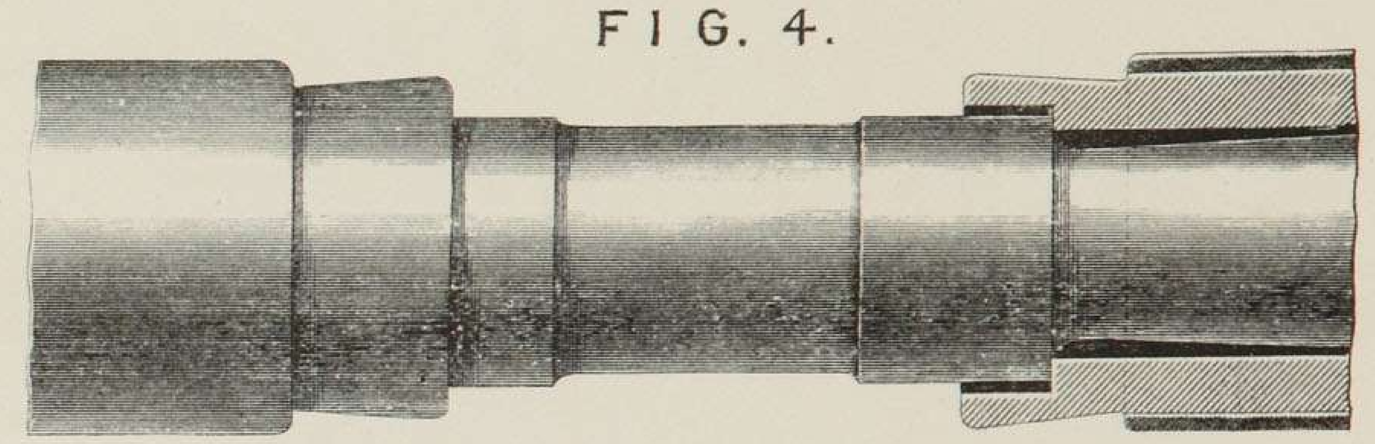


FIG. 5.

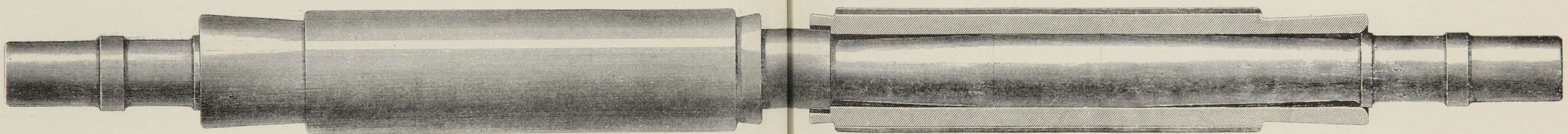


FIG. 6.

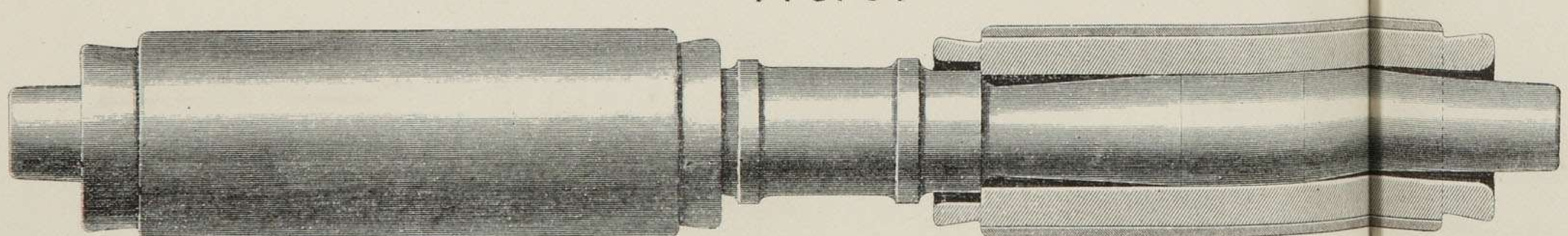


FIG. 7.

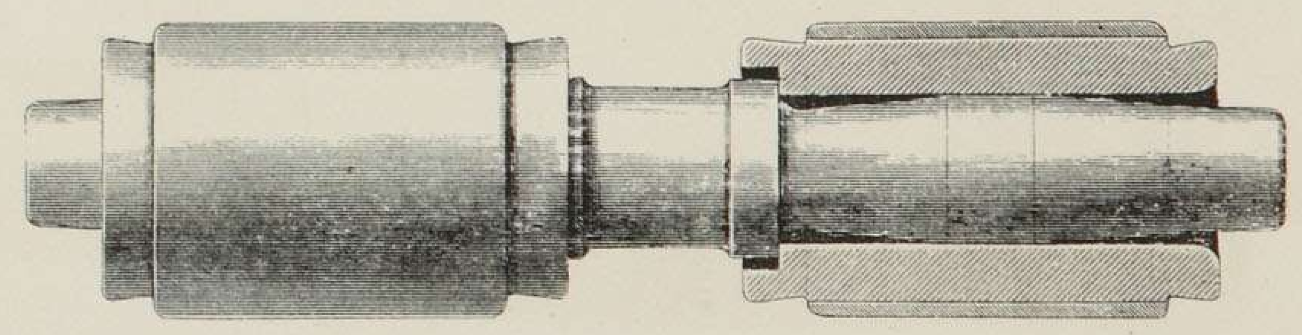


FIG. 8.

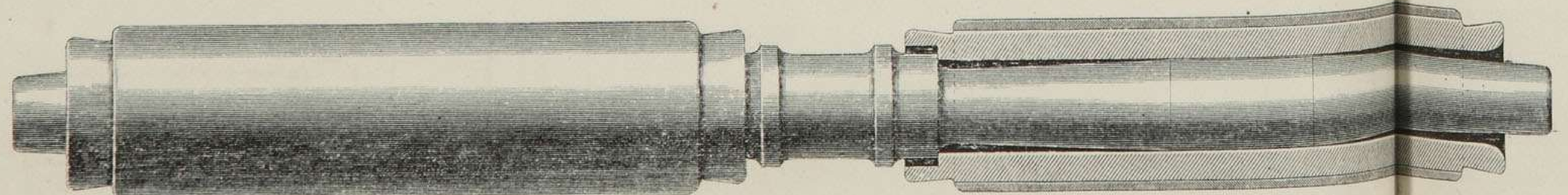
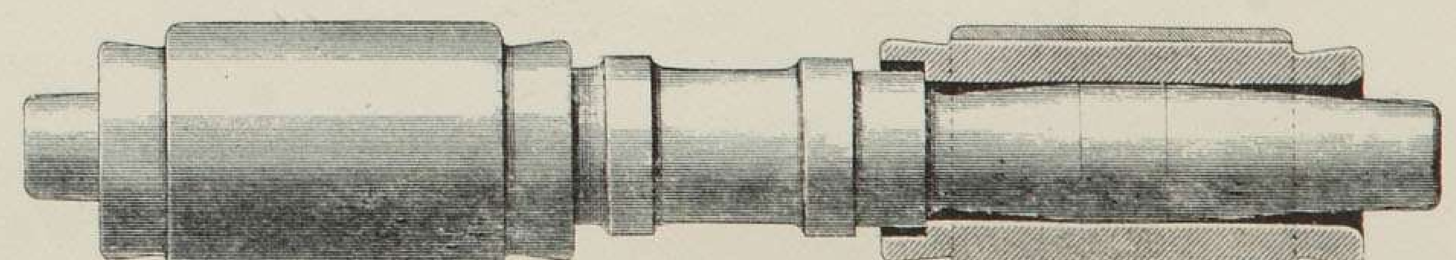


FIG. 9.



J. GALLOWAY, LITH. MANCHESTER.

callender *b* to pull the end through, after which it passes through the horizontal callenders to the coiler as usual. The stand *c* is made to slide towards the rollers for the convenience of piecing. The idea in this frame appears to be that the more perfect consolidation of the sliver, by passing it through a Dyer's tube and two callenders, as shown, will be a sufficient substitute for twist. How far this reasoning will be borne out in practice, time alone will show.

LEIGH'S LOOSE-BOSS TOP ROLLER.

After a year's unsuccessful experiments, upon which £1,300 were expended, the Loose-Boss Roller (Plate XXXI.), was patented by the author in 1857 in its present form. When correctly made, and properly worked, it effects a considerable saving both in oil, leather, and in the better working of the frames. It also saves power, and makes more regular yarn. It is, however, considerably more costly than the ordinary top roller; and if badly made, or carlessly oiled, sometimes disappoints the expectations of the spinner. Now that the patent has run out, and the manufacture is no longer confined to those who have special tools for the purpose, it is highly probable that many more badly-made rollers will get into use than formerly. Perhaps, therefore, the best service that can be rendered to spinners in this matter is, first, to explain the object of this roller, and then to show the points which require particular attention in its manufacture, and how it ought to be worked, which, if strictly attended to, highly satisfactory results will follow. On the contrary, if the spinner is indifferent about the construction or working of loose-boss top rollers, he had better discard them altogether.

However carefully covered a top roller having two bosses may be, one boss is sure to be a little larger than the other, which arises generally from the varying thickness of the leather. As the top rollers are driven by friction from the under rollers, it is evident that abrasion of the leather must take place from the lesser boss tending to make, say, 21 revolutions, whilst the larger one would go only 20 in the same time. Be it more or less, the difference must slip over the fluted surface of the under roller just the same as a vehicle running on two wheels would do if these wheels were keyed upon a shaft, as railway carriage wheels are, and one wheel were larger than the other. Such a vehicle, if drawn along a road, would necessarily turn towards the smaller wheel; and if forced to go in a straight line, must slide over the road at every revolution as much as the difference in the circumference of the wheels, making it difficult for the horse to keep in a straight line. In the same way, but to a greater extent, is stress thrown upon the under rollers of a frame or a mule by irregular top rollers, because the latter form cushioned brakes, heavily weighted, that have to slip over a fluted surface to the extent of the difference in the bosses. This, besides wasting considerable power, puts a great strain upon the squares of the under rollers. Any sceptic may soon convince himself upon this point by turning by hand a line of bottom rollers in a mule or frame, first with the ordinary solid roller, and afterwards with loose-boss tops. If the latter be marked by a chalked line, it will be found that, after a few revolutions, the marks will not come up together. The difference in the power may be measured exactly by detaching the under rollers and fixing a lever to the line of rollers, on which is a sliding weight, to be moved outward until the rollers are turned, or a cord may be wrapped round a pulley that is fixed on the under rollers, and the difference in power tested by a pair of butcher's scales. The oil required for lubricating them should not exceed 5 per cent of what is necessary for the ordinary roller, assuming that the loose-boss roller be made and worked properly. This arises from the fact that the lubrication is all *inside* the boss, where it is protected from dust and fluke; and from the principle of the journal, the oil has a constant tendency to determine *to the point of friction;* and the spindle on which the bosses revolve being dead, or stationary, no oil is required outside, nor is there any wear and tear of cap bars, saddles, or hooks. The oil is drawn to the exact spot where it is wanted simply by the law of gravitation, and it will be understood by the following diagram, *Fig.* 156,

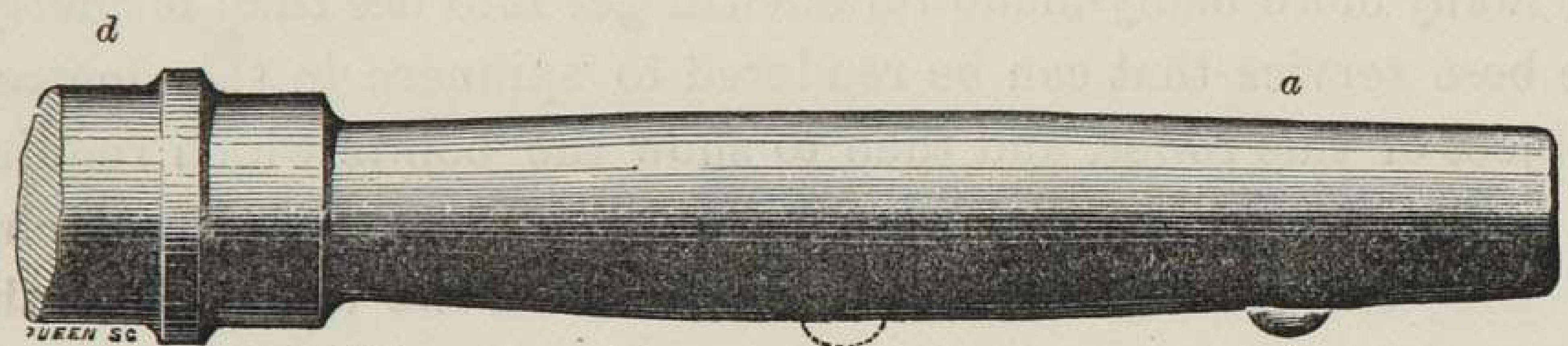


Fig. 156.

which shows the end of a roller spindle. If a drop of oil be put on the spindle at *a* it immediately falls down to the under side, and is seen at *b*, whence it moves down the inclined plane to *c*, where it rests, because on the other side of *c* is another inclined plane in the opposite direction, which it cannot ascend. Now, if a loose boss be put upon this spindle, and a weight hung upon it at *d*, the boss will be held down to the under roller by the thick part of the spindle at *c*, which alone touches it, and upon which all the friction is thrown when the boss is driven round by the under roller; therefore, as long as there is a drop of oil on the spindle it keeps constantly flowing, like a fountain, to the exact point of friction.

After these rollers have worked a few years they have been known to run six or nine months with one lubrication of good oil, which arises from the circumstance that the spindle and interior of the boss, at *c*, both being made of *cast* iron, have attained a polish like glass, and have become nearly as hard on the outer skin; for it is a property of cast iron, from its porous nature and absorption of oil, to case-harden itself when working as a journal for some time; after which it has no tendency to wear, and runs exceedingly light. The oil then remains clear and limpid, which at first worked black.

Oiling.—Loose-boss rollers should never be oiled in the frames, or when at work. The best plan is to let one person attend to the whole of them throughout the mill, and to have a spare set of each kind. When a frame is stopped for scouring through, the oiler should bring his spare set cleaned and oiled ready to put in, and take the others away. By that means they are worked with the greatest economy and perfection, and there will be no oil stains on the leather covering.

Manufacture of Loose-boss Rollers. — The greatest possible care should be observed in the making of loose-boss rollers. The castings should be of suitable metal, annealed for about three or four days in softening pots. The bosses should all be accurately bored from the solid to a templet, which is slightly under Whitworth's standard gauge, for the diameter of hole intended; they should then be turned or roughed out to nearly the external diameter required, when the mandril should be changed, and another lathe employed to finish them off with accuracy externally. The bosses should then be chucked, to receive the countersink at one end, after which they are passed on to the polisher, who chucks them in a hollow spindle lathe that runs about 4,000 revolutions per minute; then, with a polishing stick, having fine emery cloth dipped in oil wrapped round it, the holes are speedily polished out like a gun barrel to the size of Whitworth's standard gauge, a perfect set of which should always be kept, from which to make the working gauges, as they are apt to wear from constant use and must be periodically adjusted. All the bosses, after leaving the polisher, must be examined before going out of the shop, by having a gauge of the exact standard size passed through them.

The spindles must be roughed out to the proper shape and length in one lathe, and finished in another, care being taken that the parallel part, shown in dotted lines, Plate XXXI., be finished to Whitworth's cylindrical templet, in the polishing; but a very slight tendency to the barrel form must be given with the polishing cloth there, so that the boss will not be in any way too tight, and the oil can work to the centre of the bearing. The bearing or parallel part of the spindle must be about one-fourth the length of the leather covering of the boss, and its position on the spindle exactly in the centre of the leather covering, as shown. Especial care is required in turning long spindles, which require to be stayed in the middle, that the centre of the spindle where the stay is fixed, be first turned true and perfectly *round*, which is rather difficult to do, if the castings happen to be bent or oval. If the stay be fixed to an oval place, the spindle will be turned oval and spoiled.

The spindles are polished by being thrust loosely, one end at a time, into the socket of a quick running lathe, the other end being held by the hand, which is furnished with fine emery cloth in a dry state, and the bearing part is finally tested with a Whitworth cylinder gauge.

Care should be taken to leave all the spindles that are weighted in the centre larger in diameter where the weight-hook bears than the hole in the boss; then the weight-hook has a power to prevent the spindle revolving. Thousands of rollers have been spoiled by reducing the spindle to a smaller diameter than the inside bearing. In some cases, where the rollers are only weighted at the ends, the spindle cannot be larger in diameter, as the bosses have to go over the places where the weight-hooks bear, then they should be left the full size of the hole, which just answers the purpose; but the power of holding the spindle from turning is, in such cases, very slight, and it is always better where there is a long spindle to have it weighted in the middle, if there be two bosses. If there be only one boss (as in *Figs.* 1 and 2, Plate XXXI.), the spindle may be left thicker at one end than the other, then the weight-hook of the thick end will have power over it. Sometimes heating is caused by long spindles being turned crooked or too thin for the weight they have to bear,—weighted only in the middle or at the end; such spindles should always be weighted in three places.

The slide lathes used for turning spindles should be fitted with shapers to guide the tool in roughing out, so that every spindle will be roughed out exactly alike and to precisely the same length, with the humps in their proper places. Self-acting boring lathes, to bore four bosses at a time, with hollow spindles, and conical chucks arranged so that one spindle can be stopped whilst the others are going on, are the most convenient for the purpose.

THE DYER'S FRAME.

A great sensation was excited about thirty-five years ago by the introduction from America of a tube roving frame, which took the name of Dyer's Frame, from its having been purchased and brought out by the late Mr. Dyer, of Manchester, who realised a large sum of money by the manufacture, as did also many cotton spinners by its use. Its chief merit was a rough and ready way of getting through a large quantity of work. It suited the times very well; for in those days slubbing and roving frames were very imperfect, being made of small size, the spindles were driven, in most instances, by bands, the changing motions imperfect and liable to get out of order; so that the cost in attending to them was more than double what it is now. Hence the success of the Dyer's Frame.

The bobbins or rovings from this frame were taken direct to the mules or throstles to be spun; but having no twist, were easily injured, and not so good in many respects as a twisted roving. This disadvantage, which it is not possible for any ingenuity to remove, constitutes the great objection to the Dyer's Frame, so it has gradually gone out of use, and very few are now in existence, having been supplanted, as they were worn out, by slubbing and roving frames.

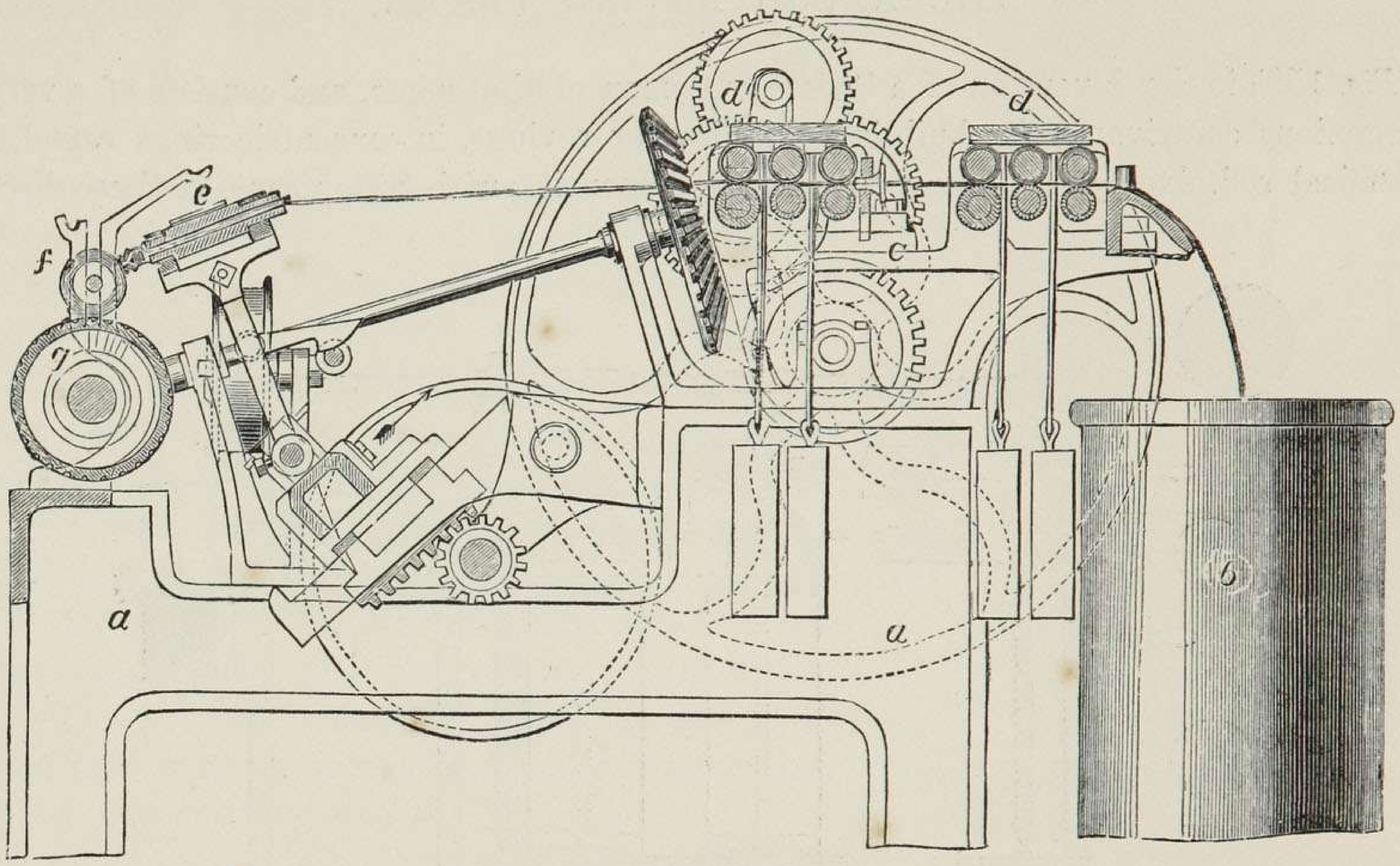


Fig. 157.

Fig. 157 shows in section the principal parts of a Danforth,* or Dyer's Frame, from which its action will be understood: *a*, the framing, carrying roller beam, stands, &c.; the cotton cans, *b*, supplying the slivers from drawing frame; *c*, a double stand, containing two sets of drawing rollers, *d* and d^1, of three rows each. After passing through the first set of rollers, the sliver was contracted by passing through a trumpet to the second set, from which it was delivered, drawn out to the thickness of roving required. As the rollers delivered it, the roving became twisted as hard as a string by the tube *e*, through which it passed, the said tube having a rapid rotary motion given to it by a strap, which passed over one tube and under the next. Of course, the twist put in by one end of the tube was taken out by the other, and the roving was deposited on the bobbin *f*, which lay in a horizontal position upon the fluted drum *g*; the periphery of this drum going at the same speed as the front drawing roller, the drag upon the end was always constant, whatever the diameter of the bobbin. The tubes *e* were slightly

* Danforth, of America, an ingenious mechanic, invented this frame.

raised, by rack and pinion, so as to keep the same gentle pressure on the bobbin as it filled, which was done very rapidly, as the front drawing roller ran at a speed of about 600 revolutions per minute.

THE ABEGG ROVING FRAME

(*Fig.* 158) is the invention of a Swiss gentleman of that name, and consists of a very ingenious contrivance for building slubbing, or rovings, in concentric rings round a vertical rod, fixed on a disc of wood, thus dispensing with cotton cans, as these discs

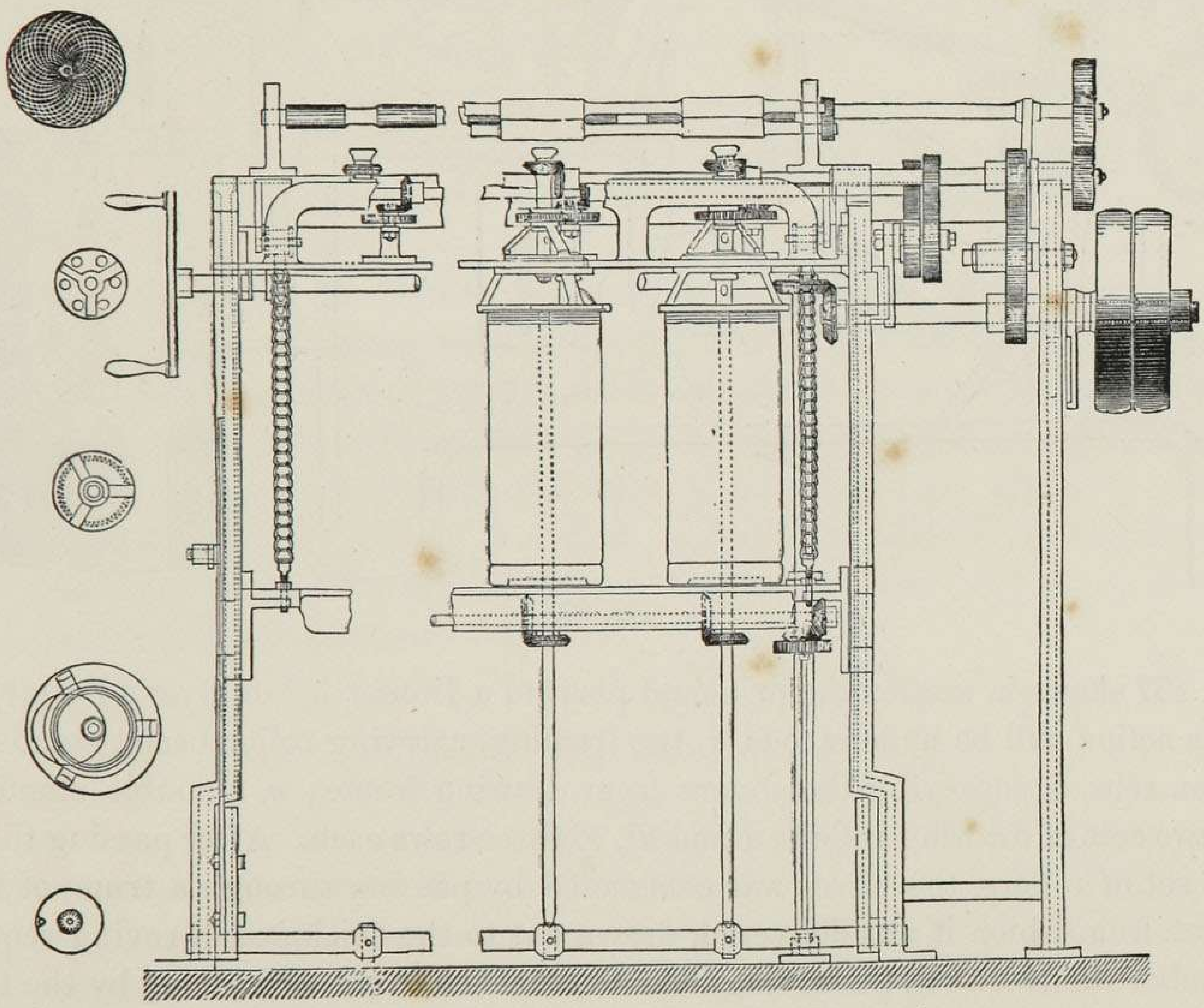


Fig. 158.--The Abegg Roving Frame. (Front Elevation.)

could be carried about and set behind other frames, after which the rod is withdrawn. This very clever contrivance has considerable merit; but it never obtained a footing amongst the English spinners, although an attempt was made to introduce it.

Fig. 158 shows front elevation; and the five small figures on the left-hand side show different parts of the coiling motion, the upper figure showing how the cotton is laid.

Fig. 159, below, shows end view of the frame, and the manner in which the set is doffed off by inclining the rod around which the slubbing or roving is built.

It is said that "no prophet is accepted in his own country;" but here is an exception, for the Swiss spinners are very fond of the Abegg frame, and continue to use it extensively.

THE ECLIPSE ROVING FRAME

is another ingenious little machine for producing in abundance untwisted rovings, using straps running in opposite directions, between which the cotton passes, being thereby twisted and untwisted as the straps rub together. This frame never came into general use in this country, having been speedily abandoned by those spinners who tried it, as its work was less certain and of worse quality than that of the Dyer's Frame.

One or two other attempts were made to produce an untwisted roving, at a cheap rate, but were practically unsuccessful, all having given way to the improvements in slubbing and roving frames which now most decisively take the lead.

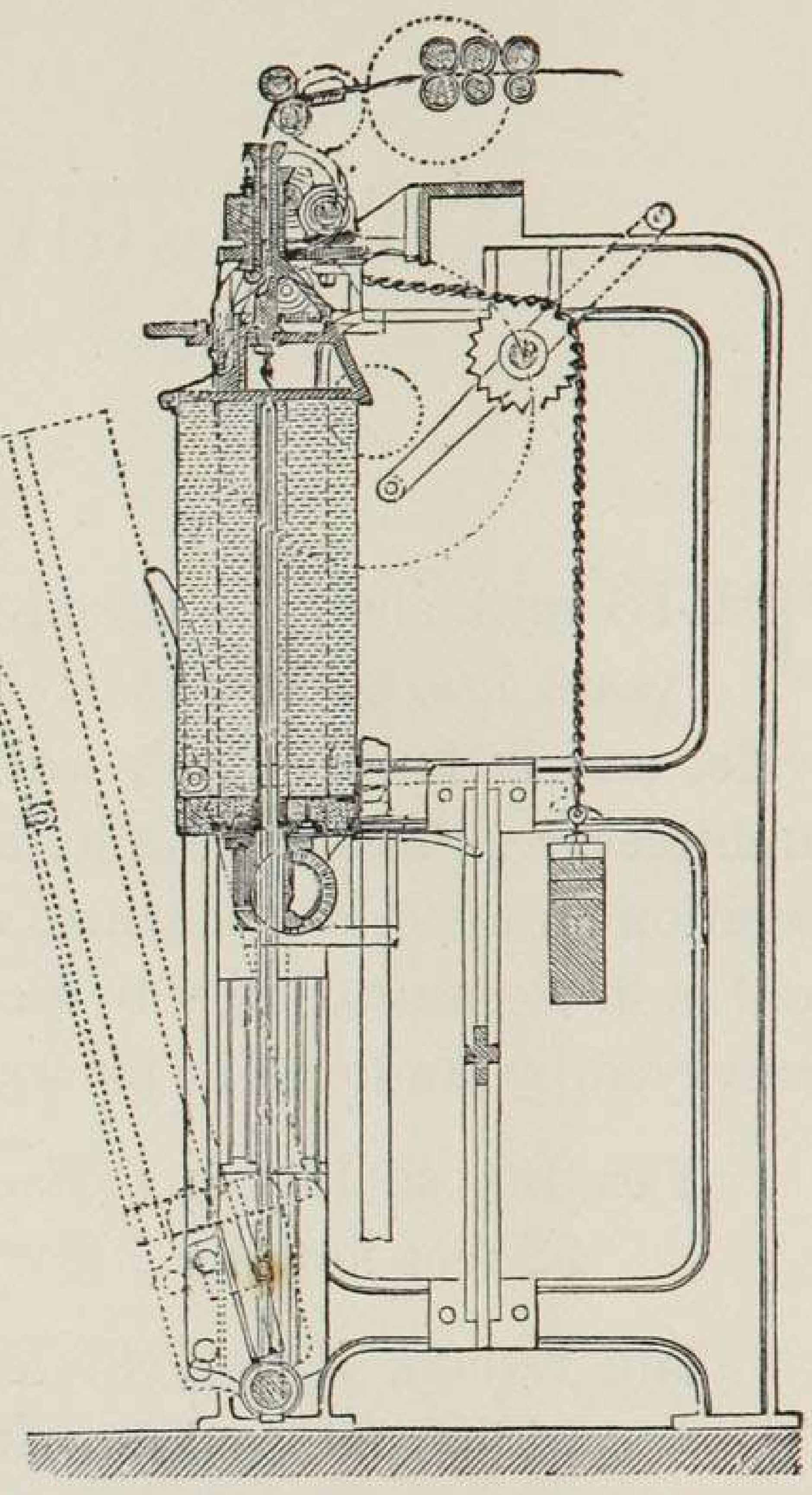


Fig. 159.—Abegg Frame. (End view.)

Product of Slubbing and Roving Frames, per Spindle, in 60 hours, allowing time for Doffing and Cleaning—say about one-sixth of the above time.

Revolution of Spindle per minute	500	600	750	900	1000	1100	1300	1500	
½ Hank	72 lbs.	84 lbs.	„	„	„	„	„	„	12-in. lift.
⅝ „	64 lbs.	71 lbs.	„	„	„	„	„	„	12-in. lift.
¾ „	57 lbs.	67 lbs.	„	„	„	„	„	„	12-in. lift.
⅞ „	„	60 lbs.	„	„	„	„	„	„	10-in. lift.
1 „	„	48 lbs.	„	„	„	„	„	„	10-in. lift.
1¼ „	„	36 lbs.	„	„	„	„	„	„	10-in. lift.
1½ „	„	31 lbs.	„	„	„	„	„	„	10-in. lift.
1¾ „	„	24 lbs.	30 lbs.	„	„	„	„	„	8½-in. lift.
2 „	„	20 lbs.	25 lbs.	„	„	„	„	„	8½-in. lift.
2½ „	„	16 lbs.	18 lbs.	„	„	„	„	„	8½-in. lift.
3 „	„	13 lbs.	12 lbs.	„	„	„	„	„	8½-in. lift.
3½ „	„	„	10 lbs.	12 lbs.	13 lbs.	14¼ lbs.	16¼ lbs.	„	7-in. lift.
4 „	„	„	8 lbs.	10 lbs.	10 lbs.	11 lbs.	13½ lbs.	„	7-in. lift.
5 „	„	„	„	7 lbs.	7¾ lbs.	8½ lbs.	10 lbs.	„	7-in. lift.
6 „	„	„	„	„	5¾ lbs.	6¼ lbs.	7½ lbs.	„	7-in. lift.
7 „	„	„	„	„	4½ lbs.	5 lbs.	6 lbs.	„	7-in. lift.
8 „	„	„	„	„	3¾ lbs.	4¼ lbs.	4¾ lbs.	„	7-in. lift.
9 „	„	„	„	„	„	3½ lbs.	4 lbs.	„	6-in. lift.
10 „	„	„	„	„	„	3 lbs.	3½ lbs.	„	6-in. lift.
12 „	„	„	„	„	„	2½ lbs.	2¾ lbs.	„	6-in. lift.
14 „	„	„	„	„	„	2 lbs.	2¼ lbs.	2½ lbs.	5-in. lift.
16 „	„	„	„	„	„	1⅝ lbs.	1⅞ lbs.	2 lbs.	5-in. lift.

THE "GIDLOW MILL," AT WIGAN.

THIS mill, shown in coloured perspective on the opposite page, was erected a few years ago, by Messrs. Rylands & Sons, at Wigan. It is 392 feet long by 108 feet wide, and is built of red, white, and blue bricks, in a novel and striking style of architecture, three storeys high, and fireproof throughout. It occupies a commanding position on a slight eminence, where it has the advantage of good condensing water, and is in close proximity to a colliery belonging to the same firm, whence the coals are conveyed by tramway in pit wagons.

THE BOILER HOUSE (*vide* Plate XXXIII.), which contains eight boilers, each 32 feet long by 6 feet 9 inches diameter.

THE ENGINE HOUSE (Plates XXXIV. and XXXV.) is 100 feet long by 40 feet wide, and contains two pairs of horizontal condensing steam engines, with cylinders of 40 inches diameter and 6 feet stroke, being of the nominal power of 60 horses each, or 240 altogether.

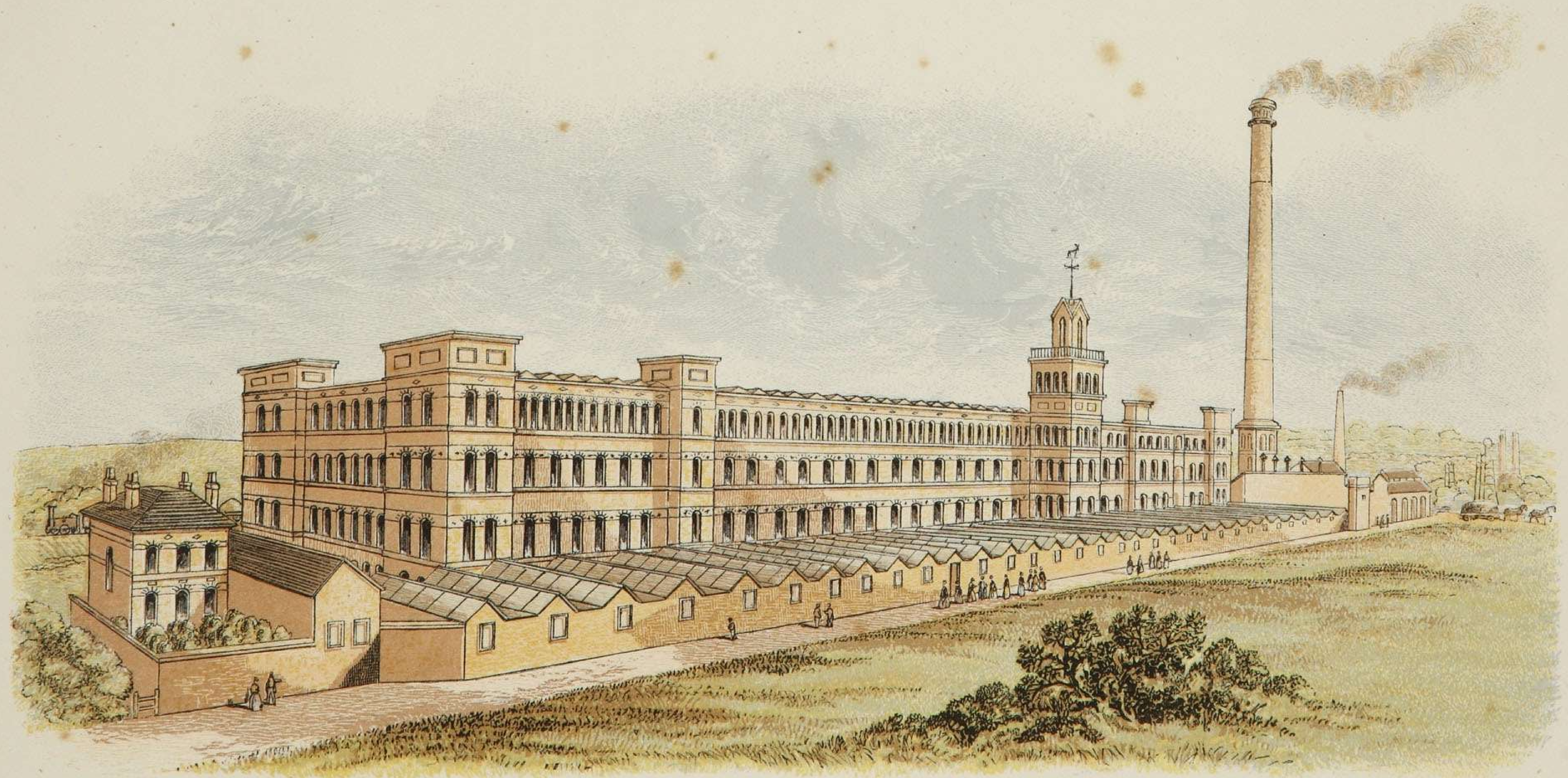
These engines, together with the shafting, have been made by Messrs. Musgrave & Sons, of Bolton, and are so arranged that, in case of accident to one pair, the other can work on and drive half the machinery throughout the mill.

No. 1 *Room* contains—

154 Throstle Frames, each 200 spindles; and
42 Roving Frames, each 136 spindles.

No. 2 *Room* contains—

140 Carding Engines.
12 Drawing Frames, each 5 heads and 4 deliveries.
14 Slubbing Frames, each 72 spindles.
20 Intermediate Frames, each of 100 spindles.
12 Roving Frames, each 136 spindles.



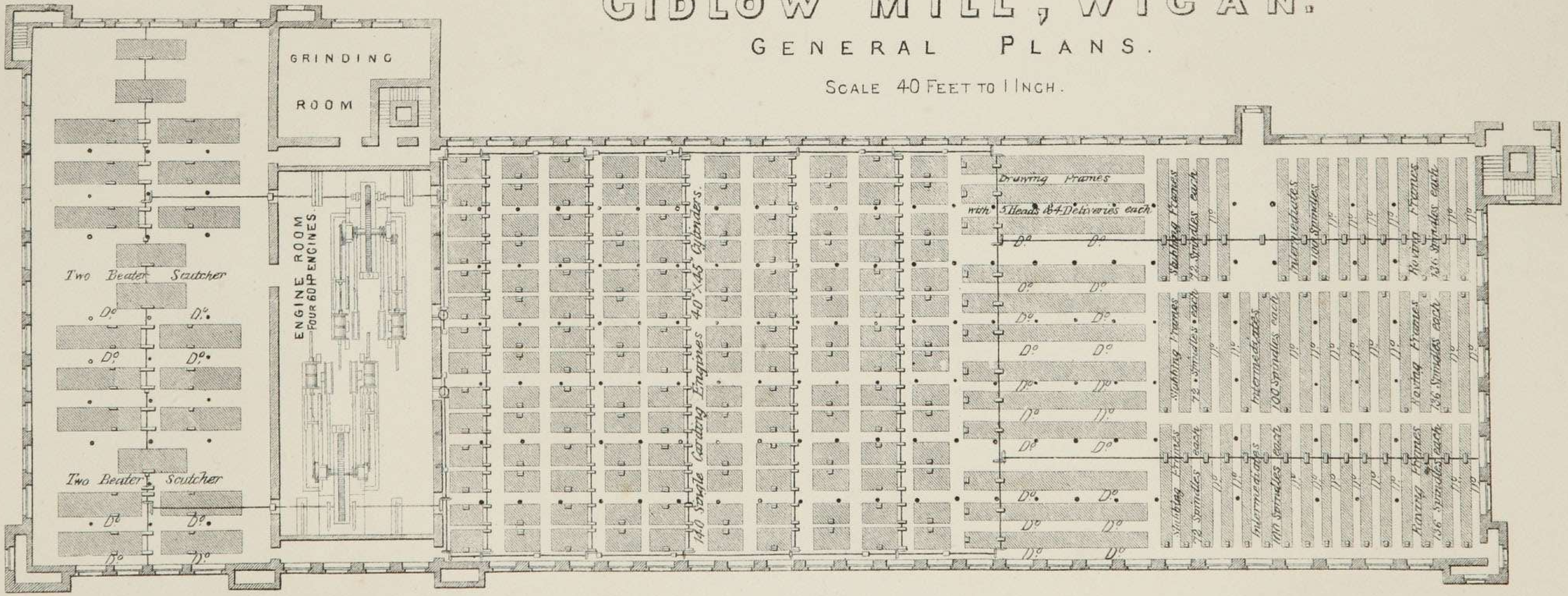
WIGAN MILL.

PLATE, XXXIII.

GIDLOW MILL, WIGAN.

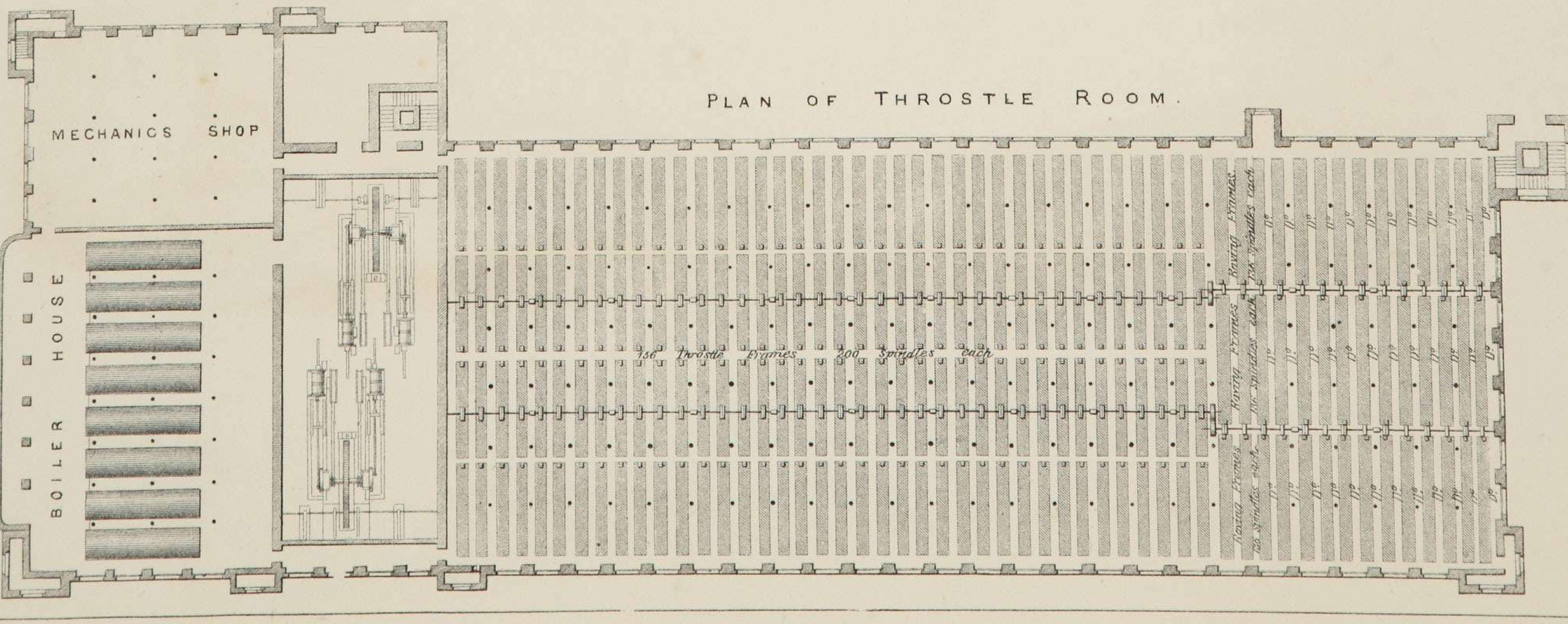
GENERAL PLANS.

SCALE 40 FEET TO 1 INCH.



PLAN OF CARD ROOM

PLAN OF THROSTLE ROOM.



J. GALLOWAY, LITH. MANCHESTER.

GIDLOW MILL, WIGAN.

FOUR SIXTY HORSE POWER CONDENSING STEAM ENGINES

PLAN OF ENGINE ROOM.

Scale $\frac{3}{16}$ Inch to 1 Foot.

J. GALLOWAY, LITH. MANCHESTER.

GIDLOW MILL, WIGAN.

FOUR SIXTY HORSE POWER CONDENSING STEAM ENGINES.

MAKERS, J. MUSGRAVE & SONS.

Scale of Feet

10 9 8 7 6 5 4 3 2 1 0 10 20 feet.

J. GALLOWAY LITH. MANCHESTER.

No. 3 *Room* contains—

13 Pairs or 26 Mules, of 1,076 spindles each mule; and
2 Pairs or 4 „ 600 „ „

Making a total of 30,800 throstle spindles, and
30,576 mule spindles; altogether

61,376 spindles.

Attached to the mill is a large *Weaving Shed*, which contains from 1,400 to 1,500 looms, together with winding, warping, &c.

The Scutching Room (Fig. 1, Plate XXXIII.) contains—

2 Crighton Openers.
12 Double Scutchers.

The card room machinery and throstles are of Messrs. Howard & Bullough's manufacture: and the mules are by Messrs. Curtis, Parr, & Madeley.

SPINNING.

EARLY SPINNING MACHINES.

THE most ancient method of twisting the fibres of cotton into yarn, or spinning, recorded in history, is by the spindle and distaff, as in *Fig.* 160.

The earliest improvement upon this was the invention of the spinning wheel, *Fig.* 161, as used in India, and *Fig.* 162, as used in England, and which became about the time of Henry VIII. a regular implement of domestic industry, used in almost every household in England for twisting and winding fibrous substances. Every young woman, both in the cottages of the poor and the halls of the rich, was taught to spin with this simple machine; hence the origin of the term "Spinster," appended in legal, and other documents to the name of an unmarried female.

Fig. 160.—Spindle and Distaff.

Fig. 162.—English Spinster at work.

Fig. 161.—Indian Woman spinning.

The first attempt to draw cotton by a succession of pairs of rollers appears, from the Patent Records, to have been made by Lewis Paul, of Birmingham, who took out a patent in the year 1738, the specification of which runs thus:—

"The said machine, engine, or invention will spin wooll or cotton into thread, yarn or worsted, which, before it is placed therein, must be first prepared in manner following (to wit): All those sorts of wooll or cotton which it is necessary to card must have each cardfull, batt, or roll joyned together, so as to make the mass become a kind of rope or thread of raw wooll. In that sort of wool which it is necessary to comb, commonly called jarsey, a strict regard must be had to make the slivers of an equal thickness from end to end. The wool or cotton being thus prepared, one end of the mass, rope, thread, or sliver is put betwixt a pair of rowlers, cillinders, or cones, or some such movements, which being turned round by their motion, draws in the raw mass of wooll or cotton to be spnn, in proportion to the velocity given to such rowlers, cillinders, or cones. As the prepared mass passes regularly through or betwixt these rowlers, cillinders, or cones, a succession of other rowlers, cillinders, or cones, *moving proportionably faster than the first* draw the rope, thread, or sliver into any degree of fineness which may be required. Sometimes these successive rowlers, cillinders, or cones (but not the first) have another rotation besides that which diminishes the thread, yarn, or worsted, (viz.) that they give it a small degree of twist betwixt each pair by means of the thread itself passing through the axis and center of that rotation. In some other cases only the first pair of rowlers, cillinders, or cones are used, and then the bobbyn, spole, or quill, upon which the thread, yarn, or worsted is spun, is so contrived as to draw faster than the first rowlers, cilliuders, or cones give, and in such proportion as the first mass, rope, or sliver is proposed to be diminished.—In witness whereof, &c. LEWIS PAUL.

"Witnesses: SAML. GUY, JOHN WYATT."

It will be seen from the wording of Paul's specification that he clearly conceived the idea of drawing out the fibres of cotton by a succession of pairs of rollers, but he shows no drawings to indicate by what mechanism it was to be done; and in the latter part of his specification he seems to have a confused notion of *giving a little twist* between some of the pairs of rollers, when he says that they have another rotation besides that which diminished the thread, by means of which the "*thread itself passes through the axis and center of that rotation.*" It would have been better for Paul's reputation, if he had left the latter part of his specification out altogether. No wonder that he found it difficult to show drawings of what he meant, and therefore he omitted them altogether. This machine, from its description, should rather have been termed a "drawing" than a "spinning" frame.

During the time that Paul was engaged upon this machine, he was connected in partnership with John Wyatt, who signed his specification as a witness. Although the patent was taken out in Paul's name, Wyatt claims to have been the principal agent in compiling the machine, and says that so early as 1733 he made a model two feet square, which had two cylinders, through which he passed wool that had been carded in the common way, "from whence the bobbin drew it by means of the twist." He and his friends further say that he let this invention slumber for some years for want of means to prosecute it, and that he ultimately showed it to Paul, who promised to find capital and assist him in getting it out. How far Wyatt's statement is true it is now impossible to say, but according to Wyatt's own account he constantly lived in London about the time that Paul was beginning to work his machine, and acted as salesman for the concern, leaving Paul in management of the machinery at Birmingham.

It is impossible to say what kind of a machine it was that Paul and Wyatt brought out, but certain it is that they succeeded in making some kind of yarn about the year 1741, a hank of which is said to be still extant, but, nevertheless, the concern was unfortunate, and was broken up in 1743. Subsequently works were established at Northampton, containing 250 spindles, in five frames of 50 spindles each, which were driven by water power, and employed fifty people altogether. Wyatt, who appears to have been a very intelligent man, wrote a "Systematic Essay on the Business of Spinning," in which he fully describes this concern, and says that each frame was reckoned to spin 15 skeins or hanks per day, No. 15 to the lb., and the yarn was supposed to have about 20 twists to the inch. The wages paid weekly amounted to about £2. 19*s.* 7*d.*, or say £3. Like its predecessor in Birmingham, this concern became unfortunate, and got into the hands of a Mr. Yeo, a London lawyer, in 1764. The machinery in this mill was probably made upon Paul's latest improvements, for which he took out a patent in 1758, as the frames are said to have had 50 spindles each, the number which Paul shows in the drawings and full description lodged with his specification, which runs thus :—

"PAUL'S *Specification, A.D.* 1758.

"Now, know all men by these presents : That I the said Lewis Paul, do by this present writing under my hand and seal, declare the nature and form of the said Invention to be, and the manner the same is to be performed, is as follows (to wit) : The wooll cr cotton to be spun by the said machine or engine must be first carded upon a card made up of a number of parelel cards, with intervening spaces between each, and the matter being so carded, must be taken off

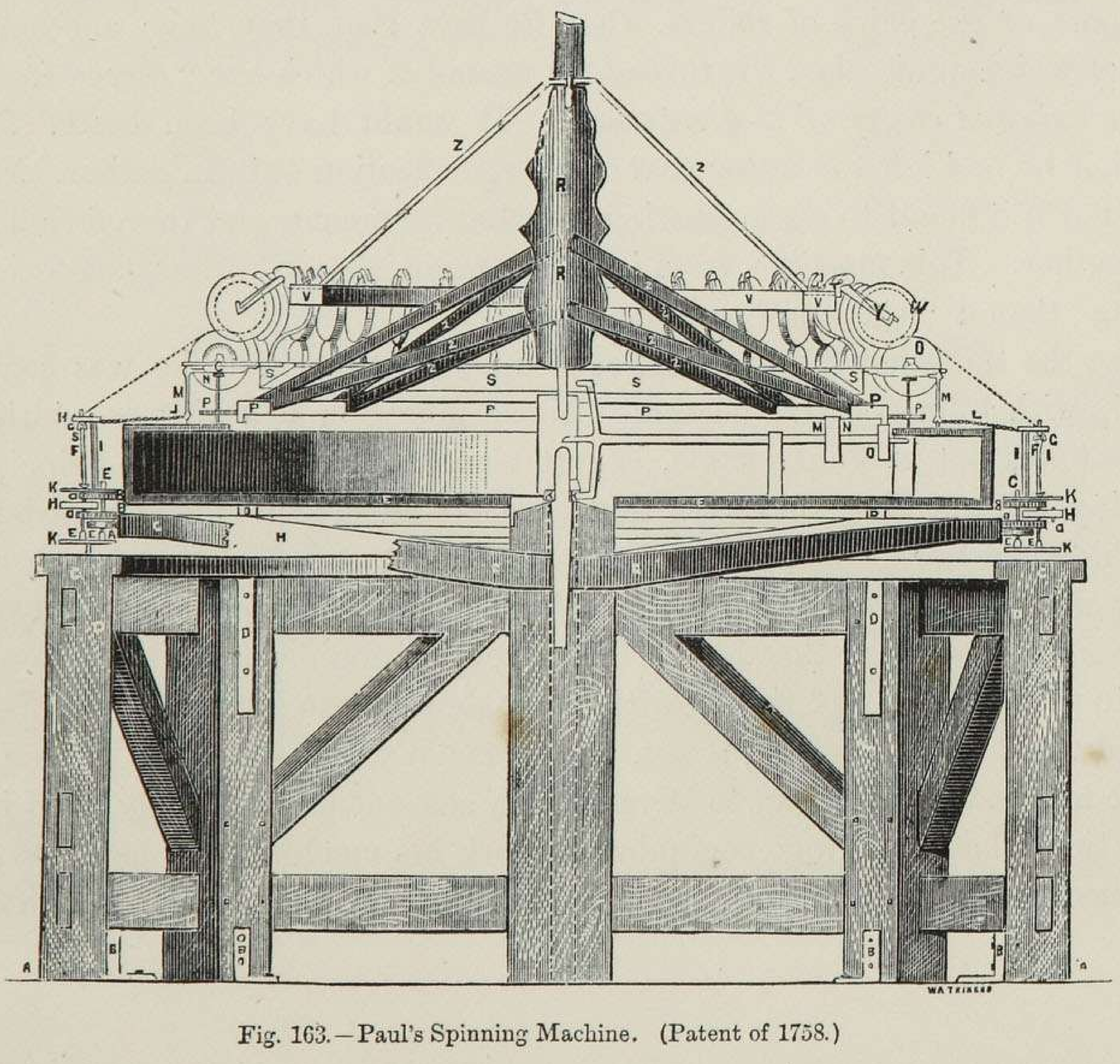


Fig. 163.—Paul's Spinning Machine. (Patent of 1758.)

each card seperately, and the several rowes or fillaments so taken oft must be connected into one entire roll, which being put between a pair of rollers or cylinders is, by their turning round, delivered to the nose of a spindle in such proportion to the thread made as is proper for the particular occasions. From hence it is delivered to a bobbin spole, or quill, which turns upon the spindle, and which gathers up the thread or yarn as it is spun. The spindle is so contrived as to draw faster than the rollers or cylinders give, in proportion to the length of thread or yarn into which the matter to be spun is proposed to be drawn; a further explanation of which is set forth in the Plans and Draughts thereof hereunto annexed, marked with the Figures 1, 2, 3, 4, 5, and the explanation thereof marked 6 and 7.

"In witness whereof I have hereunto set my hand and seal this Twenty-eighth day of October, 1758.

"LEWIS (L.S.) PAUL."

Fig. 163 shows elevation and part section of Paul's machine, which was built in the round form; and *Fig.* 164 shows enlarged section. There are other elaborate drawings deposited with his patent, but no further explanation or description.

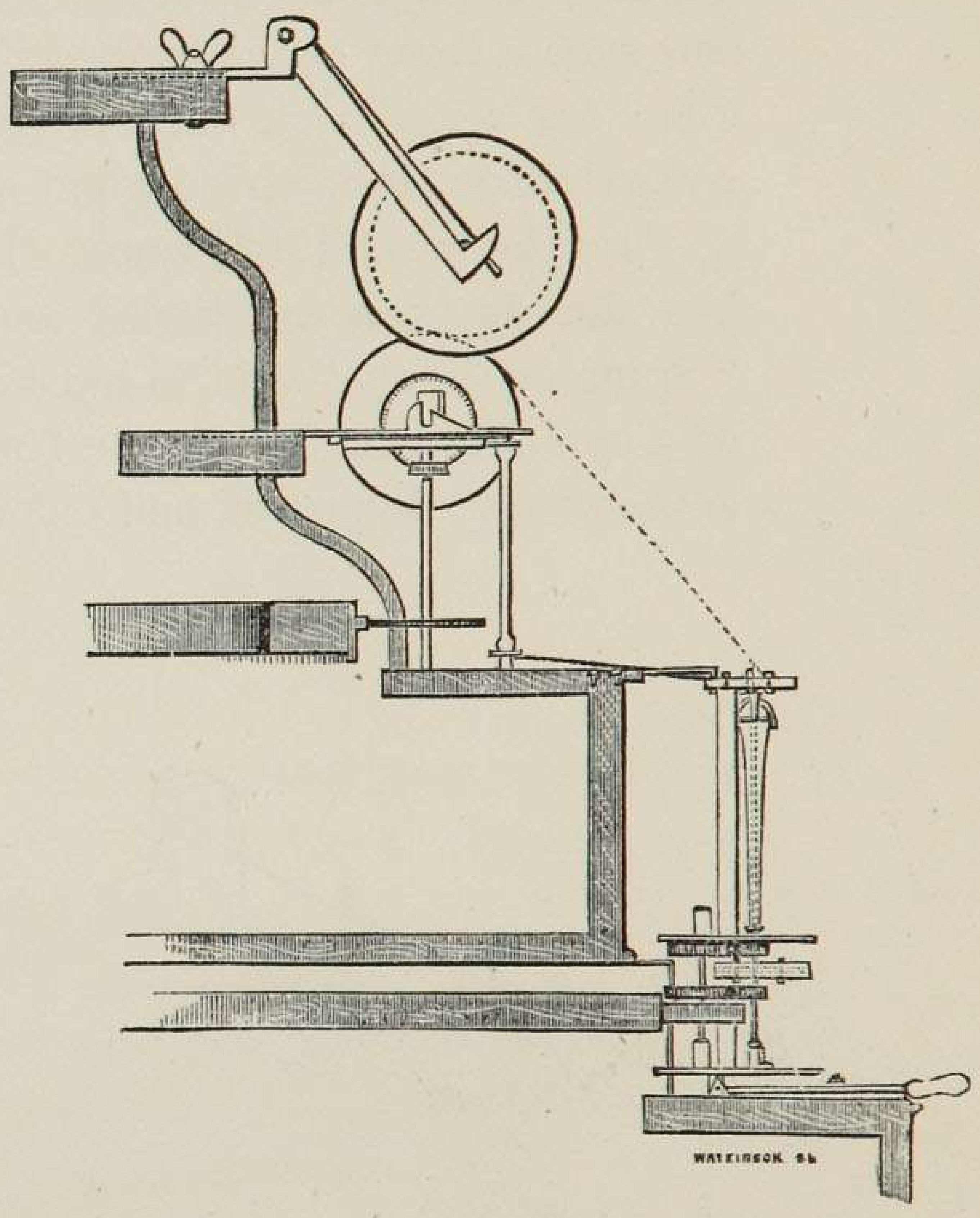


Fig. 164.—Enlarged Section.

Although Paul, in his first specification, mentions drawing cotton by a succession of pairs of rollers, it is almost certain that he never used anything of the kind; had he done so it is not likely, after twenty years' experience, that he would have gone back to a single pair in his new patent. Although this spinning machine, like Paul's former one, proved commercially unsuccessful, nevertheless it displays considerable ingenuity.

Paul must have worked hard and diligently to effect spinning by machinery. Arkwright was but a boy five and a half years old when Paul took out his first patent in 1738; and his second patent for spinning, in 1758, was taken out eleven years before Arkwright appeared on the field.

In the interval between his two patents for spinning, Paul appears to have turned his attention to carding, as his patent for carding, previously described, was taken out in 1748. The ingenuity, energy, and perseverance displayed by Paul, subsequent to his connection with Wyatt, considerably weakens the assertions of the latter and of his relatives, that he was the inventor of the first spinning machine. No doubt he tried experiments, perhaps earlier than Paul, but those experiments must have been practically unsuccessful, either from inferior mechanical knowledge, or a want of that indomitable perseverance which is necessary to success, and does not always accompany mechanical ability.

Some historians think that Arkwright must have seen Paul's spinning machine before he brought out his own. This is hardly probable; for Paul's second attempt at

A A

spinning became a failure, five years before Arkwright took out his patent, and they lived widely apart from each other, at a period when the means of travelling and the diffusion of scientific knowledge were very limited. Moreover the principles of the two machines were so totally different, that Arkwright could have derived no benefit from Paul's invention, even if he had seen it. True, Paul had thrown out the theory of drawing cotton by a succession of pairs of rollers, each going faster than the other so early as 1738. But the problem was too difficult to accomplish by the then existing mechanical resources, and he failed to show, either by drawing or otherwise, how such a thing could be done. Besides this, Paul's patent of 1758 was still in force when Arkwright took out his patent of 1769, and Paul never made any claim upon Arkwright for the infringement of his patent.

In the year 1767, James Hargreaves, of Blackburn, in Lancashire, whose name has already been mentioned as the inventor of the "stock card," brought out his "Spinning Jenny," said to have been suggested to him by the accidental overturning of a spinning wheel. He first made a rude machine with eight spindles, which he subsequently improved and enlarged, as shown in *Fig.* 165.

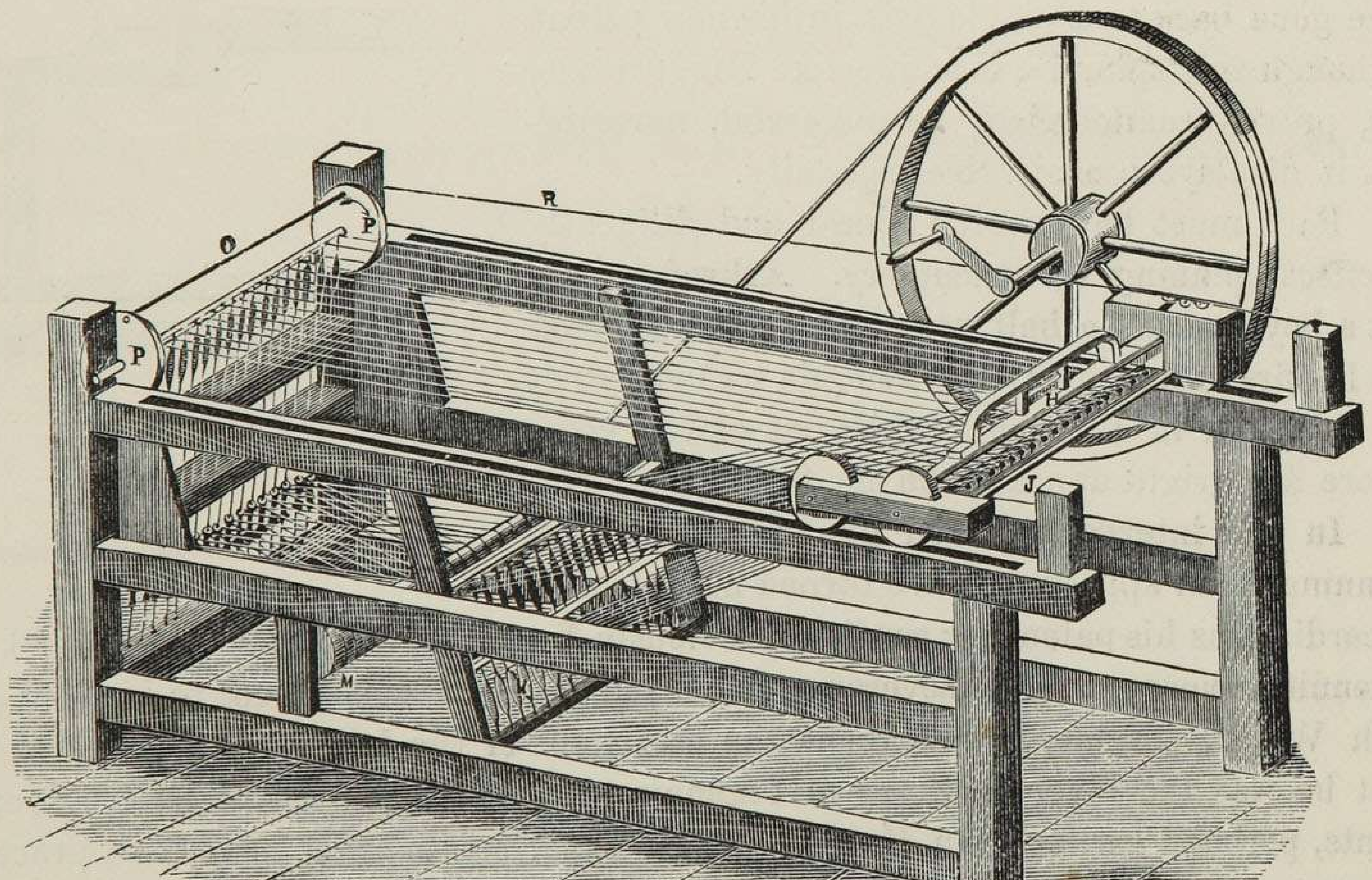


Fig. 165—Hargreaves' Spinning Jenny.

It will be seen that Hargreaves' method of spinning was totally different from that of Paul; for, instead of rollers, a certain length of the rovings were passed between two pieces of wood, one of which was fixed in a horizontal position, and the other suspended over it, until brought down by the spinner, when the rovings were clasped and held, whilst the carriage or clasp receded from the spindles, thus drawing out the threads while the spindles were revolving rapidly and converting the rovings into yarn; then, by the ingenious contrivances of the faller, backing off and putting up the carriage, the yarn was wound upon the spindles in the form of a cone or cop, after which the operation was repeated until the spindles were full, the *set* was then doffed off, and the cops held together ready for the loom shuttle, or other purposes. Hargreaves produced in this manner yarn without either bobbin or flyer, of a soft and woolly texture, admirably suited for weft.

Hargreaves' invention came very opportunely, for, in consequence of Kay's invention of the fly shuttle about this time, the demand for *weft* so far exceeded the supply, that weavers were often obliged to lose time in search of it, and the poor spinsters were sorely taxed and overworked.

ARKWRIGHT'S FIRST SPINNING MACHINE.

About the same time that Hargreaves invented his spinning jenny, Arkwright was busily engaged in contriving his machine for spinning on a totally different principle, for which he obtained the undermentioned patent.

Arkwright was reduced to great poverty about this time, and his biographers say that he repaired to Preston, his native town, and procured assistance from Mr. Smalley, a liquor merchant, through whose influence he was allowed to make use of a parlour belonging to the Free Grammar School, to fit up his machine.*

The drawing of Arkwright's machine, as deposited with the specification of his patent, in 1769, above-named, is given in *Figs.* 166 and 167, and his description of it runs as follows:—

"Now know ye, that I, the said Richd. Arkwright, in compliance with the said proviso, do hereby describe and ascertain the nature of my said Invention, and declare that the said Plan thereof drawn in the margin of these Presents is composed of the following particulars, (that is to say):—

"A, a cog wheel and shaft, which receive their motion from a horse; B, the drum or wheel which turns C, a belt of leather, and gives motion to the whole machine; D, a lead weight, which keeps F, the small drum, steady to E the forcing wheel; G, the shaft of wood which gives motion to the wheel H, and continues it to I, four pair of rollers (the form of which are drawn in the margin), which act by tooth and pinion, made of brass and steel nuts, fixt in two iron plates K. That part of the roller which the Cotton runs through is covered with wood, the top roller with leather, and the bottom one fluted, which lets the Cotton, &c., through it, and by one pair of rollers moving quicker than the other, draws it finer for twisting, which is performed by the spindles T K, the two iron plates described above; L, four large bobbins with cotton rovings on, conducted between rollers at the back; M, the four threads carried to the bobbins and spindles, by four small wires fixt across the frame in the slip of wood V; N, iron levers

* See Baines's History of the Cotton Manufacture.

with small lead weights hanging to the rollers by pulleys, which keep the rollers close to each other; O, a cross piece of wood to which the levers are fixed; P, the bobbins and spindles; Q, flyes made of wood, with small wires on the side which lead the thread to the bobbin; R, small worsted bands, put about the whirl of the bobbins, the screwing of which tight or easy causes the bobbins to wind up the thread faster or slower; S, the four whirls of the spindles; T, the four spindles which run in iron plates V, explained in letter M; W, a wooden frame of the whole machine."

Fig. 167.

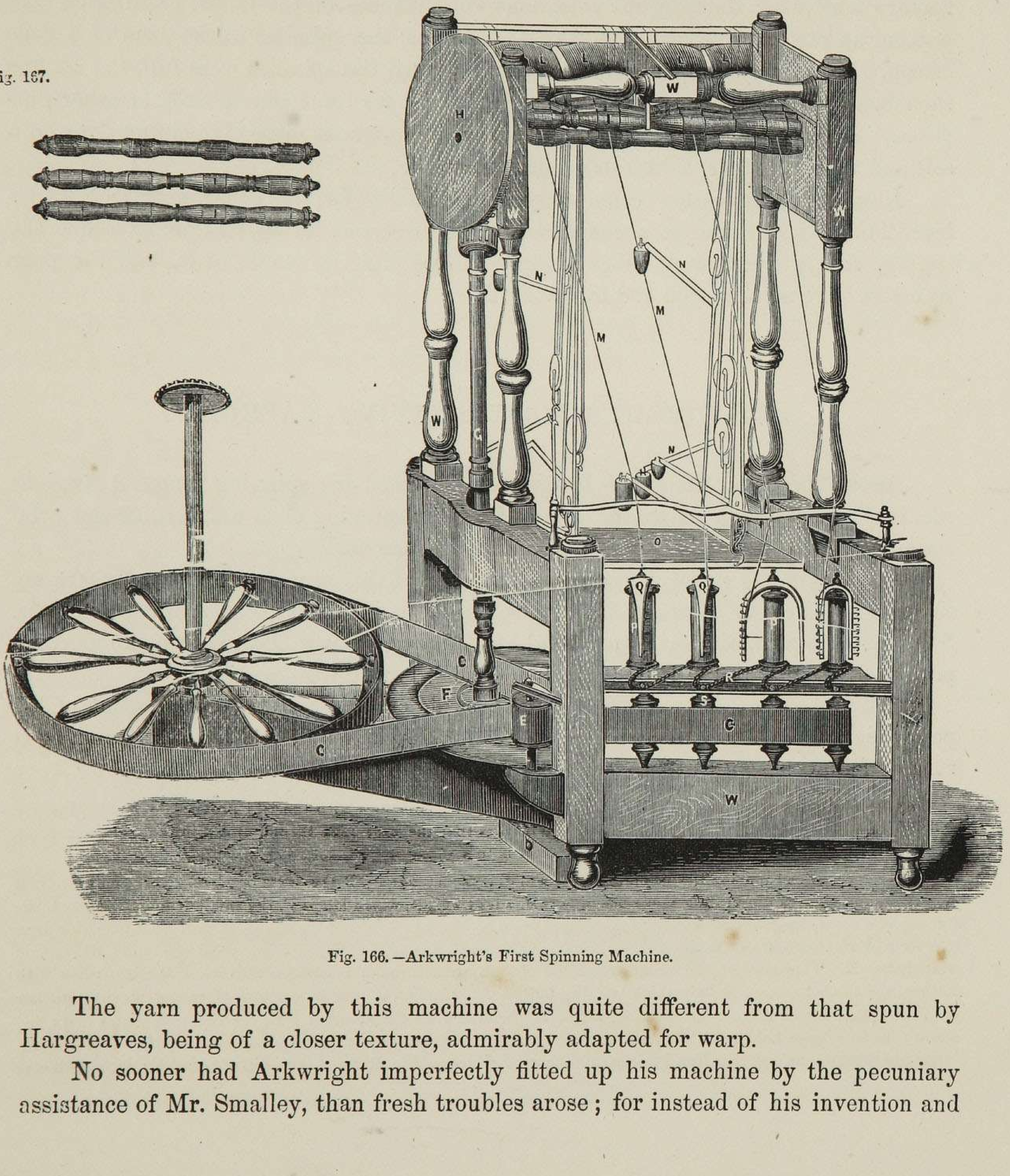


Fig. 166.—Arkwright's First Spinning Machine.

The yarn produced by this machine was quite different from that spun by Hargreaves, being of a closer texture, admirably adapted for warp.

No sooner had Arkwright imperfectly fitted up his machine by the pecuniary assistance of Mr. Smalley, than fresh troubles arose; for instead of his invention and that of Hargreaves being hailed as a public boon, they were looked upon with jealousy and alarm. In those days there was little travelling or scientific education; men's thoughts and ideas were concentrated within the narrow circle of their own vision. They argued that if a spinner using a jenny could do the work of half a dozen or more hand spinners, somebody must starve, consequently they broke into Hargreaves' house and destroyed his machine. Later on they rose in a mob and broke up all the carding engines turned by power, and spinning machines having more than twenty spindles, thoughout the country.

These misguided men had no idea how valuable were the inventions of Hargreaves and Arkwright. Improvements in machinery have always had a directly opposite effect to what might be expected, even in the locality in which they occur. Instead of diminishing, they have increased the wages and comfort of the operatives. By cheapening the production of manufactures, they have vastly augmented the demand, and thus enabled the operative to earn, with better tools, more money. The true theory of trade and the results of machinery were not at all understood in the days of Arkwright and Hargreaves, nor are they much better understood now.

After the lapse of a century, constant struggles are occurring between capitalists and labourers, and Trades Unions, or combinations, for forcing up the price of labour, are more rife than ever. It seems to be forgotten altogether that there is a law which governs those things, as immutable as the motions of the heavenly bodies, and no amount of scheming or contrivance can divert its course or accelerate its speed; therefore all the money that is spent in unnatural attempts to this end is not only lost, but the waste of capital thereby occasioned only retards the commerce of the country and well-being of the operatives.

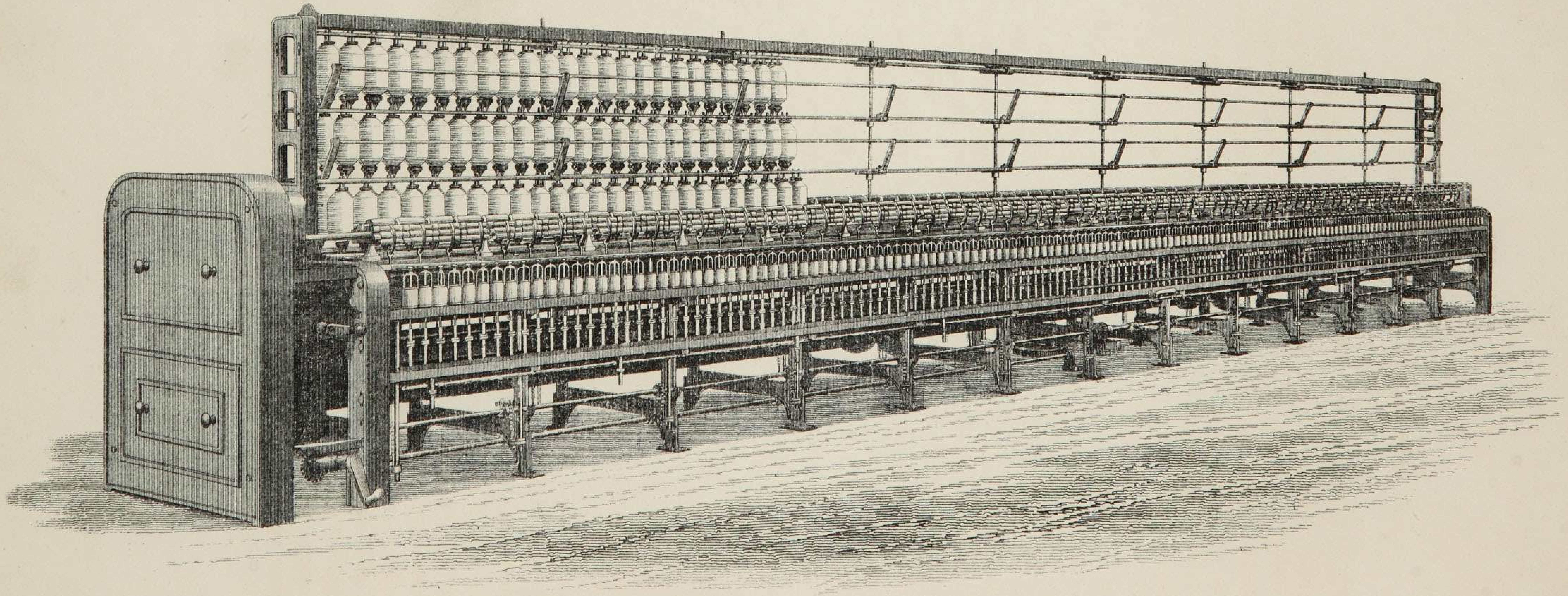
As machinery improves and the capital of a country increases, so also increase the comforts and wages of the operative, and no combination of masters can prevent it. Much more might be said, and abundance of convincing statistics exhibited, to illustrate the truth of this, were it necessary to do so. If the theory of the relations of capital and labour are not yet understood, the results of machinery are, so far as freedom from persecution goes. Inventors are no longer driven away from their homes as were Hargreaves and Arkwright. Looked upon as enemies of their species, instead of friends, they were bitterly persecuted and compelled to leave their localities. Hargreaves retired to Nottingham, where he could work out his inventions in peace, and was speedily followed by Arkwright. They were men of extraordinary natural ability. Hargreaves' talents were almost exclusively mechanical. He lacked the business capacity of Arkwright. Although his invention was quite as valuable as that of Arkwright, and his opportunities equal, it does not appear that he took any steps to secure a patent for it until three years after he introduced it, an illegal course; and the Lancashire spinners, being threatened with actions for infringement, decided to offer

Hargreaves £3,000 for his rights. On his refusing it, they combined against him, set him at defiance, and used his patent without paying him anything, because he had sold machines before leaving Lancashire, to buy clothing for his children, and prior to obtaining a patent. Hargreaves made nothing from royalties. He was borne up by his inventions, and glided into a quiet partnership with Mr. Thomas James, who found money to establish a small mill at Hockley, carried on with moderate success until Hargreaves' death in 1778, which took place at his house near the mill. It has been asserted by some writers that he died in abject poverty; this is not true, Mr. James paid his widow £400 for Hargreaves' share of the business, and he had previously saved money, as he led a quiet and an unostentatious life.

Not so with Arkwright; his daring and ambitious spirit led to a more restless and active life. After struggling for some time against pecuniary difficulties in Nottingham, he was introduced to Mr. Samuel Need of that place, the partner of Mr. Jedediah Strutt, of Derby, who was not only wealthy, but himself also a mechanical genius, being the patentee of an improved stocking frame. Mr. Strutt highly approved of Arkwright's machine, and he, together with Mr. Need, joined him in partnership.

Fig. 163.—Portrait of Jedediah Strutt.

Arkwright's pecuniary difficulties now ceased. Under the friendly auspices and prudent guidance of this amiable gentleman, who understood the proper use of wealth and true value of science, Arkwright's genius was nurtured, his rude manners cultivated, and his abilities developed. A mill was first erected at Nottingham by Arkwright and his partners, which was driven by horses, and afterwards a more extensive one at Cromford, in Derbyshire, which was turned by water power,—hence the designation of "water frame." A full tide of prosperity set in now upon Arkwright and his partners. Other mills were erected in Derbyshire, Manchester, and even in Scotland, which he managed with consummate skill, working hard, it is said, from five in the morning to nine at night; and to economise time in travelling had



COMMON THROSTLE FRAME.

WITH LATEST IMPROVEMENTS.

J. GALLOWAY, LITH: MANCHESTER

generally four horses to his carriage. In 1783 his partnership with the Messrs. Strutt terminated, when he retained the works at Cromford, and Messrs. Strutt those at Belper.

In 1786, after having been appointed High Sheriff of Derbyshire, he received the honour of knighthood, on presenting an address of congratulation from that county to the King, on his escape from attempted assassination.

As "Sir Richard" he did not live long to enjoy his wealth and honours, for, being troubled with a severe asthmatic affection, he died at his house at Cromford, on the 3rd of August, 1792, in the sixtieth year of his age.

Thus, honourably, ended the career of this remarkable man, who may be said to have been the founder of the factory system. Had he lived ten years longer his character might have developed some new phase that would have astonished the world as much as his inventions, for some of his speculations were vast and daring, though generally successful.

It is stated that he once contemplated buying up all the cotton in the world, so as to retail it out at a large profit to his competitors in the cotton trade.

THROSTLE SPINNING.

The "Water Frame" of Arkwright became gradually improved in construction as the cotton manufacture increased, and, after the introduction of steam power, the frame was called "Throstle" instead of "Water Frame"; but the yarn or twist spun upon it still retains the old title of "Water Twist." Why the name "Throstle" was given to the machine is not known, unless from the humming or whistling noise made by the machine when at work.

The Common Throstle is now made in a most substantial and elegant form, as shown in Plate XXXVI. It has only attained its present perfection by slow degrees. It is the simplest of all spinning machines, and remains, in principle, the same as when invented by Arkwright; nevertheless more attempts have been made to improve it, and more patents have been taken out for improvements or alleged improvements, than in any other machine in the whole range of processes of carding, preparing, and spinning.

It is almost impossible for anyone, having a mechanical turn of mind, to watch a throstle frame at work, without feeling an irresistible desire to experiment upon it; hence it has been the toy of the machinist and plaything of the juvenile spinner. In contemplating visionary improvements in throstle spinning, the young aspirants to mechanical fame have burned their midnight lamps and built their castles in the air.

Flyers of various shapes have been invented, or they have been dispensed with altogether. Disappointment has followed failure, still the restless mechanician has not been discouraged. Now and again some new idea has flitted through his brain and broken his night's repose; a new idea, principle, or combination has been presented to his view, and he has risen afresh to the attack upon the old frame, forgetting all his past failures. As he proceeds, however, some new difficulty arises which he had not taken into calculation, and disappointment again succeeds, leaving the old throstle frame in its original simplicity, unaltered and triumphant. As the young enthusiasts of former times became old and experienced, their judgments settled down in a firm conviction that nothing *could be done* to effect any material improvement in throstle spinning, and further attempts in that direction were looked upon with incredulity.

THE DANFORTH THROSTLE.

For several years prior to 1829 no attempt, worthy of note, had been made to disturb the existing order of throstle-spinning machinery, when suddenly, spinners were surprised by a remarkable invention introduced from America. Notwithstanding all the experiments made in this country with throstle frames, it appeared that they were invariably directed to alterations of the spindle, or flyer, with the mode of supporting, or driving them, and for improving the drag. But at this time steps in a sharp-witted American—a man of no experience, bred in a country where cotton-spinning was only in its infancy,—who showed that to spin cotton it was not necessary to have either spindle or flyer! and to obtain a drag he used neither washer cloth nor any other such clumsy device, but got it from the atmosphere! As for speed—why, instead of creeping on at the rate of three or four thousand revolutions per minute—his frame ran at the rate of 7,000 revolutions, and worked all the better for it, being obliged to go quick to obtain a proper drag. Instead of a live spindle and flyer, he used merely a peg or dead spindle, fixed in the rail, with a hollow cap on the top; on this dead spindle ran a tube carrying the bobbin, the cap guiding the yarn on the bobbin as it was moved up and down by the lifting rail, as shown in *Fig.* 169.

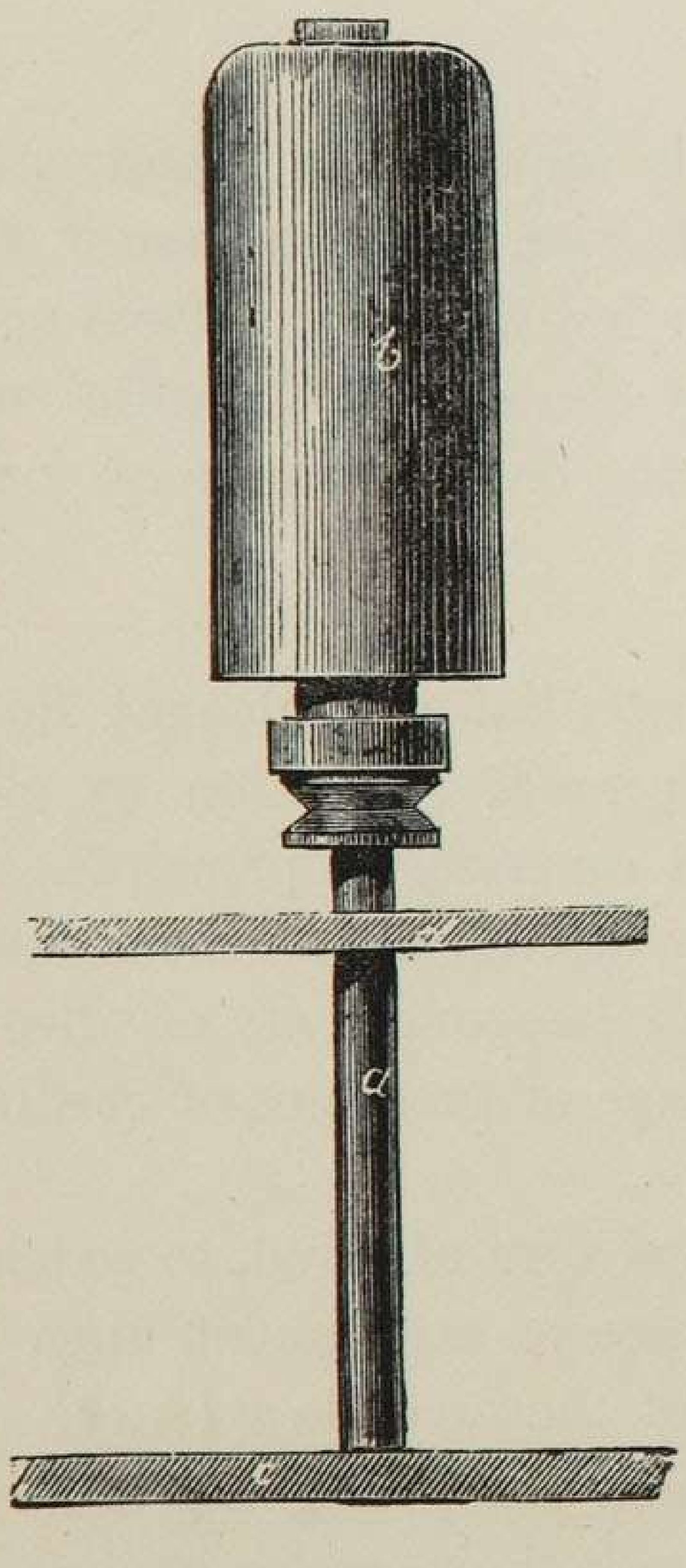


Fig. 169.—The Danforth Throstle.

The principle of this frame is highly scientific, and its construction also simple and ingenious. There is a dead spindle *a*, on the top of which is fixed the hollow cap *b*. This spindle or peg is firmly fixed on the rail *c*. On the dead spindle runs a cast-iron tube with wharve at bottom, and on the tube the bobbin fits. The bobbin goes inside the hollow cap when lifted up and down by the copping motion, or lifting rail *d*, and the bottom edge of the hollow cap guides the yarn upon the bobbin, the drag being obtained from the rapid whirl of the yarn through the air. To prevent too great an expansion of the thread when the frame is at work, a semicircle of tin *e* (*Fig.* 170) is

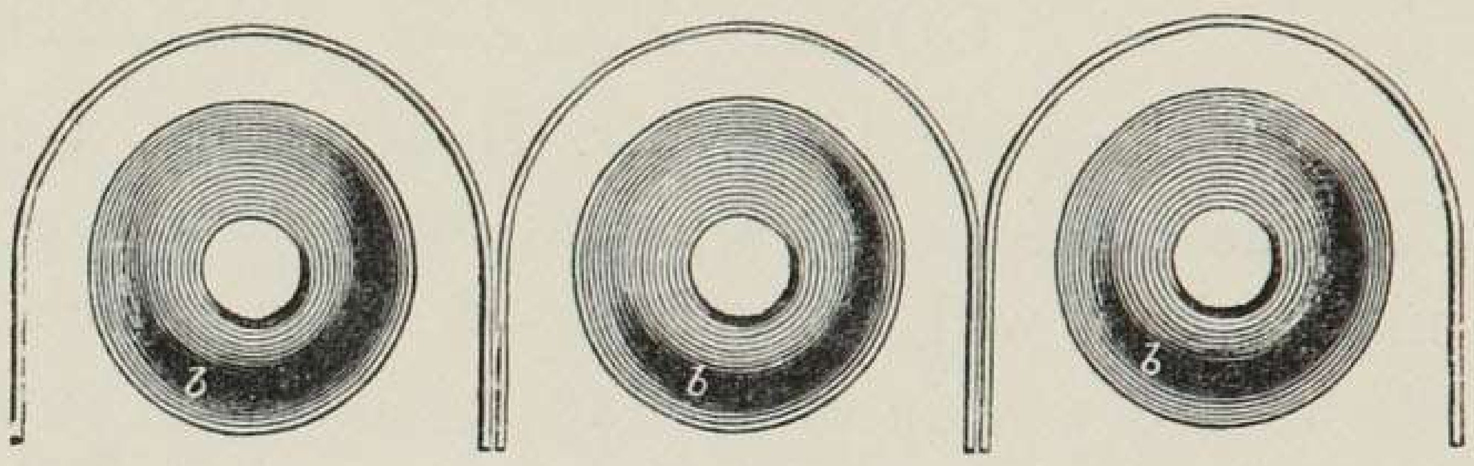


Fig. 170.—Thread Guides, Danforth Throstle.

placed at a short distance from the hollow cap. In some modifications of this machine the hollow cap is made of a conical form, as in *Fig.* 171, and the yarn is built upon the bobbin in the cop form, so as to reel off at the ends.

As before observed, the introduction of this machine caused a great sensation amongst the trade, for it threatened to make a complete revolution in spinning. But it engendered "hopes too bright to last." After being somewhat extensively used and fairly tested by a number of enterprising manufacturers, they discovered the following objections, viz.:—(1) It required much more power than the ordinary throstle. (2) The rollers were obliged to be more heavily weighted in consequence of the light drag not assisting them to draw. (3) To wind on at all, it must needs run at a great and uniform speed. (4) Every time the frame was stopped the ends formed a long snarl, which could not be removed by any operation of the machine itself. (5) In doffing, or piecing, the yarn frequently got streaked with oil, that left its black stain upon the cloth. (6) The yarn, being of a more woolly nature than ordinary throstle yarn, and somewhat darker in colour, could not be mixed with it, but had to be sold, or woven separately, therefore it did not command so good a price, being in fact like half-mule yarn. This latter objection was perhaps the most fatal of all, as

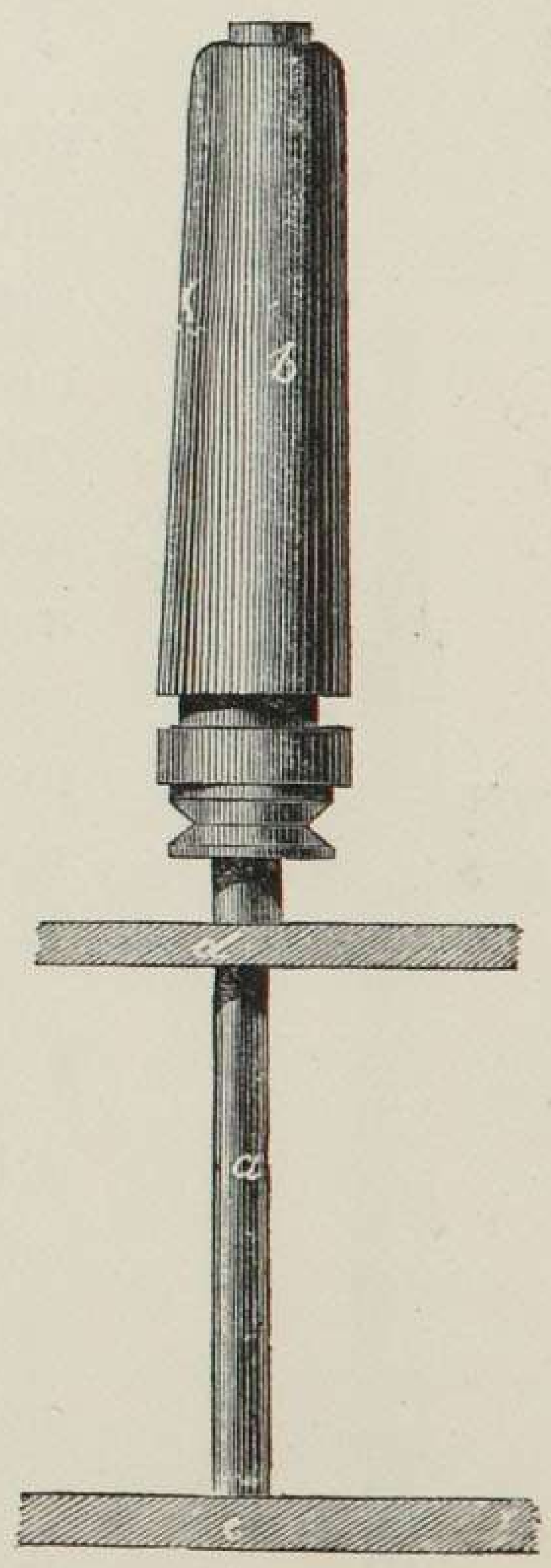


Fig. 171.—The Danforth Throstle.

the price of "water twist," or genuine throstle yarn, is so much greater for the same numbers than mule yarn; hence the Danforth throstle, so full of promise, so very clever in construction, lost caste, and has almost become extinct in this country.

It has been observed that the English experiments in throstle spinning, up to this time, had no particular result further than improved construction of the ordinary machine; but the introduction of the Danforth frame stirred up the latent energies of machinists and spinners to other efforts, and as some of these were more or less successful, they have been thought worthy of mention here.

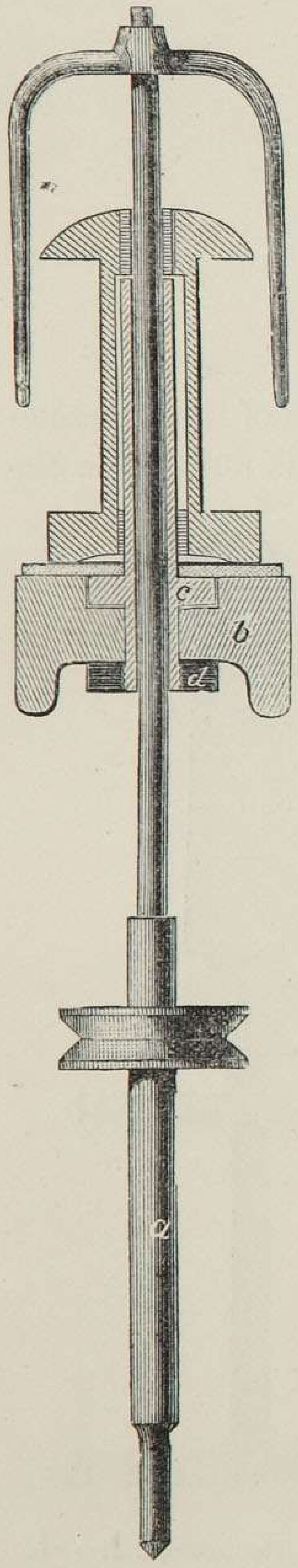


Fig. 172.—Gore's Throstle.

GORE'S PATENT THROSTLE.

In the year 1831, Mr. Henry Gore, a machine maker of Manchester, took out a patent for certain improvements in spinning, which will be understood on reference to *Fig.* 172, which shows the way in which the spindle was worked after it came into practical use, although a somewhat different arrangement was described and illustrated in the patent. It will be seen that Mr. Gore's idea was to save power, by using a very light spindle, and he was enabled to do this by carrying the bolster about two inches above the bolster rail, which he also used as a lifting rail.

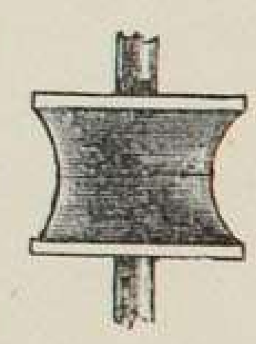
In one illustration a tube is shown as running upon this projecting bolster, and the bobbin is placed upon the tube. When this frame came into practical use, the latter tube was dispensed with, by bushing the bottom of the bobbins with white metal, to run upon the tube, whilst the top of the bobbin worked upon the spindle, being bushed with hard wood as usual, and having a hole of only half the diameter of the bottom bush. Mr. Gore had a considerable run with these frames, as they were used for both spinning and doubling. So long as he lived the frames were well made and they continued in favour, but his works were broken up at his death, and the frame has gradually gone out of use. If the tubes or bolsters of this frame were made of steel, instead of cast iron, as they could now be made, they might be of smaller diameter; and if run so much higher up the spindle, so as to allow the bobbin to work *entirely* on the dead tube—being of course, bushed with white metal equally at each end—the spindle and flyer would have a still better support, and it would probably make a good frame for low numbers.

Referring to this figure, *a* is a light throstle spindle with flyer screwed on the top, as usual; *b* is the bolster rail, which moves up and down as a lifting rail, having cloth washers upon which the bobbins rest, to form the drag as usual. In the bolster rail *b* is fixed a cast-iron tube *c*, which extends upwards as far as the top bush of the bobbin; the flange on the tube is let in flush with the rail, and is secured by the nut *d* at the bottom.

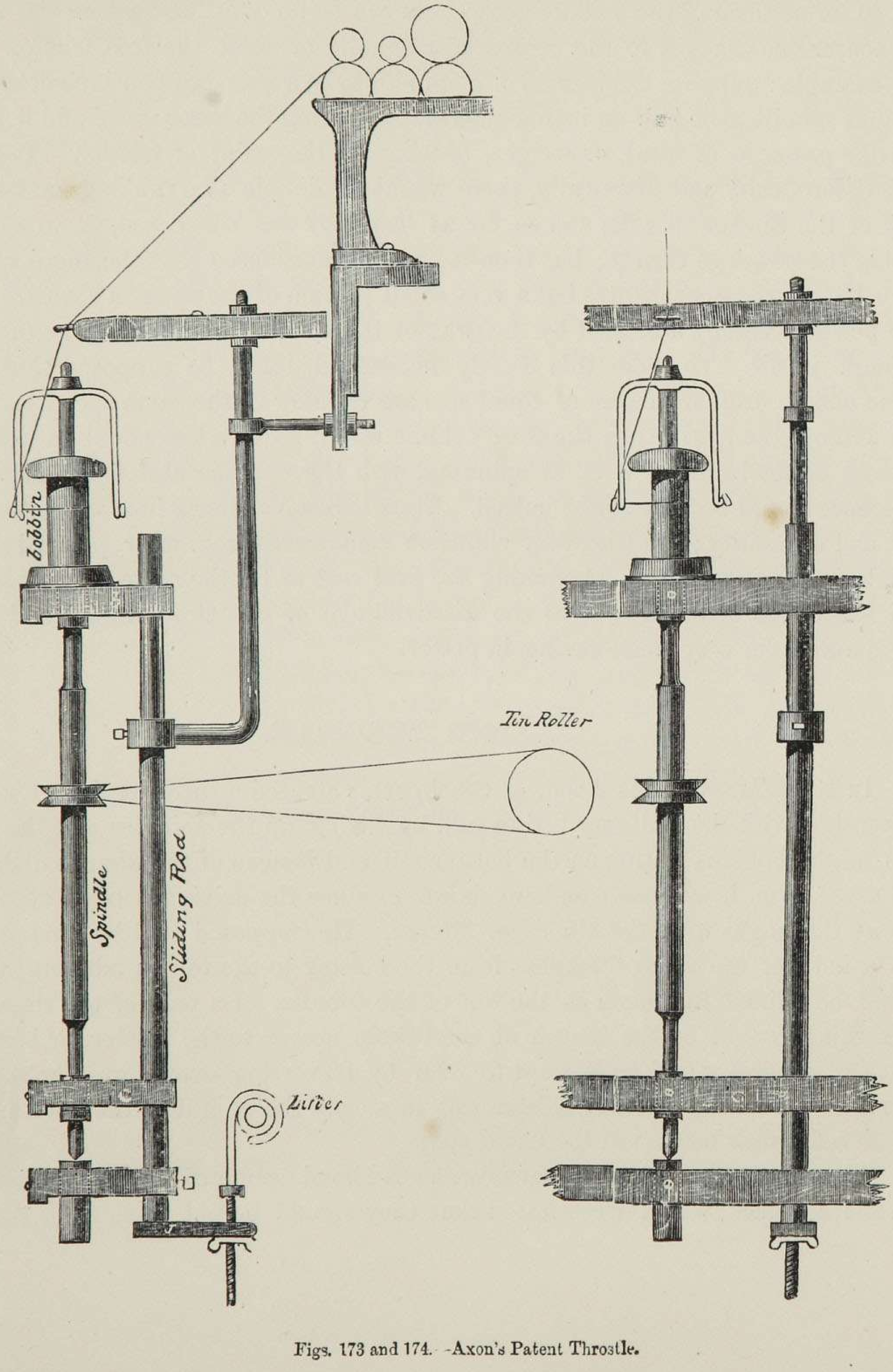
Mr. Gore's idea, when he contrived this throstle, was, no doubt, to save power, and so far as turning the spindle goes, there can be no question that he was right; for the nearer one can get to the centre of a spindle or shaft, the less friction there is. For example: suppose the journal of a spindle to be a quarter of an inch diameter, and another spindle to be half an inch diameter, both going the same speed and both having the like pressure of band, or weight, bearing on the point of friction. In this case, both theoretically and practically, there would be double the rubbing surface on the neck of the thicker spindle, and so far as *that part* was concerned, it would require double the power to turn it; but then it must be considered that the mere rubbing of the bolster surface constitutes but a very small portion of the power a throstle requires. The power is chiefly absorbed by the drag of the bobbin and the passage of the flyer through the air. To make this clearly understood, let it be supposed that a Gore's frame and an ordinary frame of equal size are running at the same speed, both empty and without the flyer; then the Gore's frame would require less power to turn it; but let both be set in actual work at spinning, with the bobbins and flyers on, then the difference would be very slight indeed. Thus it resolves itself into a question of first cost and durability; for whenever vibration commences from wear, power is absorbed and bad spinning ensues. Assuming the first cost to be the same, the wear and tear and extra cost of bobbins is to the disadvantage of the Gore frame, and probably outbalances the very small saving in power.

AXON'S THROSTLE.

In 1832, Mr. Charles Axon, of Stockport, patented a throstle, *Figs.* 173 and 174, dispensing with the ordinary lifting rail, by lifting up the spindles and thread board instead, the bobbins resting on the bolster rail, and instead of the wharve nick being in the usual form, it was made as here shown, to allow the driving band to stop on, as the angle with the tin roller altered. He supposed that by having the spindle of the same thickness from the bolster to the top an advantage would be gained, inasmuch as the top of the spindle, for a part of the time of working, would be the length of the bobbin nearer to the bolster, or bearing, and that the spindles would be less apt to wear by traversing over a greater surface; he also placed a second or lower bolster rail to steady the spindles, the bottom of which ran in a flat dish instead of the usual step.



This arrangement did not answer, as the bands came off as soon as they became in the least slack, which necessitated that they should be put on so tight that a great deal of power was absorbed and oil consumed. This defect being perceived by his neighbours, Messrs. Brown and Powell, they took out a patent to lift the two rails, which they connected together and made of wrought iron. This dodge upset Axon's patent; and Brown and Powell had a considerable run in the manufacture of their frames, as shown in *Fig.* 175.



Figs. 173 and 174. -Axon's Patent Throstle.

Neither Axon's nor Brown and Powell's throstle frames proved to have any real merit, as they both required considerably more power to drive them than the ordinary frames, and consumed double the quantity of oil, which more than compensated for the extra speed and production; therefore, after a fair trial, they only led to disappointment.

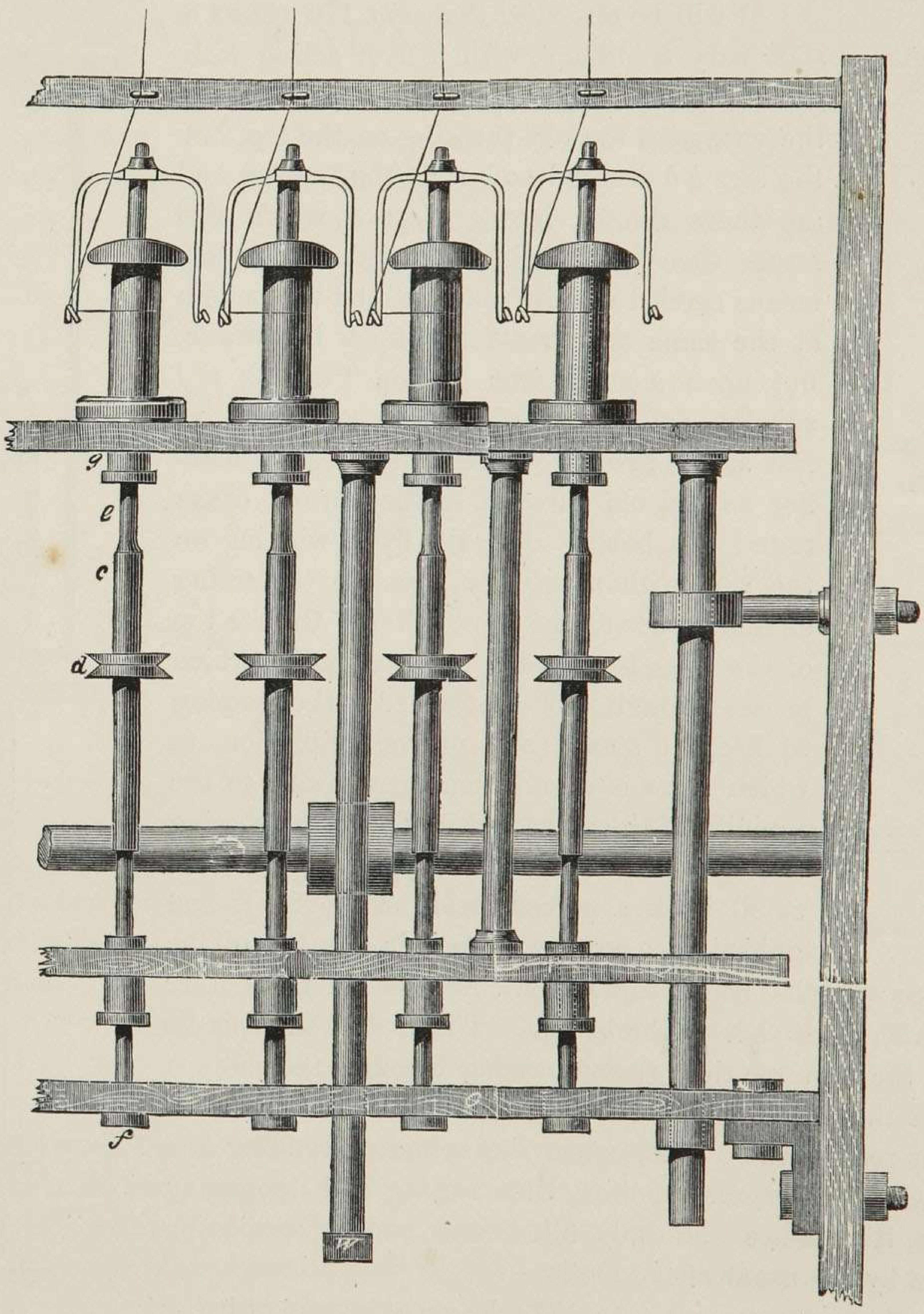


Fig. 175. Brown & Powell's Throstle.

THE MONTGOMERY THROSTLE.

In the year 1832 Mr. Robert Montgomery, of Johnston, Scotland, obtained a patent for a throstle spinning frame on a new principle. The novelties in this machine were principally confined to the spindle and flyer, with copping arrangement, and were of a striking character, as may be seen in *Figs.* 176 and 177.

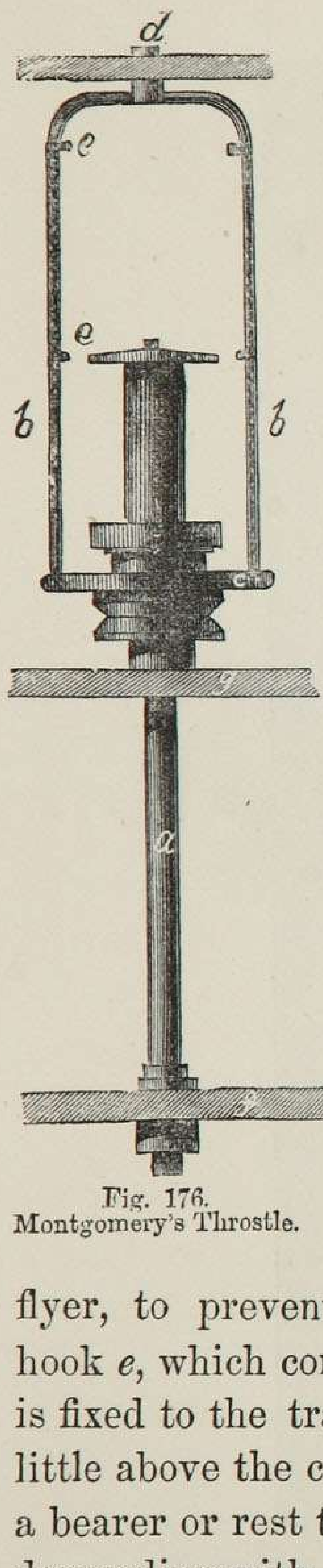


Fig. 176.
Montgomery's Throstle.

It will be observed that *Fig.* 176 shows a stationary spindle, *a*, with a flyer acting with great velocity. The flyer is not fixed, as is the case with the old throstle, on the top, but the legs *b b* descend so low as the warves, and are there riveted into a plate *c*, which also forms the warve below it, and is by this means carried rapidly round, whilst the bobbin at the same time rests not upon the warve, but upon a small iron button fixed on the spindle, and is retarded from revolving so fast as the flyer by washers, in the same manner as the old throstle. The thread drags round the bobbin after the flyer, winding on the yarn with a velocity equal to the acting circumference of the front roller. On the top of the flyer is placed a small funnel *d*, which passes through a collar attached to the framing to keep it steady and prevent vibration, to which there is a great tendency, owing to the rapidity of the movement. The yarn, passing through the funnel at the top, descends to the small hook *e*, placed inside of the flyer, and guided by a groove formed in the leg of the flyer, to prevent its being thrown out, is thus led to another hook *e*, which conveys it to the bobbin. The foot of the spindle is fixed to the traverse rail, *f*, and passing through the rail *g*, a little above the centre, tends to steady the spindle, and serves as a bearer or rest to the warve, when the spindle ascending and descending with a regular motion, thus raising and depressing the bobbin, it becomes uniformly filled from end to end, being acted upon by the usual lifting motion.

By another arrangement (*Fig.* 177) the yarn, instead of being

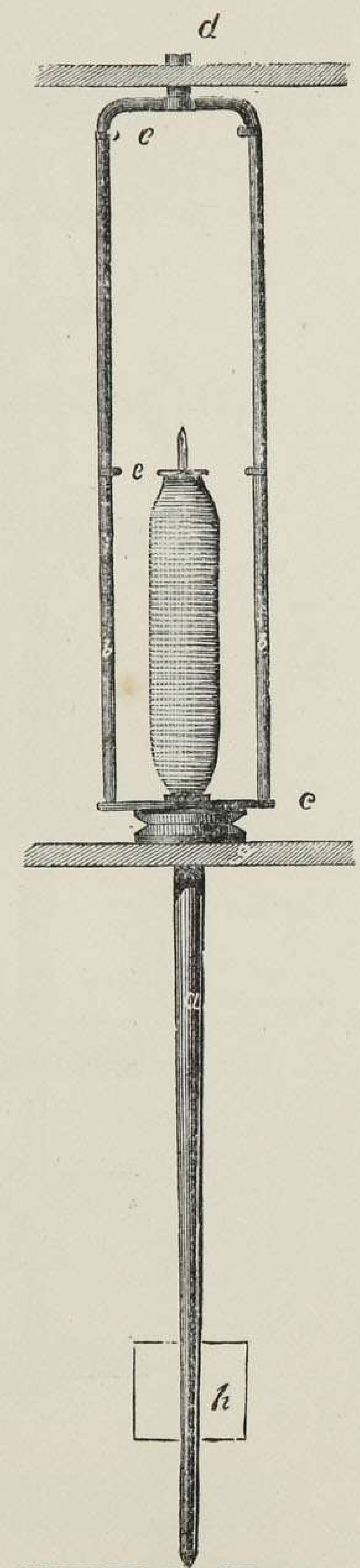


Fig. 177.
Montgomery's Throstle.

wound upon a bobbin, was built on the spindle in the form of a cop, as in the mule; the fan *h* being fixed on the spindle *a*, retarded its motion and formed the drag.

Great results were at first anticipated from this throstle, but it appears to have died out in this country, although it is still in successful operation in America, where it is esteemed by some spinners for the excellent quality of the yarn it produces.

SHAW AND COTTAM'S PATENT THROSTLE.

In 1848, Messrs. Shaw & Cottam, of Manchester, obtained a patent for driving throstle spindles with two tin rollers instead of one, as shown below; *Fig.* 178 representing the old, and *Fig.* 179 the new mode.

Referring to *Fig.* 178, it will be seen that the band forms a considerable angle, from the driving roller to the warve of the spindle; and unless the tin roller be very

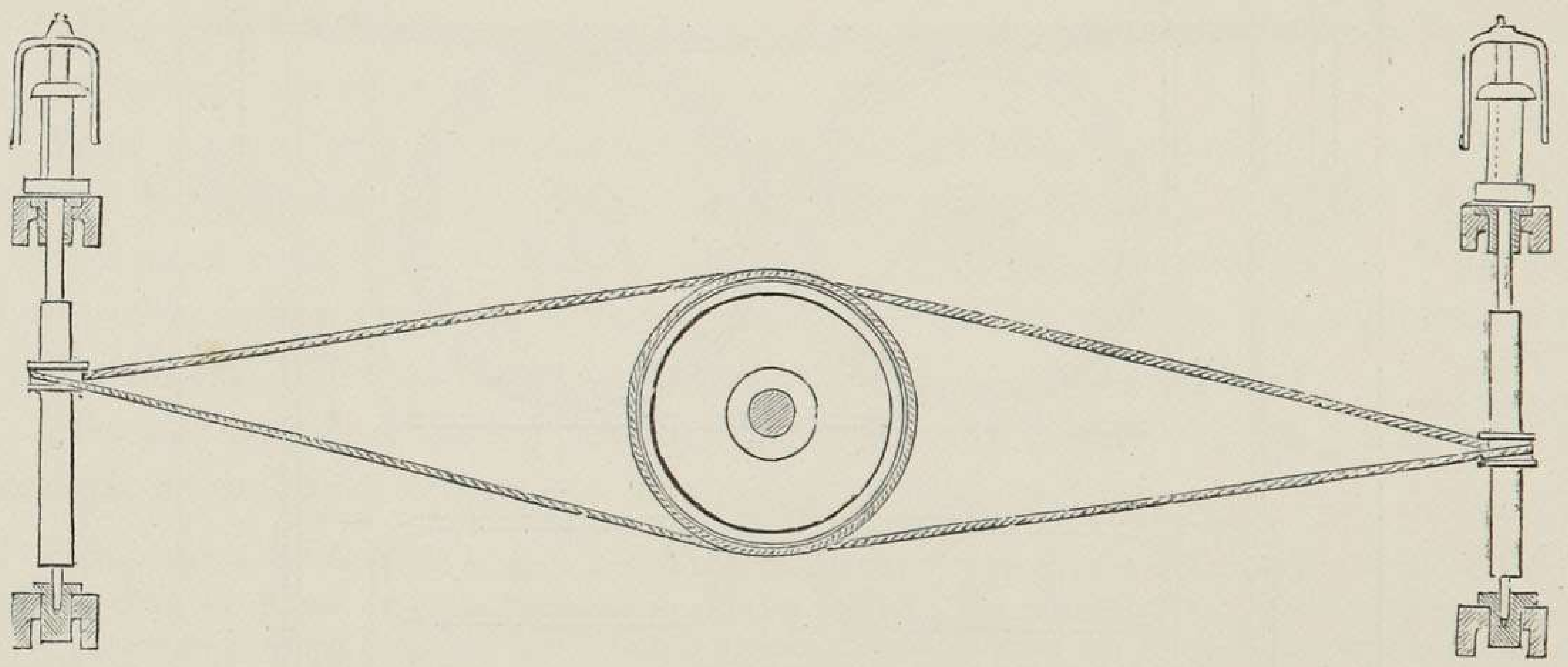


Fig. 178.—Throstle with one Driving Roller.

small in diameter, there is a great loss of power, and wear of bands, arising from the rubbing of the latter against the outer flanges of the warve. Thus, suppose the bottom of the warve to be three inches in circumference, and the flanges, where the band rubs, to be four inches, there is a difference of one-fourth in the space passed through between the band and warve flanges, and of course a rubbing to that extent. To avoid this as much as possible, other evils and inconveniences have to be submitted to—viz., small tin rollers and wide frames.

Fig. 179 shows the new arrangement of having *two* driving rollers of larger diameter, the bands going round one and over the other alternately. This arrangement not only allows the bands to come straight upon each warve, but also the width of the frame to be considerably contracted, thereby saving about one-fourth of the room occupied by the ordinary frame. The pair of tin rollers work in opposite directions, but it is only necessary to apply power to one, as the bands drive the other. Over 1,200,000 spindles are said to be working on this principle of driving, and the following advantages are claimed over the single tin roller:—(1) The bands are longer in proportion

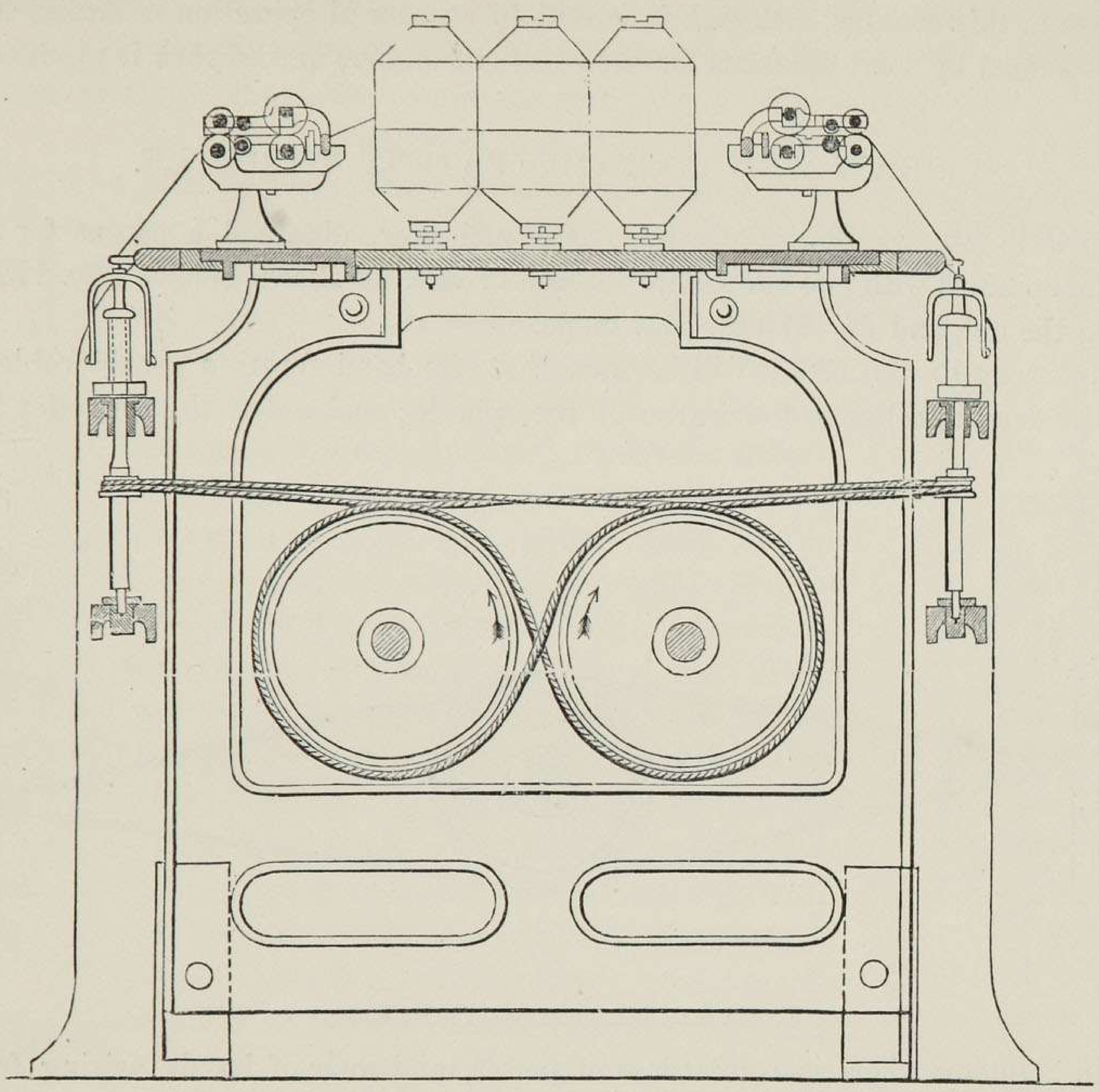


Fig. 179.—Shaw & Cottam's Patent Throstle.

to the width of the frames, allowing the latter to be reduced, so as to get two frames 2ft. 6in. wide into a 9ft. bay; or two frames 2ft. 10in. into a 10ft. bay; a frame 2ft. 6in. wide, with double tin rollers, having longer bands than a frame 3ft. 6in. wide with single tin rollers. (2) The pull of the bands being horizontal, all the advantage of the tape driving is secured with a separate band to each spindle, which can be pieced up without stopping the frame. (3) The diameter of the tin rollers and warves can be made larger than with a single tin roller; a greater regularity in the twist of the yarn is thus obtained. (4) In consequence of the preceding advantages, the bands need not be so tight as with single tin rollers, whereby a great saving in the wear and tear of the bands and in the driving power is obtained.

BERNHARDT'S THROSTLE WITH DOFFING MOTION.

The process of removing the bobbins from throstle spindles when full, and replacing them by empty ones, is called *doffing*. This operation is generally performed by children, and their number is regulated by the number of spindles; but it is usual to employ one doffer to every thousand spindles in order to get through the work quickly. Still there is a great loss weekly and annually in the production, in consequence of the stopping of the frames, which generally amounts to a loss of time of five minutes at each doffing. The annual cost per spindle is from 4*d.* to 6*d.* in wages. There is also, in consequence of the rough usage of the bobbins by the doffers, a great deal of bad yarn produced, necessitating the constant renewal of the bobbins. It is also found that the bands, which are pulled off and on the warves of the spindles in the act of doffing, to allow the flyers to be more readily unscrewed and screwed on again, become slack, and thereby make soft yarn. The presence of the doffers in mills when not actually at work, is also very undesirable for various reasons well known to their superiors.

To overcome these objections Mr. Bernhardt has introduced a *doffing motion*, which performs the various duties of the hand doffer completely, and in the remarkably short space of time of less than a minute.* The ordinary well-tested form of the spinning frame has not been deviated from, the doffing motion having been simply added; and the doffing could even be performed in the usual manner.

The following is a description by Mr. Bernhardt of the various parts and their functions, as well as modifications of already existing parts :—

" The spindles have a coarse single square thread fitting the flyer in place of the usual fine V thread, the object being to prevent the fastening of the flyers to an unusual degree. The sockets of the flyers are made 11-16s inch long, so as to present a long guide and good wearing surface. The bottom of the spindles are slightly enlarged and shaped to allow a shaft, extending the entire length of the frame, to force down the spindles, when the foot-step rails are lowered, as will be seen presently. The spindles rest, as usual, in the footsteps of footstep rails, and these rails are connected to cross slides working in grooves on the spring-pieces by means of racks and pinions, and are counterbalanced.

" The dust-boards are made with a top table for the empty bobbins to rest on, and the roller-beams have holes in a line behind the spindles for the reception of the bobbins. The dust-boards are connected to the footstep rails by means of pillars, and therefore can rise up and down with them when required.

" In a recess formed in the dust-boards are the flyer bars, which have projecting fingers cast on, one for each flyer, for placing them all readily into one position, and hooks are provided by which the flyers are suspended when unscrewed from their spindles. The flyer-bars are fastened to cylindrical toothed guides, which receive motion from pinions fast to a central shaft. A sheet-iron slide, working in inclined slots in front of the dust-boards, covers up the flyer-bars and prevent any accumulation of loose cotton fibre adhering thereto. Behind the dust-boards, and hinged to cylindrical-toothed guides, hang the bobbin carriers, which, in their forward movement, are made to assume a horizontal from their almost vertical position by means of spring guides forcing levers attached to them. The upward motion of the footstep rails push these spring guides to one side, thereby allowing the bobbin-carriers to drop after delivery of their bobbins. It will also be seen that the front roller weights are placed in a different position and are made of a different form than ordinarily so as to make room for the doffing parts, and consist of cylindrical castings crossing the frame and suspended from each end.

* The author has timed it to half a minute.

"Bobbin boxes made of light sheet-iron of an L section are placed in front of the bolster rails to receive the full bobbins after doffing. There is also a thin plate attached to the front of the bolster rails, which, by means of inclined slots and an end push, or pull, is made to rise or fall, the object of which will be described hereafter.

"To prevent the drawing rollers turning the wrong way when the tin roller is turned backwards, the twist-wheel is provided with a saw-tooth catchbox, working loose on the twist-wheel stud. A corresponding catchbox, sliding on a key, is pressed up to the twist-wheel by means of a spring, and compels the twist-wheel to impart motion to the roller wheels, but as soon as the tin roller is turned backwards the catchbox slips by and the rollers become stationary. The front edges of the top of the bolster rails are provided with a V groove for guiding a circular disc cutter in the act of separating the threads between the full and empty bobbins. All the motions are worked from the off end by means of handles or hand-wheels."

Having now described the various parts of this doffing motion, the doffing is performed by the overlooker, or his assistant, in the following manner:—

"After the empty bobbins have been placed in the holes of the roller beams, the bobbin boxes suspended from the bolster rails, and the slides on dust-boards lowered, all which is done during spinning. When the bobbins are full and the copping or bolster rails have arrived at their central position the frame stops by a self-acting arrangement. The flyer-bars are then partly pushed forward, and, at the same time, a slight forward motion is given to the tin roller. This will bring all the flyers instantaneously into one position. A quick reverse motion is then imparted to the tin roller, by which means all the flyers strike against the projecting fingers of the flyerbars, loosening and unscrewing them; the flyer-bars are then brought forward to their extremity; after that, the footstep rails are slightly lifted so as to enable the spring latches supporting them to be released by turning the shafts at the bottom of the spindles a little, and then the rails and spindles are lowered, taking with them the empty bobbins. The bobbin carriers then advance and, in assuming their horizontal position, take a firm hold of the bobbins and, still advancing, push over the full bobbins into the boxes. The empty bobbins are then in the position of the full ones. The spindles now, being raised about one inch, pass through the empty bobbins, and the bobbin carriers drop by having their spring guides pushed to one side. The bobbin carriers are then withdrawn, and the upward motion of the spindles being continued, the spindles will enter the flyers which are held suspended over their centres, and the spring latches will secure the original position of the footstep rails. The tin roller is then turned forward to screw all the flyers on, and the flyerbars are partly withdrawn. The tin roller is then again slightly turned forward and backward in order to strike the flyers against the projecting fingers of the flyer-bars for fastening them, after which the flyer-bars are finally withdrawn. Then the slides in front of the bolster rails are raised, and with them all the ends from the full bobbins. If, then, a little forward turn is given to the tin roller the flyers will wind a few turns of yarn from the full bobbins on the empty ones above the flanges. The slides are then lowered and the ends cut asunder by running the circular disc cutter along in the groove of the frame, pressing slightly down.

"This finishes the operation of doffing, and spinning may be recommenced.

"It will be interesting to show how far the advantages of this doffing motion exceed the old mode of hand doffing.

"As an example of the Flyer system, take a mill of 40 throstles of 250 spindles each,—10,000 spindles,—spinning 20's.

"From correct particulars received it is known that the average cost of hand doffing in various mills is sixpence per spindle per annum, and the average time occupied in doffing one frame, five minutes. This on 10,000 spindles is £250 per annum in wages alone; and as there will be 20 doffings per frame per week for 40 frames:—

	Hours.	Minutes.
800 doffings per week at 5 minutes, on the present system	66	40
" " 1 minute, with Bernhardt's doffing motion	13	20

or a saving of 53 hours 20 minutes in time.

"Taking the production per spindle at 24 hanks for 60 hours, or 21 for 53 hours; therefore for 53 hours and 250 spindles there is an increase in production of 5,250 hanks, or 262 lbs. weight per week, which, at 2½*d.* per lb., will amount to £141. 18*s.* 4*d.* per year. Thus, by applying the doffing motion, a saving is effected in wages of £250, and an increased production of £141. 18*s.* 4*d.*=£391. 18*s.* 4*d.* per annum, which, taking the extra cost for the doffing motion to be 4*s.* per spindle on the 10,000 spindles,=£2,000, showing a saving of 19½ per cent on the extra outlay."

It has been thought best to allow Mr. Bernhardt to give his own description of this very ingenious invention, because it is one of those things that may, eventually, be extensively adopted, especially for low numbers, where doffings are so frequent, besides it is not seen why it should cost half the price, in new frames, that Mr Bernhardt has assumed.

REMARKS.

Before entering upon the subject of "ring" spinning, a few observations will be made upon the common throstle, as the class of yarn made by the flyer throstle stands alone in respect to its smoothness, strength, and peculiar suitability for "thread" and warp purposes.

It has been shown that the machine was invented by Arkwright, and became gradually improved until it settled down into the common throstle with separate lifting rail. For a long period it resisted all further efforts, until Gore's, Axon's, and Montgomery's frames were introduced in 1831—32, which only met with partial success. It is probable, however, that these frames gave the first idea of lifting the bolster, and dispensing with the separate lifting rail.

Should the Bolster Rail lift, or is it better to have a separate Lifting Rail?—This is a question upon which opinions are somewhat divided—it may be said unequally divided; for by far the greater number of *modern* throstle spinners have been trained to the bolster rail lift, some of whom have never seen any other.

The theory of the bolster rail lift is very plausible, viz., that for a great portion of the time a frame is working, the bolster is higher up the spindle and nearer to the flyer, and that the traverse of the bolster over so great a portion of the spindle prevents the latter wearing oval, as is sometimes the case with fixed bolsters. To a certain extent this is true, but when a bobbin rests on the bolster rail the drag is not so regular, as the washer cloth becomes saturated with oil, of which a greater quantity is used, and the frame certainly does not spin so well as when a well-made fixed bolster is used, with a separate lifting rail, as shown in *Fig.* 180. Referring to this figure it will be seen that the bolster *a* is made to extend upwards as high as possible, so as to pass through both the lifting rail and washer cloth, nearly touching the bottom of the bobbin, that should be well hollowed out. It has a collar upon it which is dished out as a receptacle for oil.

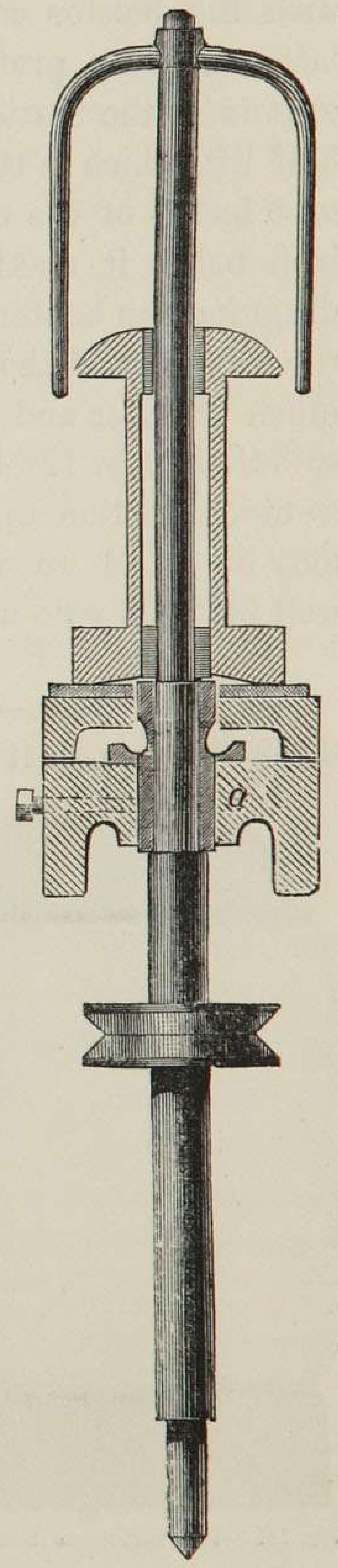


Fig. 180.—Improved Common Throstle.

and at this part a groove is turned in the bush, with a hole at the bottom to allow the oil to flow to the spindle. If a bit of worsted yarn be wrapped in this groove so as to touch the spindle at the hole through the bush, it is thought that the spindles would not only be self-lubricating to a certain extent, but the spinning would be more cleanly and the frames work better than the traversing bolster, and at the same time would fully equal it in durability.

The author thought highly of the bolster lift when it first came out, but subsequent experience, after thoroughly testing it against a well-made separate rail frame with the bolster carried up to the bobbin as in *Fig.* 180, convinced him that the latter was far preferable. As a matter of fact this was proved, but, theoretically examined, the stationary bolster ought to be better, thus:—Suppose the rail to be at half lift, which is the average for comparison, then in the bolster lift there is a length of 5 inches of the thin part of the spindle out of the bolster at the top side, and one inch below it, making altogether 6 inches subject to vibration caused by the flyer dragging the bobbin round at a rapid rate. Now in *Fig.* 180 there is only 4⅝ inches of the thin part of the spindle altogether, the remainder being all rigid; therefore it is much steadier and will run better at a high speed. Again, if the upper part of the spindle in *Fig.* 173 be made the same thickness as the bolster part of *Fig.* 180, it has so much friction upon the bushes of the bobbin that the drag is spoiled; therefore it may be relied upon that the bolster lift is not so economic in several respects as a well built throstle with separate lifting rail and high bolster, like *Fig.* 180.

Lifting Gear.—It is very important to have good lifting gear in the ordinary throstle frame, as it not only enables greater length to be got on the bobbin, but saves much of the time lost in doffing, and considerably less waste is made in the winding or reeling of the bobbins. Some makers employ what is termed the "heart motion," for moving up and down the lifting rail; others use the mangle wheel, which is better, but neither of these is perfect. Despite all care in construction, the "heart" makes irregular bobbins. Sometimes they are bellied out too much in the centre, or they have too much or too little yarn wound at one end or the other; both are great evils and occasion considerable loss. Although the mangle wheel lifts with perfect regularity, there is nevertheless a slight dwelling at the ends, preventing the bobbin being filled up in the middle as it ought to be. What is really wanted to make a perfect bobbin is a parallel lift to within about a quarter

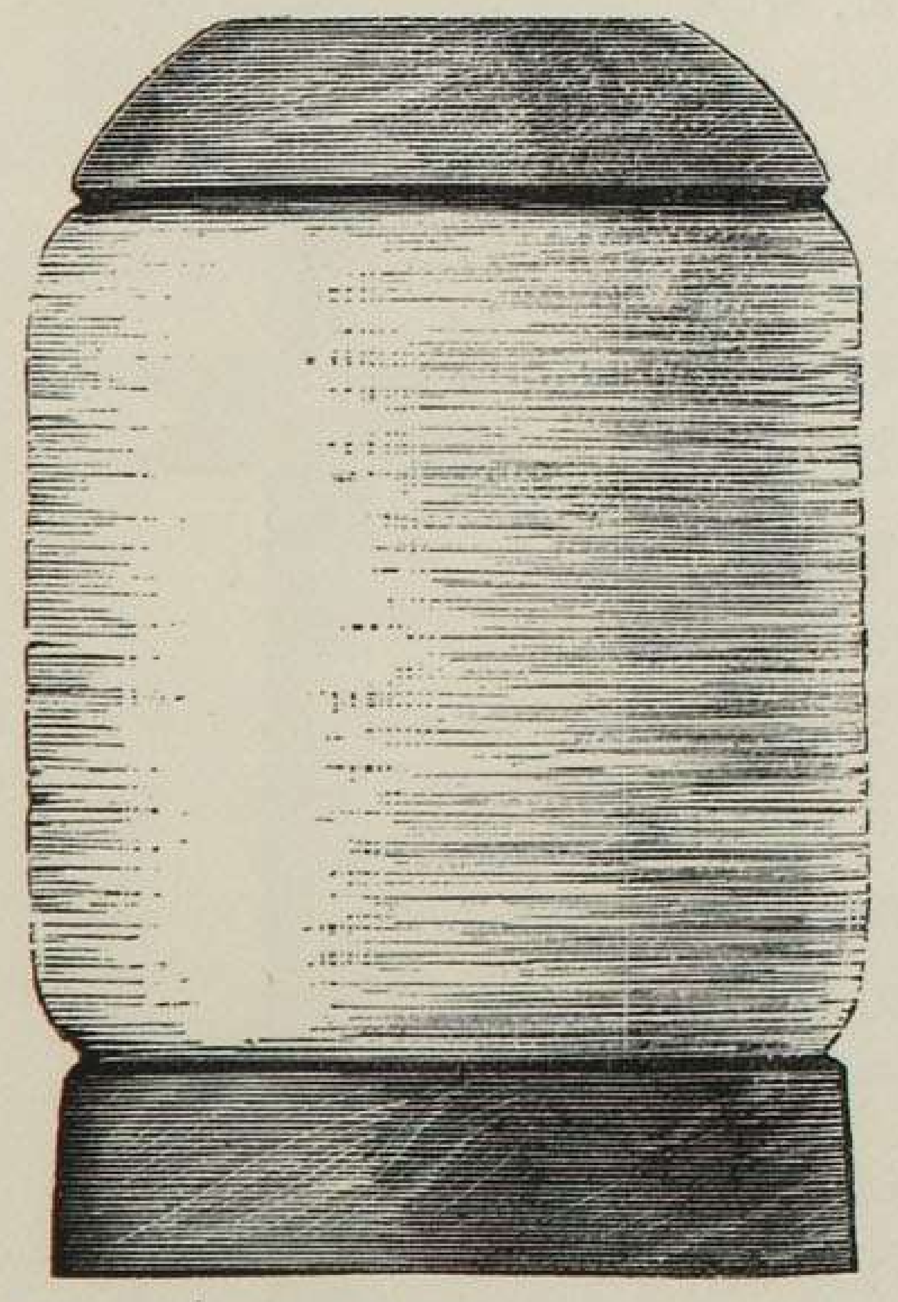


Fig. 181.—Full Bobbin as it ought to be.

of an inch at each end, and then to taper off, as shown in *Fig.* 181. This may be accomplished in a very simple manner, by altering the shape of the mangle wheel a little at each end, as represented in *Fig.* 182.

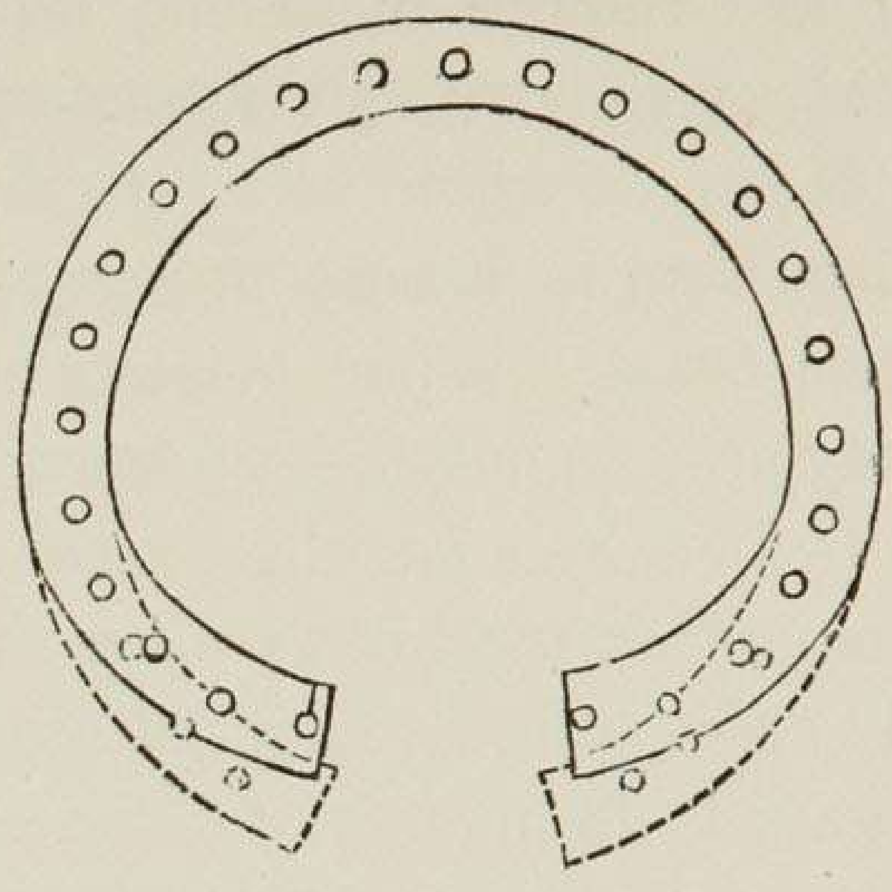


Fig. 182.—Mangle Wheel (alteration).

The Manufacture of Throstle Frames.—Simple as the throstle frame looks, it nevertheless requires considerable care in its manufacture, as well as good special tools for boring the rails accurately. The bolster and step rails should be screwed together face to face, after being planed, before they are bored, and the holes in each should be both of the same diameter—say ⅝in. diameter bare. After the frames are erected, a rimer of sufficient length to go through both holes should be passed through; this rimer should be the exact size to *slightly* enlarge the holes so that a long Whitworth templet will just pass through them.

The bolsters and steps should all be turned to the exact size to fit the holes in the rails, being tested by a Whitworth cylindrical gauge as they are made, after which they will fit the holes in the rails anywhere. In boring the bolsters, the same care should be observed by drilling the hole slightly too small at first, *two drills being used*, after which they are put upon a maundrill to be turned externally; and when this is accurately done they should be chucked in a hollow spindle lathe, which runs at a speed of not less than 3,000 revolutions per minute, and polished out with an emery stick to a Whitworth templet of the same size as the neck or journal of the spindle. The spindles should be of the best steel, and after being carefully turned should be polished in the journal, so that the cylindrical Whitworth gauges will just pass over them, when everything will fit to a nicety, and the very best results will be secured *at a small expense*, if done by a division of labour and with proper tools.

The bolsters and steps should be made of *cast iron*, in large quantities, and tested by the proper gauges before they are put in store. By this system a considerable sum is saved in the erecting, and the pernicious custom of rimering out each bolster to its spindle, when frames are finally set up in a mill, will be dispensed with. Some spinners argue that by having brass bolsters and steps, the frames will be worth more when broken up. This is short-sighted policy, for spindles soon get slack in the bolster when brass is used; after which they will not run well at a high speed, and all along they take more power and require more oil; whereas if made as above indicated, they will run for twenty years without requiring repair, using less oil, less power, and spinning well all the time, which will save more in value than a hundred brass bolsters. Cast iron, also, from its absorbent nature, requires less oil, and runs much lighter in journals than brass. When bolsters and steps are fitted in their places as above indicated, they are not only kept perpendicular, but they require very little securing, and this is best done by a small set screw, as shown.

In making throstles or any other machinery upon the above-mentioned system, it must not be forgotten that, in order to secure perfect accuracy at all times, it is necessary to adjust the working gauges frequently, by the standard set, as they become worn. If the oil cups, shown on the bolster (*Fig.* 180), are made from brass beads, forced on after the plain part is turned accurately to the templet, they may be made with great rapidity in two or three lengths, either from annealed cast iron or cold drawn steel tube; but however made, the most perfect accuracy must be insisted upon, both inside and out, otherwise the above system cannot be carried out.

RING SPINNING.

THE RING SPINNING FRAME.

A FEW years after the introduction of the Danforth Throstle, the Ring and Traveller Spinning Machine was introduced into England from America. Like the Danforth frame it was highly scientific in principle and original in conception, as will be seen from *Fig.* 183. Had the Ring frame been introduced before instead of after the Danforth, it is very probable that it would have come into extensive use, but, through the disappointment occasioned by the failure of the latter, the Ring frame became neglected, although undoubtedly better in every sense of the word than the Danforth. Notwithstanding that about forty years have elapsed since it was

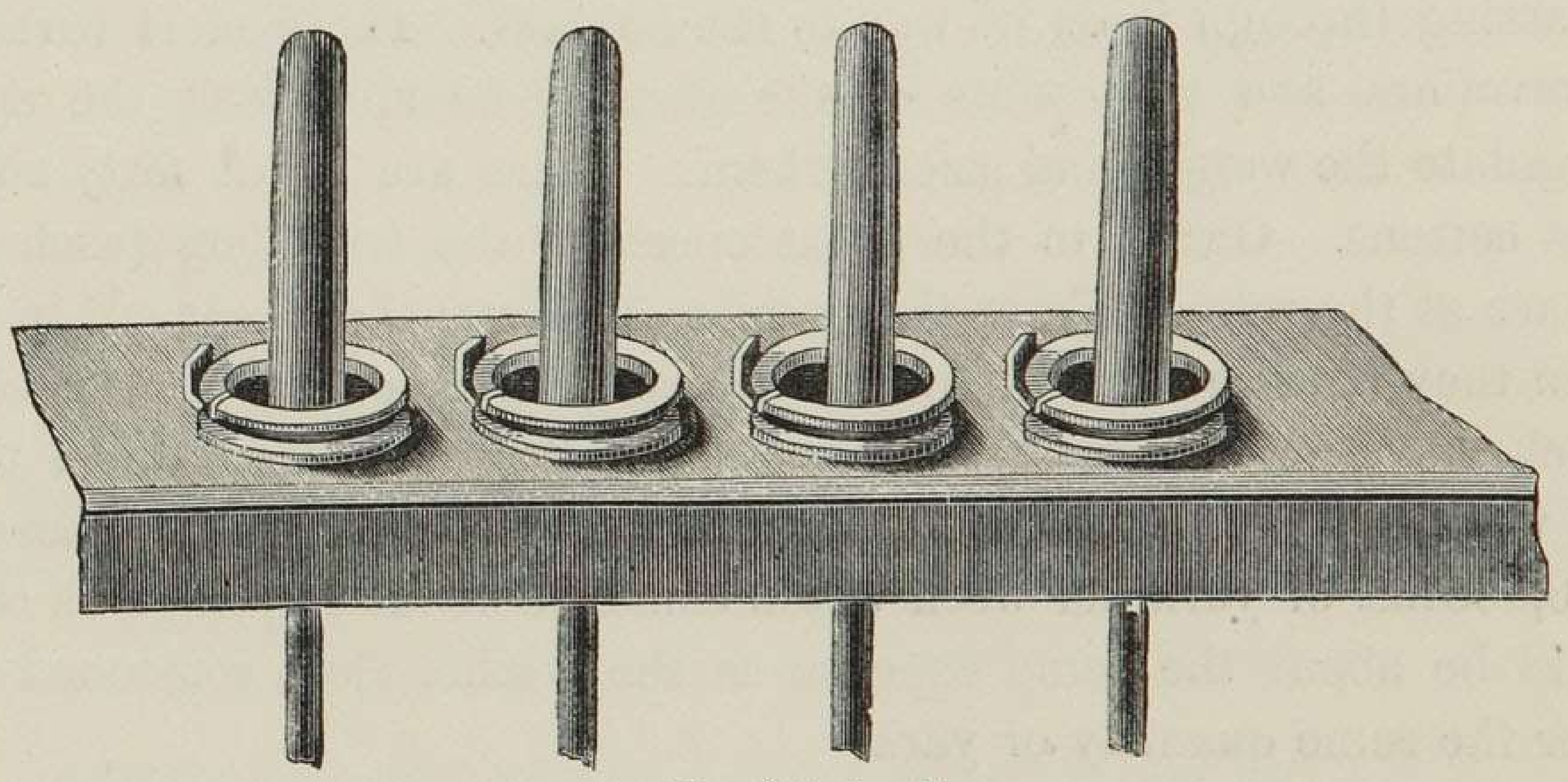


Fig. 183.—Ring Spinning Frame.

brought into England, not a single spinner has yet ventured to try it on a large scale; but in America, from the first, it has steadily gained ground and become an "institution," being used almost exclusively for warp yarns in preference to any other kind of throstle spinning and, in some instances, for weft also. Like its predecessor the Danforth, it is suitable for high speeds, and the yarn produced is of a somewhat similar nature, but better in colour, without snarls or oil streaks. It has a great advantage over the Danforth, or indeed any other kind of throstle, in regard to the power it requires to drive it.

It is said to have been invented by Mr. Jencks, of Pautucket, Rhode Island. When introduced into this country, it was, compared with its present state, very imperfect in its construction—one cause of its not being well received. Another cause was the usual difficulty attending the introduction of any new principle in machinery from inconvenience, prejudice, &c. The Americans, however, from the very first, perceived its advantages, and have steadily persevered in improving its construction, until at length it is beginning to attract considerable attention in this country. At one time driving the spindles by friction discs was advocated, which did not answer, and the entire Ring frame was condemned in consequence.

The ring-spun yarn is more woolly in appearance than flyer-throstle yarn, and less woolly than mule yarn. Its cost is less than the former, and probably a little more than the latter, which it exceeds in value. It can be spun softer than that of the flyer throstle, but not quite so soft as mule; therefore, for all numbers above 100's the mule still holds its own, and probably always will.

The principal difference between the ring and flyer frame consists in dispensing with the flyer, and substituting a ring fastened in the lifting rail, which is made to traverse for the filling of the bobbins. The winding on, or drag, is got by means of a small piece of flat steel wire bent in a half-circular form, with the ends turned in, as

annexed, which is dragged round on the top flange of the ring by the yarn passing through it on its way to the bobbins. These steel wires are called travellers, and the counts of the yarn to be spun and the speed of the spindles regulate the weight and size of them. There are about forty sizes made to suit various cottons. Owing to the great speed of the travellers (each one passing through space at the rate of about thirty miles an hour) they wear out in six or eight weeks, when they require to be renewed. Going at a speed of 6,000 revolutions per minute, each traveller will produce about 100 miles of 32's twist, on the average, before it is worn out, which is equal to about six pounds of yarn; therefore, a concern spinning 10,000lbs. of yarn per week would consume about eleven gross of travellers, which would be about the same expense as the washer cloth consumed by the flyer throstles for the same quantity of yarn.

The rings are generally made of fine-grained Low Moor iron, carefully finished, hardened, and polished. Their sizes also need to conform to the different weights of yarn; and the finer and softer this is required to be spun, the smaller must be the rings. The average size of them is 1⅝in. diameter inside, and the annexed sketch (*Fig.* 184) shows their form. It is necessary to oil the rings three or four times a day to prevent rapid wear and reduce friction. If proper care be taken by attending to their lubrication, the rings will last from six to ten years. A great variety of rings have been

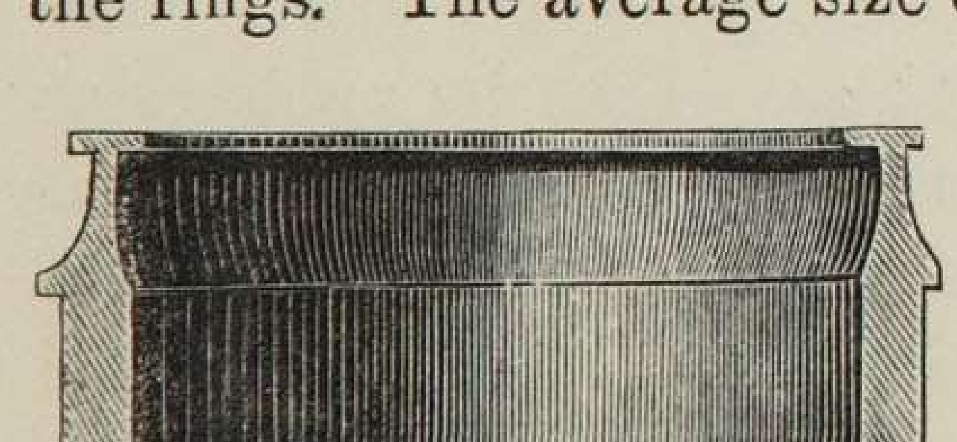


Fig. 184.—Section of Ring.

patented from time to time, and different advantages claimed for each. One of the best is by Carroll, of the United States, which is made for reversing, so that when the top flange becomes rough it is turned over, and so presents a new wearing surface. The tracings below show these rings in sections. *Fig.* 185 is for cotton yarns of the finer descriptions; the other for heavy carpet yarns.

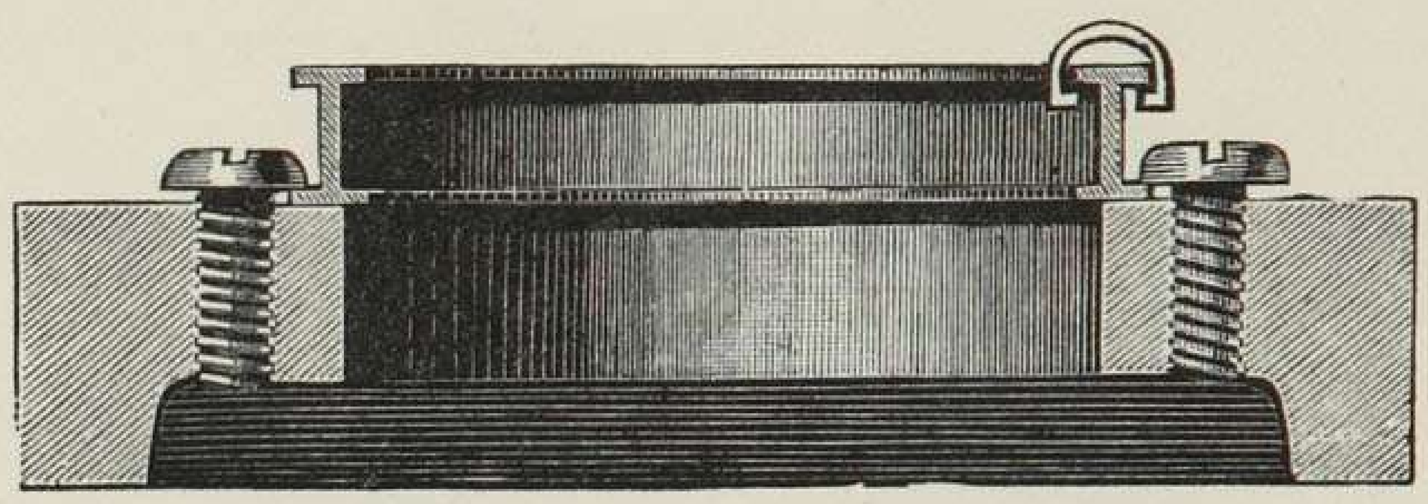


Fig. 185.—Section of Spinning Ring.

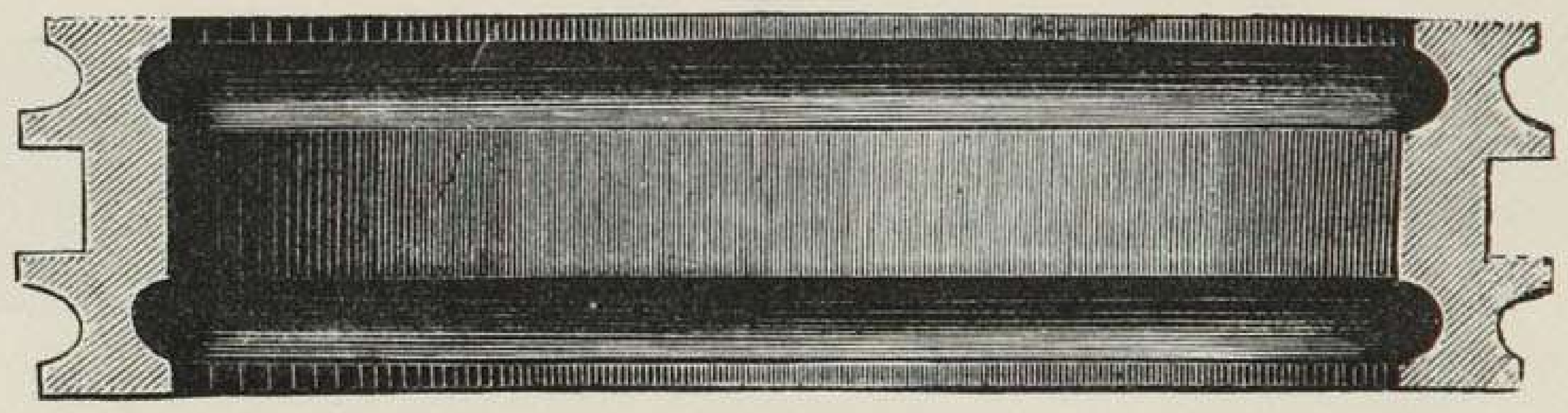


Fig. 186.—Ring for Carpet Yarns.

It will easily be understood that these rings ought to be perfectly concentric with the spindles in all positions of their traverse; but as machine makers experience some difficulty in attaining this desirable object, a plan was once adopted of using three set screws placed radially, for adjustment, shown below; the holes in the lifting

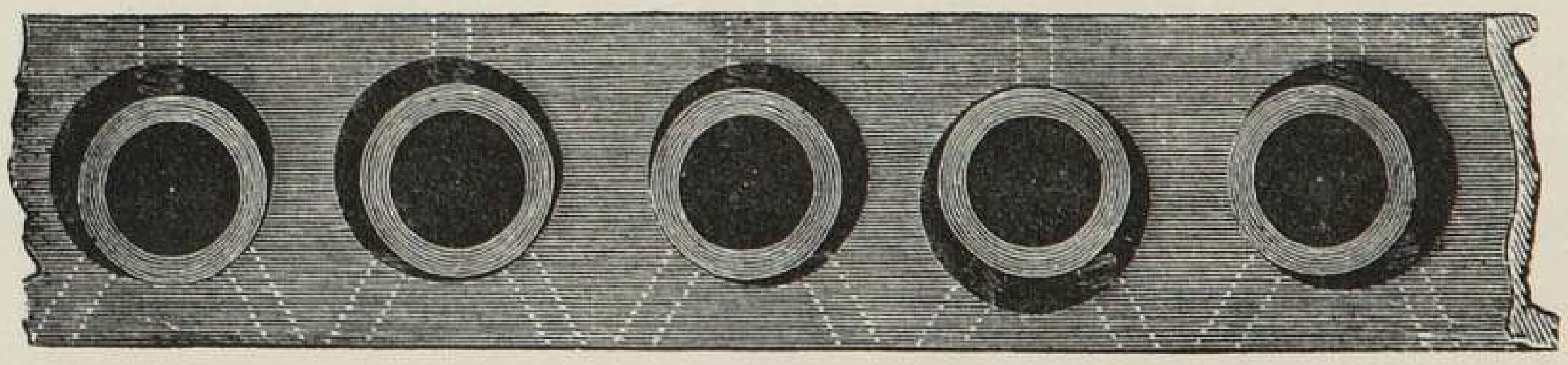


Fig. 187.—Old method of making Rings concentric.

rail being bored out about 3-16ths of an inch larger to allow of this. A much better plan consists of an eccentric liner, fitted on the ring and inserted in the rail, whereby the concentric setting is accomplished in a neat manner, as represented in *Fig.* 188; the liner being cut through in the narrow part, and a small set screw holds both the ring and liner.

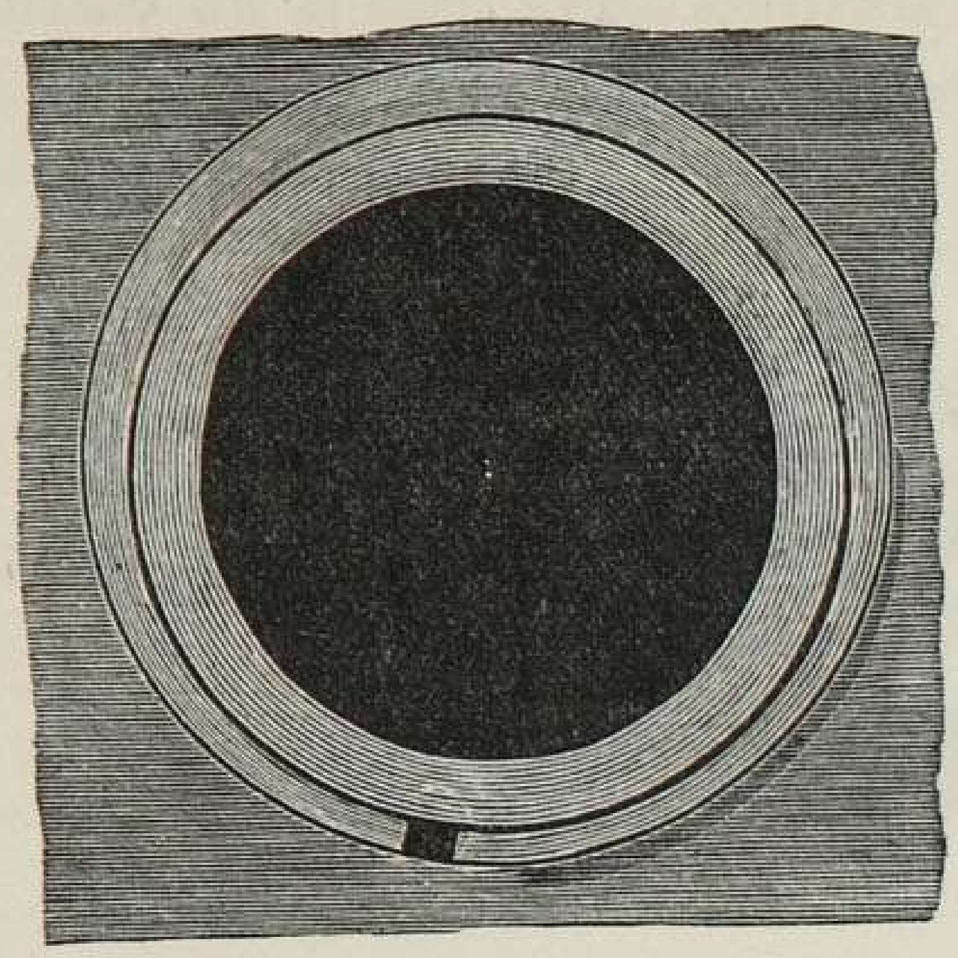
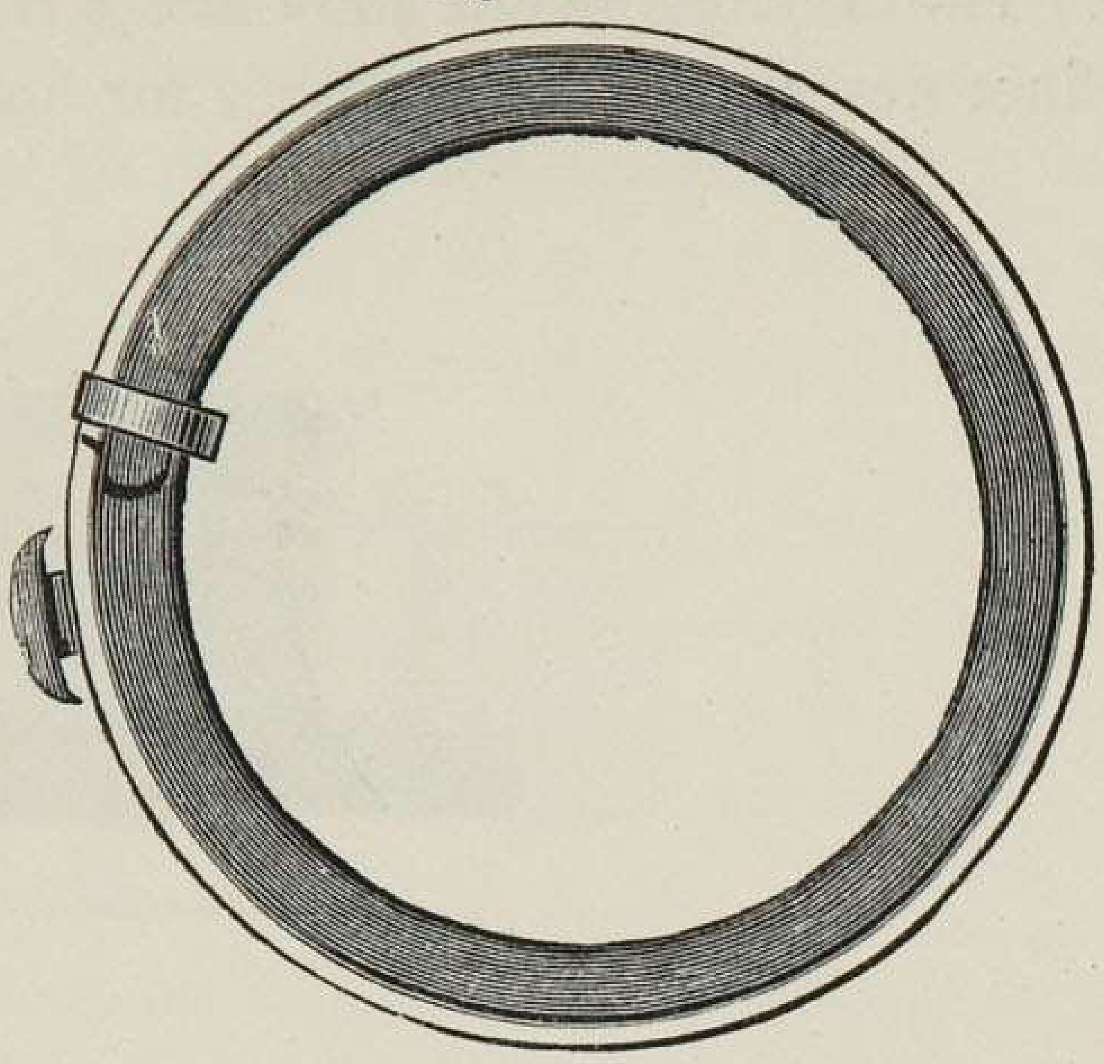


Fig. 188.—Ring with Eccentric Liner.

Fig. 190.



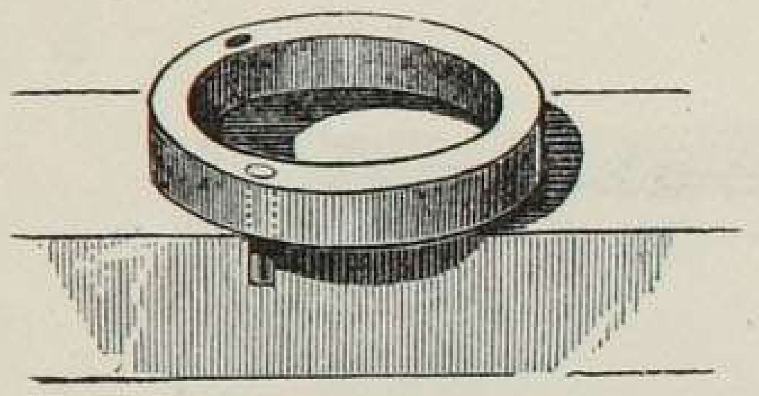


Fig. 189.—Pin and Gauge.

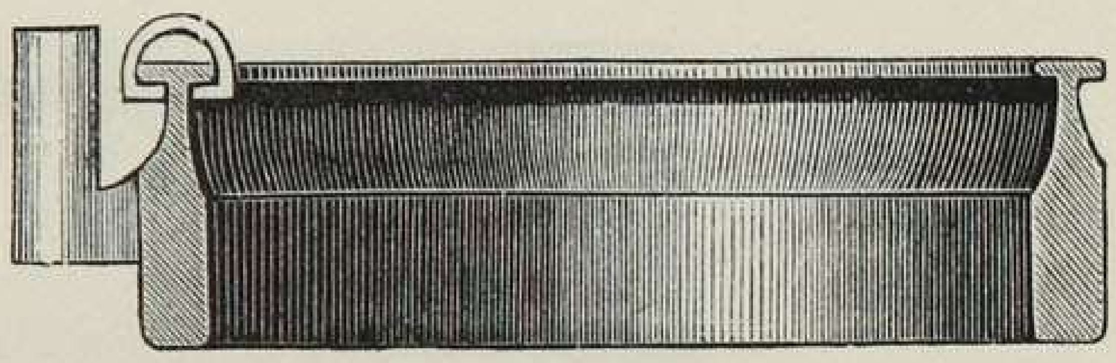


Fig. 191.

As loose cotton fibres are apt to accumulate round the travellers, thereby adding to their weight and increasing the drag, several plans have been tried to keep them clear, one of the best of which is a small block of soft metal cast upon a wire shank, which fits in a hole drilled in the rail, as here given. This is understood to be the invention of Mr. John C. Dodge, of New York, who also contrived a gauge of the form shown in *Fig.* 189, for drilling the holes in the rail to hold them. This gauge fits on the outside of the ring, and ensures the holes being drilled exactly right, a point of considerable importance. When placed right it just misses the traveller, as seen in *Fig.* 190. It is sometimes soldered to the side of the ring, as shown in *Fig.* 191.

Fig. 192.

The first method employed was by a wire brush moving to and fro, so as just to miss the travellers. Another plan was by fixing a plate to the copping rail, as in *Fig.* 193; this plate has sharp angular projections, against which the accumulating fibres lash, and the traveller is thus kept clean.

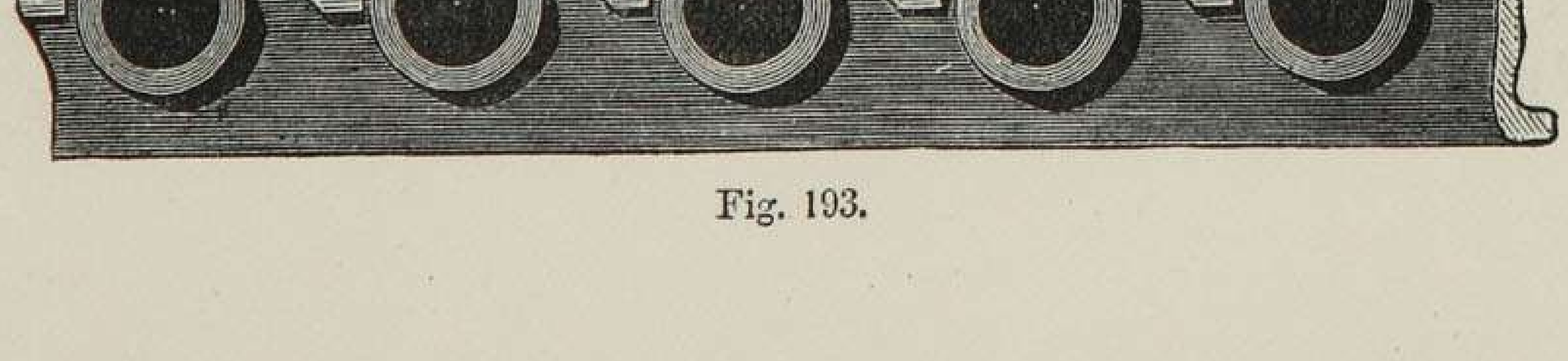


Fig. 193.

The best oil for the lubrication of the rings is sperm, but in America a mixture of paraffin and tallow, or paraffin oil alone, is used; and if the latter is pure, it will not permanently stain the yarn.

Figs. 194 and 195 show full-sized bobbins filled with yarn, one double-headed and the other plain.

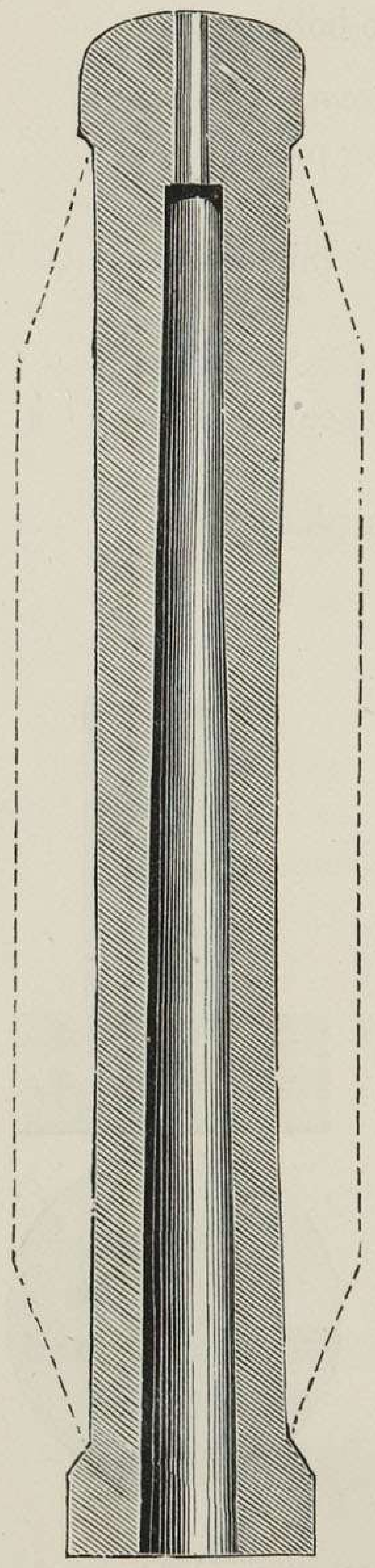


Fig. 194.
Double-headed Bobbin.

Double-headed bobbins are now rarely used for spinning, because it is found that they make about 25 per cent more waste in reeling off than the quills or bobbins with bottom flanges only, on account of the frequent breakages of the ends, which get wedged under the bobbin head and lost to sight. Much time is lost thereby, and the many piecings made spoil the yarn. The double-headed bobbins also must be placed lower or farther away from the thread-wire to prevent the yarn rubbing against the top flange in the act of spinning; and it is necessary to preserve as close a distance in that respect as possible. Two inches is a good practice, as shown in *Fig.* 198, page 229.

The bobbins are always driven direct by the spindles, either by being pressed on to a taper blade or by a bead or braid with pins fast to the spindle and fitting into corresponding recesses in the bobbins. The form of bobbin in the first case is a plain tube called a quill, which is generally $6\frac{3}{4}$ inches long, but varying with the length of the traverse. The size at the bottom is $\frac{7}{8}$in. diameter, and the size at the top $\frac{13}{16}$in.; the centre part, where the yarn is wound, being turned slightly hollow for holding it firmer. The tops of the bobbins are well rounded off. The holes in the bottom of the bobbins are $\frac{3}{8}$in., and near the top $\frac{1}{8}$in. diameter.

The traverse for these quills is generally about $1\frac{1}{4}$ to $1\frac{1}{2}$in. shorter than the length of the bobbins. There is a lengthening taper motion provided to secure the end layers and prevent them from falling off. This kind of spinning frame runs very steady, owing to the well-balanced bobbin. The usual speed is 6,000 to 8,000 revolutions per minute of spindles

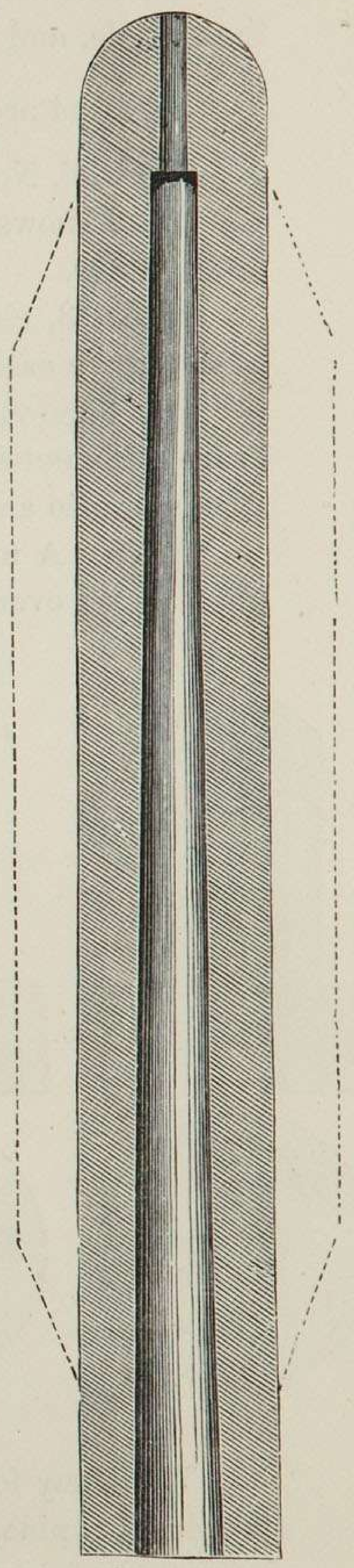


Fig. 195.—Plain Tube.

for spinning No. 30's warp. Still there is an objection in piecing up and in doffing, because the bobbins stick so fast on the spindles that, when required to be taken off, much time is lost in loosening them, thereby endangering the straining of the spindles, and pushing off the yarn from the bobbins.

Another form of bobbin is the straight tube, with bottom flange fitting loosely on the spindle, and being driven by the braids with pins.

Annexed are different forms of bottom flanges as arranged for these bobbins.

Fig. 196, No. 1, represents the bottom flange of a bobbin with a groove.

No. 2 shows a plan where two holes are bored, into which the driving pins of the braids enter.

In No. 3, circular grooves are provided for the driving pins to get hold of the bobbin more easily.

No. 4 shows a groove turned in the underside of the bobbin, and a pin is driven in from the outside, by which means the braid drives the bobbin. A piece of sheet steel will also answer the same purpose.

No. 5: A metallic piece is inserted in the bottom of the bobbin, in place of the pin rivetted over, for fastening.

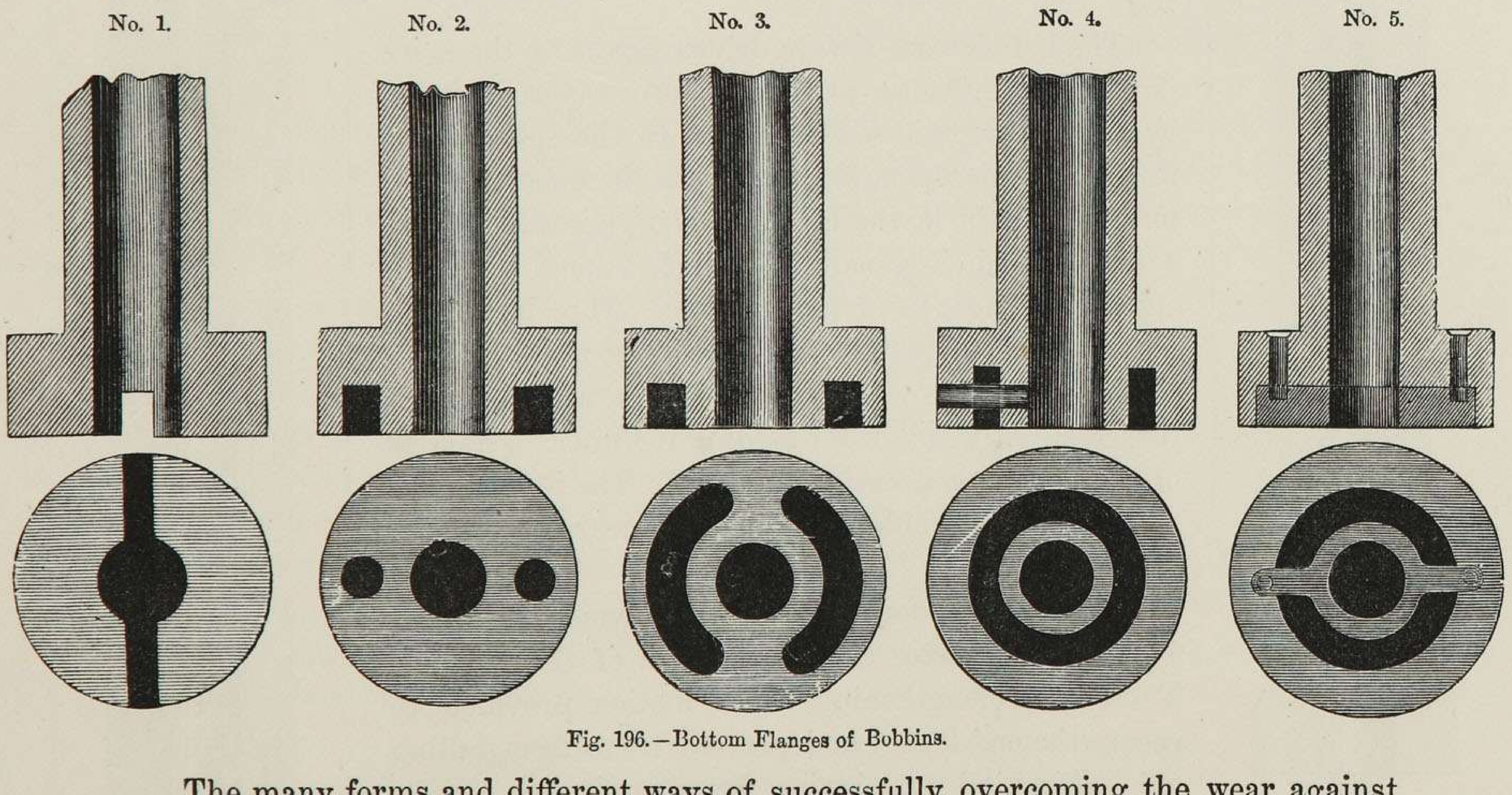


Fig. 196.—Bottom Flanges of Bobbins.

The many forms and different ways of successfully overcoming the wear against the driving pins, led Mr. Bernhardt to introduce a spring, with projections inserted in an undercut groove in the bottom flange of bobbin as shown in *Fig.* 197. These springs cannot come out, because the groove is turned conical and larger in the inside, and the spring fits it, pressing all round, by which means it is prevented from turning. The springs can be used over and over again for new bobbins when the old ones are worn out.

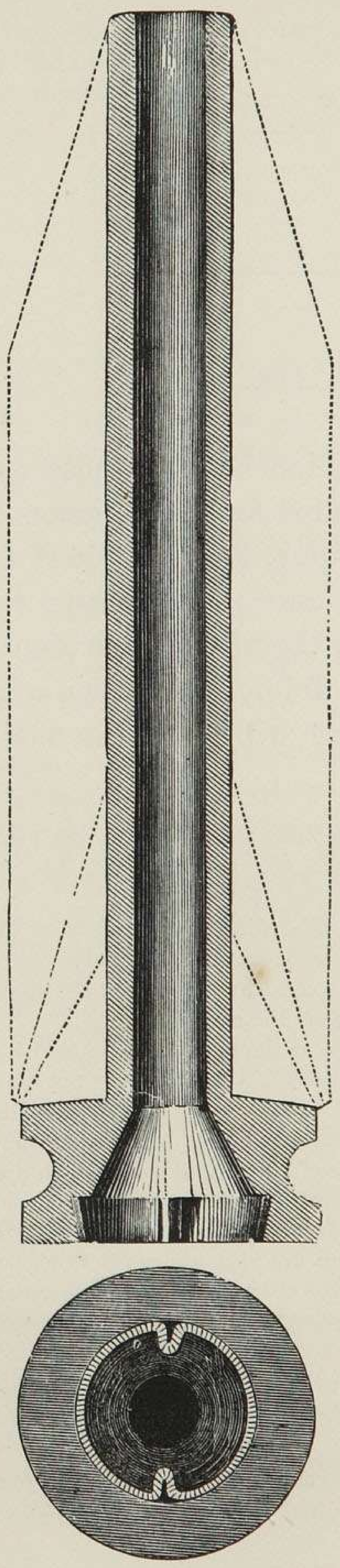


Fig. 197.—Bernhardt's Bobbin.

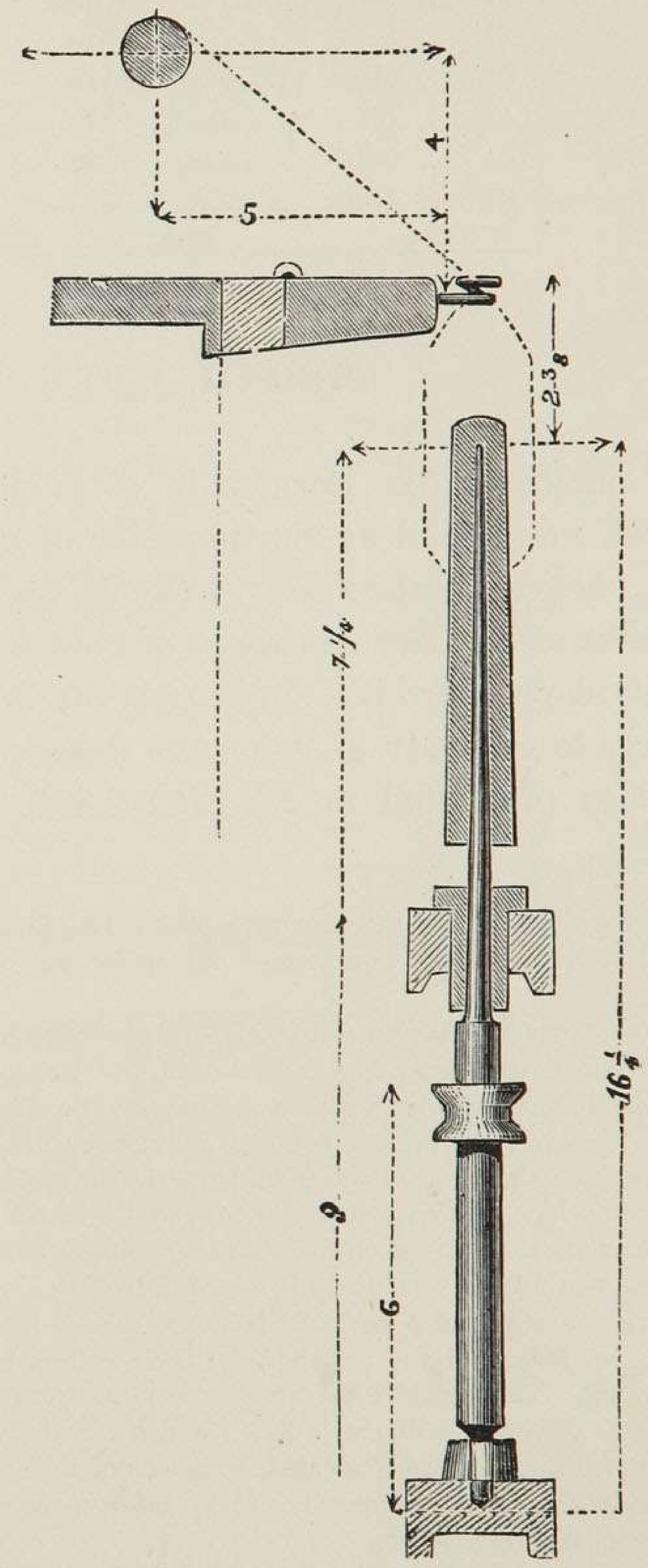


Fig. 198.

The length of traverse for the various counts varies from $3\frac{1}{2}$ to $5\frac{1}{2}$ inches; and for the guidance of those interested the following particulars are appended:—

For Spinning		Size of Ring.		Length of Traverse.
6's to 10's	....	$1\frac{7}{8}$ in. internal diam.	....	$5\frac{1}{2}$ in.
11's ,, 16's	....	$1\frac{11}{16}$ in. ,, ,,	....	$5\frac{1}{4}$ in.
17's ,, 20's	....	$1\frac{3}{4}$ in. ,, ,,	....	5 in.
21's ,, 30's	....	$1\frac{5}{8}$ in. ,, ,,	....	$4\frac{1}{2}$ in.
31's ,, 40's	....	$1\frac{1}{2}$ in. ,, ,,	....	4 in.
41's ,, 60's	....	$1\frac{3}{8}$ in. ,, ,,	....	4 in.
61's ,, 80's	....	$1\frac{1}{4}$ in. ,, ,,	....	$3\frac{1}{2}$ in.
81's ,, 100's	....	$1\frac{1}{8}$ in. ,, ,,	....	$3\frac{1}{2}$ in.

BERNHARDT'S RING FRAME.

The ingenious Mr. Bernhardt, of Radcliffe, near Manchester, whose name has before been mentioned as the inventor of a doffing motion for the common throstle, has paid particular attention to the Ring spinning frame, and contrived a doffing motion for it also. The drawings of this useful contrivance would occupy too much space to be shown here in a sufficiently intelligible form; therefore it has been thought best merely to give Mr. Bernhardt's description of the frame in his own words, and refer parties interested to Mr. Bernhardt himself, who will show the machine in operation.

"The drawings of this machine represent a ring frame for flanged bobbins (see *Fig.* 197), the yarn of which may be used either for warp when reeled off, or for weft when the bobbins are put direct into the shuttles for weaving off.

"The rings are $1\frac{9}{16}$in. diameter inside, and the traverse or lift is $4\frac{1}{2}$in. There is a motion provided whereby the bobbin at the bottom is filled up in a conical form, which changes into a building motion self-actingly.

"The bobbins have bottom springs, to prevent the objectionable wear caused by the pins in the driving braids. There is also a groove turned in the bobbins, and notches are cut for breaking off the ends in doffing.

"The spindles are 16in. long, $\frac{9}{17}$in. thick in the middle, and $\frac{3}{8}$in. diam. at the top. They have roomy warves, 1in. diameter, 1in. long, and shaped to allow the knotts of the bands to pass easily. The braids are not screwed on to the spindles, nor are they driven on to flats as is customary, both of which cases have a tendency to strain the spindles, and make them run untrue; but there is a conical seating formed, on which the braid fits. This is sufficient to drive the bobbins without slip, and a perfectly balanced spindle is obtained, capable of running at a very high speed. The braids are $1\frac{1}{16}$in. long, and the underside of their collars have a sharp serrated edge for assisting in cutting the ends when doffing. The thread-wires are placed $1\frac{3}{4}$in. from the top of the bobbins. The perpendicular distance of front rollers from centre of bobbins is $3\frac{3}{4}$in., and horizontally the front rollers are $2\frac{3}{4}$in. above the roller beams. At the off end the front rollers are connected, by means of mitre wheels, to a cross shaft provided with a square, so that by applying a key they may be turned, and by interposing spring catch boxes at the gearing end the roller wheels remain stationary during that time.

"The drawing rollers are placed at an angle to allow the twist to run right into the bite of the front rollers; the back rollers are placed 1 inch higher than the front ones. The roller weights consist of bars $1\frac{3}{4}$-inch diameter, and stretch across the frame, each end being suspended by opposite sides.

"The ring rails are plain bars $2\frac{3}{4}$in. wide, and $\frac{9}{16}$in. thick, and they form a hinge with the front part of their cylindrical guide rods, so that they may assume an inclined position when required. They may also be moved up and down by hand, besides their usual self-acting traverse motion, for which purpose the copping shafts are provided with gearing at the off end, and a catch box for actuating either of these motions.

"Each ring rail carries a number of projecting pins, at intervals of about 2 yards, which are placed in the centre of them; and it will easily be understood that when, by means of the hand motion, these rails are lowered, the pins come in contact with the bolster rails, and they are lifted into an inclined position, their front end being held by a pin in the heads of ring rail guides. At this moment a spring, fastened to the back of ring rail guide, and carrying, a small block, is liberated and shoots forward under the ring rail, and prevents its going back into the horizontal position. But if the ring rails are now lifted to their highest position, pins fastened to the bobbin-plates come in contact with the springs, pulling them out from under the ring rails, which thereby are allowed to drop and assume their horizontal positions.

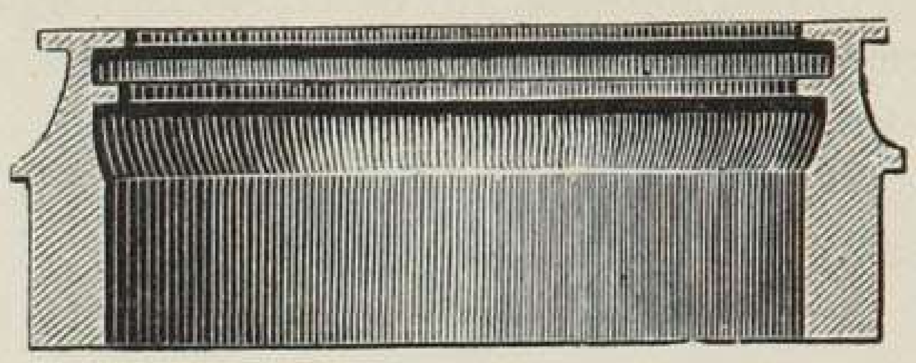


Fig. 199.—Bernhardt's Ring.

"The rings of this machine, of which the annexed figure is a full-sized section, have an additional internal rim to prevent the end from escaping the traveller when the ring rail is moved up and down during doffing. There is also a very simple contrivance for cleaning the travellers from the accumulating fibres during spinning. This consists of a piece of wire fastened to the back of ring rail close to the ring and far enough away to prevent the traveller touching it whilst rotating.

"The threadwire boards consist of an iron underplate with a wooden back rail to which the hinged boards are screwed. There is a separate hinge for each spindle, so that any bobbin may be taken off for piecing, &c., without interfering with its neighbour. Holes are drilled in the threadwire boards and their underplates, into which the empty bobbins are placed previous to doffing. Their positions are between the threads. The threadwire boards rest on the bobbin plates—so called from carrying or supporting the empty bobbins. These plates extend the entire length of the frame, and are fastened to the spring pieces and frame ends. There are pins at convenient distances, and the underplates of the threadwire boards have inclined slots which correspond with these pins. The object of this arrangement is to enable the threadwire boards to slide forward and backward on the bobbin plates if an end pull or push is applied; and to make both sides move simultaneously, a cross shaft is provided at the off end, carrying levers for this purpose. When the threadwire boards are in their forward position, the bobbin holes correspond exactly with the spindles, and it is for this position that the front rollers are required to make about one third of a turn forward to give out some more thread, which, if not done, would possibly break, in consequence of the greater distance between the front rollers, the threadwires, and the spindles.

"The dust plates are suspended from the bobbin plates by means of hinges, to enable their lower edges to be brought forward against the empty bobbins, for the purpose of lapping a turn of the slack end on, whereby all the ends start after doffing.

"Motion is given to the dust plates by means of links working from discs on a central shaft, which is moved by a handle at the off end. For the reception of the full bobbins in doffing, portable boxes, made like camp stools, for folding up when not in use, are placed on the floor in front of the frame.

"The operation of doffing is then performed by the overlooker or his assistant in the following manner:—

"When the ring rails have arrived at the top, the copping motion is thrown out of gear and the rails lowered by hand, the ends still lapping on to the bobbins, and, slipping into the lower groove of the bobbins, pass on to the braids, where a few turns are delivered and then the machine is stopped. This last process is precisely the same as that of the mule, whereby a connection of the thread with the spindle is secured for the starting of the new cops. When, now, the ring rails are brought still lower, their projecting pins come in contact with the bolster rails, and they assume an inclined position, which brings the rings under the full bobbins. After this the ring rails are raised and with them the full bobbins, which in the act break their connection with the spindle braids, and, having arrived at the top, the full bobbins fall over into the troughs placed in front of the machine. Then a little yarn is given out by turning the front rollers forward, after which the empty bobbins are dropped on to the spindles by sliding the threadwire boards forward. The ring rails are then lowered, so as to allow the dust plates to be brought in contact with the empty bobbins, after which they are raised again under the dust plates. A slight forward turn of the tin roller now laps the slack thread on the empty bobbins, and, after withdrawing the dust plates, the frame is started and the copping clutchbox put in gear.

"These few simple motions take less than a minute to do, and the certainty with which the ends start is very satisfactory.

"To show the advantages of a doffing motion more clearly we will suppose a mill containing 10,000 spindles, or 40 frames of 250 spindles each. These frames will doff 24 times per week, or 960 doffings in all per week.

960 doffings, at 10 minutes to each doffing, by hand	=	160	hours.
960 doffings with Mr. Bernhardt's doffing motion	=	16	"
Difference		144	"

"Take the counts of the yarn to be 20's; the production per spindle per week of 54 working hours to be 35 hanks; the total production of the 10,000 spindles will be 17,500 hanks per week, or 875 pounds weight. This at 2½d. per ℔ gives £455 per annum as a saving of time by the doffing motion. Add to this the wages paid per annum for hand doffing, viz., £250; we have a total saving of £705 per annum.

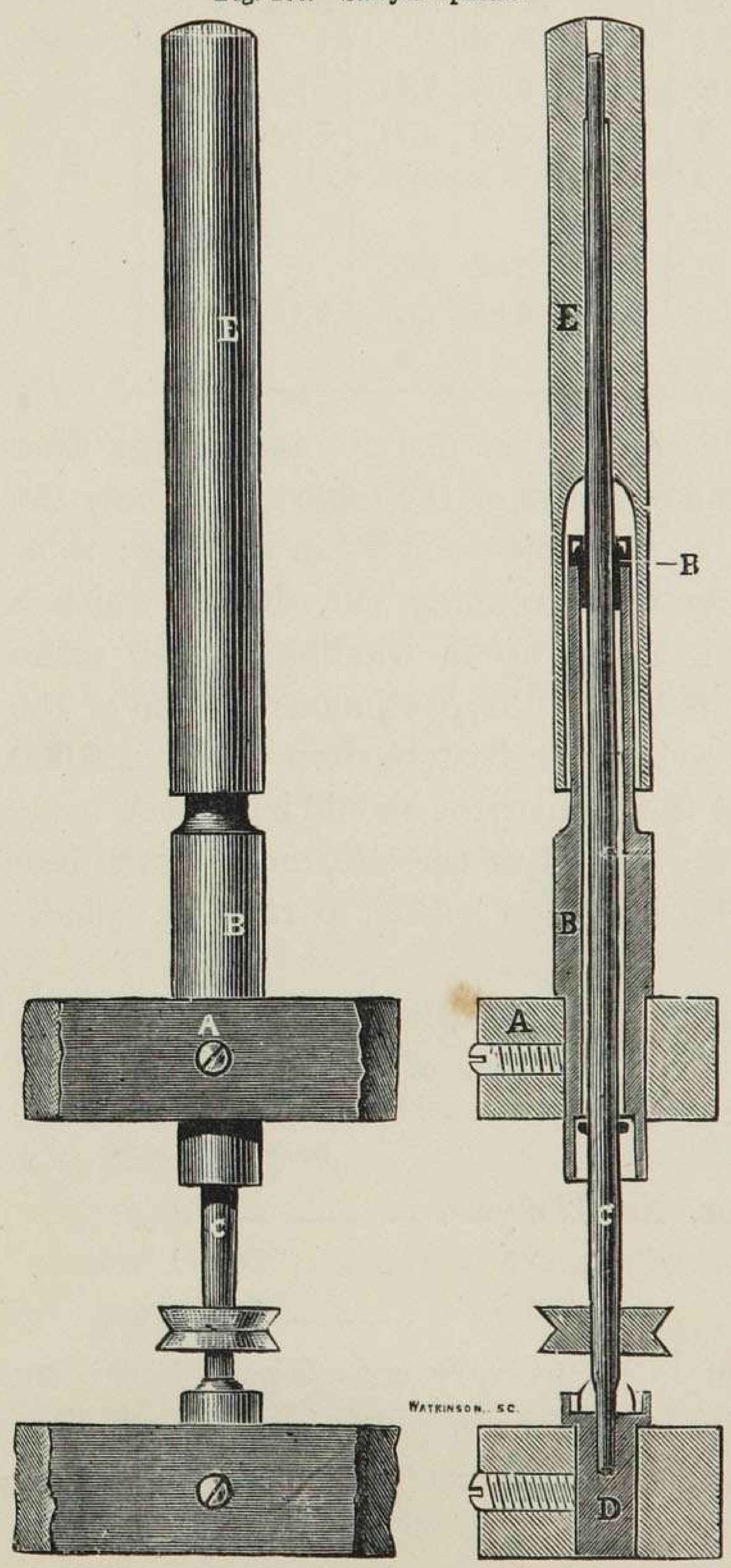
"Take again the extra cost for making the doffing motion at 3s. per spindle, or £1,500 on 10,000 spindles; the outlay on capital will be found to be a saving of 47 per cent per annum.

THE SAWYER SPINDLE.

The superior quality of Throstle over Mule yarn, and consequently higher price it always commands in the markets of the world, have ever been an inducement to enterprising spinners and machinists to reduce the cost of throstles, lessen the power they require, or increase their production, which has the same result. The history of the Throstle, from the days of Arkwright, shows that for nearly a century desperate efforts have been made to this end, some of which have already been recorded

Although the invention of Ring spinning forty years ago opened another channel for further improvement, it appears to have escaped notice that, for twisting a slender thread, a far more ponderous spindle was used than is absolutely necessary. True, the pleasing thought has occurred to many inventors, how nice it would be, if the light spindle used in mules could be continually kept running, and have its yarn wound on, until the *set* was full or the cop completed, without the rollers stopping! This has long been the dream of enthusiasts, but abandoned as an impossibility. The honour of solving this difficult problem has fallen upon two American inventors, the first of whom is Mr. Jencks, who discovered Ring spinning; the other, Mr. J. H. Sawyer, of Lowell, Mass., who found out a method of supporting the spindle within the pirn or bobbin on which the yarn is wound. This useful invention is shown in *Fig.* 200, which gives elevation and section, half size, as used for coarse work. In this figure A represents the bolster rail, B the bolster, C the spindle, D the footstep, and E the bobbin or pirn, as adapted to Ring spinning. The weight of this spindle, with the empty bobbin upon it, is only that of a light mule spindle, such as is used for mules of 1¼in. gauge, or about 3¼ ounces, with bearings $\frac{9}{32}$in. diam. at the bolster, and $\frac{9}{64}$in. diam. at the step, whilst those of an ordinary throstle weigh 13 ounces, with bearings $\frac{7}{16}$in. diam. at the bolster and ¼in. at the step; therefore a great saving of power is obvious, over the ordinary throstle as well as over the common ring frame with the usual bolster and heavy spindle. From actual experiments made by the "N. E. Cotton Manufacturers' Association" of America, and exhibited at their "Sixth Annual Meeting," held in April, 1871, it appears that the Sawyer spindle, when spinning No. 13 yarn, absorbs a power equal to 6 foot-pounds per spindle per second when going at the rate of 7,046 revolutions per minute, and the common ring spindle absorbs the same power at a speed of 5,206 revolutions per minute; whilst the flyer throstle, with dead spindle, can only go 3,300 revolutions per minute in taking up that amount of power.

Fig. 200.--Sawyer Spindle.



Front Elevation. Transverse Section.

The weak point in the Sawyer principle appears to be the thin shell formed by hollowing out the wood bobbin or pirn which fits on the top of the spindle. Unless great care be observed in making them of good timber thoroughly dried, after being roughed out, and then carefully finished so as to prevent any possible rubbing against the bolster, these pirns might occasion much trouble and loss of power by vibration, etc. A more perfect bobbin is clearly indicated here, as well as in the common flyer throstle, rather than trusting to fragile wood, which is ever getting damaged by warping and the rough usage in a mill. Although cheap to commence with, wood bobbins become very dear in the end from excessive wear and tear, bad spinning, and the loss of power they occasion when out of balance; therefore a simple, but permanent, improvement in that direction is much wanted.

The advancement of art and science makes it possible to do in this generation what could not be done before; therefore the time has now arrived, and the necessary material and appliances exist, for improving the spinning bobbin permanently, so the attention of inventors is earnestly directed thereto, as the right sort of thing might be lucrative to manufacture as well as a public boon.

The following interesting table, showing the relative power of different spinning machines, is also borrowed from the American Cotton Manufacturers' Association :—

Table showing the power in foot-pounds, per second, per spindle, for various spinning machines.

Kind of Machine.	No. of Yarn.	Revolutions per minute of Spindle or Flyer.						
		2000	3000	4000	5000	6000	7000	8000
		ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.
Throstle Frame, heavy flyers...	13	2.65	5.12	8.34	12.33			
Ring Frame, common Spindles	13	1.69	2.82	4.14	5.66	7.37		
Ring Frame, Sawyer Spindles .	13	1.11	1.85	2.69	3.66	4.74	5.94	
Mule, Sharpe & Roberts.........	13	1.14	2.60					
Throstle Frame, light flyers ...	30		3.75	5.93				
Ring Frame, common Spindles.	30	1.59	2.61	3.77	5.08	6.53		
Ring Frame, Sawyer Spindles .	30	1.05	1.70	2.43	3.25	4.16	5.14	6.21
Mule	30	0.99	1.75	2.69				

It will be noticed that the speed of mule spindles is placed much lower than they actually run, which is accounted for by the compiler of the table giving only the twists actually made per minute, after deducting the time occupied in winding; thus, if the speed of a spindle be 5,000 per minute while running out, during which it occupies 0·7 of the time, and the other 0·3 is taken up in winding, it will make $0{\cdot}7 \times 5{,}000 = 3{,}500$ twists per minute, as compared with the continuous motion of the throstle or ring spinning frames. But the speed of the best modern mules is 6,000 to 7,000 revolutions of spindle per minute, and the comparison should have been made with them. The same remark will apply to the light flyer throstle, made on the best principle, as in *Fig.* 180, which might likewise have the bottom part of its spindle shortened and reduced in thickness.

From various tests made at the Boott Cotton Mills to ascertain the difference in power, under the direction of J. B. Francis, Esq., Engineer of Locks and Canals at Lowell, the following result was arrived at:—

			Revolution of Spindle per Minute.
Throstle, 73 spindles per horse power,	No. 32's yarn	....	4,200
Ring, 102 spindles	,,	,, ...	5,900
Mule, 296 spindles	,,	,, ...	5,650

The great difference in favour of the mule seems very conspicuous here; but tried, as in the previous manner, by deducting time lost in putting up or winding, would give $0{\cdot}7 \times 5{,}650 = 3{,}955$ twists per minute as the continuous speed of 296 mule spindles per horse power.

It would have given a more correct idea of the relative productive power of these machines per horse power, had Mr. Francis based them all on the same continuous speed of spindle. This, however, is easily found, and gives the following result (supposing them all to run at 5,000 revolutions per minute);—

	Revolution of Spindle per Minute.
Throstle, 61 spindles per horse power, No. 32's yarn	5,000
Common Ring, 121 spindles „ „	5,000
Sawyer's Frame, 211 spindles „ „	5,000
Mule, 234 spindles „ (supposed continuous speed)	5,000

Touching the relative strength of throstle, ring, and mule yarn, fifty trials of the three different kinds made at the Boott Mill from the same bobbins of roving, made upon an English yarn tester, showed the following results with a lea of 80 threads:—

	Per inch.		lbs.
Throstle frame, No. 32's yarn, exact twist,	$27\frac{1}{8}$,	breaking strength	52
Ring „ „ „	$27\frac{1}{5}$,	„ „	48
Mule „ „ „	$27\frac{1}{6}$,	„ „	41

The throstle frame is supposed to make the least waste, the mule and ring frame about equal; that is in mills where a good quality of yarn is spun, otherwise throstles are intolerable.

Remarks.—There can be no doubt that ring spinning is now assuming a very important phase, especially in America, the cradle of its birth, and where the operatives have been trained up to its use. Even in this country the old prejudice against it is wearing away, and its use is extending, especially for doubling frames.

Each of the above spinning machines may be said to have an individuality, neither can supplant the other.

The flyer throstle will always, in the nature of things, make the strongest yarn, and continue to hold its own for particular purposes. As used in England, with the light flyer and live spindle, this throstle takes much less power than the Montgomery principle, with dead spindle and heavy long-legged flyer with wharve at the bottom, besides which it costs less than the latter. The only possible advantage of the Montgomery frame is that it twists the yarn through a funnel at the top of the flyer, and throws the twist up to the rollers without the intervention of a thread board; but this can also be done with the common flyer by boring a small hole in the top and making a saw-gate in it to catch the thread, a plan which was patented a few years ago by an American gentleman, who did the same thing with mule spindles, and so stopped the vibration of the yarn. The old throstle frame had, sixty years ago, a corkscrew-topped flyer that was abandoned in favour of the thread board wire guides, but the American plan is a much neater way of effecting the same object. The great power absorbed by the flyer throstle is not in the spindle and flyer as such, but in dragging round a clumsy unbalanced bobbin at nearly the same speed as itself, some of which have larger holes in than others, causing both vibration and irregular drag. But for this the common throstle would be a much more perfect machine than it is.

THE MULE, OR MULE JENNY.

THE important machine bearing this singular appellation had its origin at Hall-in-the-Wood, a picturesque dwelling near Bolton, and was the invention of Samuel Crompton, the only son of Mr. George Crompton, who cultivated a small farm at Firwood, where Samuel was born December 23rd, 1753.

Shortly after Mr. George Crompton's removal to the ancient house called Hall-in-the-Wood he died, leaving Samuel and his sister to the care of their mother, who continued the occupation of farming, and devoted her spare time to carding and weaving with such domestic machinery as then existed. The family had one of Hargreaves' jennies with eight spindles, upon which Samuel worked from the age of sixteen to twenty-one, when he commenced experimenting with the machine. After many failures, these experiments culminated in 1779 in a movable carriage on which his spindles were erected, and one pair of rollers through which the cotton sliver, or rove, was drawn. Later on, two pairs of wood rollers, covered with sheepskin, were used, having iron axles, with square ends, upon which pulleys were fixed of different sizes, so that one pair would go faster than the other, and thus draw out, or elongate, the sliver as the carriage and spindles receded, thus giving twist to the yarn. He finally put dents of brass reed wire into his under rollers, and thus obtained a fluted roller. The faller, as in Hargreaves' jenny, was fixed to the carriage, and now moved with it, so as to be worked by the left hand. In 1780, after bringing his machine to a practical and profitable state, Crompton married, after which he and his wife worked the spinning wheel, or *muslin wheel*, as it was sometimes called, in a cottage adjoining his mother's house, where he had taken up his abode.

By the help of this machine he could spin both finer and better yarn than his competitors, for which he obtained his own price, and thus worked on in secret. The demand for Crompton's fine yarns at length became so urgent, and the advantage he possessed over his competitors became so marked, public curiosity was aroused to such an extent, that the quiet spot of Hall-in-the-Wood was invaded, and all sorts of impertinent stratagems were employed to get at his secret. The annoyance to which he became subject at length was so intolerable, that concealment was no longer possible; and having no money to patent his invention, he yielded to the liberal, but treacherous, promises of neighbouring manufacturers to divulge his secret, on the assurance that they would get up a handsome subscription to reward him. All they got for him was £106!—some refusing to pay their guinea or half-guinea, for which they had put down their names, denouncing him as an impostor! Crompton's subsequent life was of a chequered description, notwithstanding that his invention turned out to be of so important a character, giving a vast impulse to the cotton trade and employment to hundreds of thousands of workpeople.

Fig. 201.

Application was at length made to Government on his behalf, and Parliament granted him a pitiful allowance of £5,000, which his friends expected would have been at least £50,000, considering the vast benefit he had conferred on the nation. His fellow-townsmen subscribed again for him in his latter days, and bought him an annuity of £63. He died on the 22nd June, 1827; and in thirty years afterwards a large bronze statue was erected to his memory in one of the public squares of Bolton.

Crompton's spinning wheel was only worked by hand for some years after he brought it out. It is believed that Mr. William Kelly, of Lanark Mills, in Scotland, first applied water power to turn the frame and draw out the carriage. This enabled one spinner, as he had only the carriages to put up, to spin upon two mules, right and left hand. This was about the year 1790, ten years after Crompton brought out his spinning wheel.

It is probable that the designation of "Mule" was after this given to it, as it was a combination of Hargreaves' hand-jenny improved and Arkwright's water frame. It differed from Hargreaves' jenny in this respect that, in the latter, the rove, or cotton, was stretched, not drawn; but in Crompton's, the roving passed through rollers, and was drawn out as fast as the carriage receded, and at the termination of the draw, or stretch (about 56 inches), the rollers were stopped and the carriage also, after which a second and slower motion was given to the carriage, stretching out the yarn a few inches more, during which time the spindles were revolving, and the yarn received its full modicum of twist. This was termed "the jacking motion," or "after-draft," and tended greatly to make the yarn more level and uniform; for whenever a thread is produced from fibrous materials, the twist always flies to the thinnest part, and any stretching of the yarn during the operation comes necessarily out of the thickest part, which is the softest. Thus the mule became adapted to spin finer numbers than was practicable on the water frame, because in the latter the yarn had to drag the bobbin round on which it was wound, whilst in the mule no bobbin was required; the yarn, being built on the naked spindle, and crossed so as to hold together when doffed, the term "cop" was given to it. Hence the mule is distinguished for fine and delicate yarns: it throws in the twist from the top of the spindles very gently, and preserves the elasticity of the thread as the carriage recedes from the rollers, accommodating any weak, cut, or damaged part; whereas in the throstle any such delicate part would have immediately to bear the strain of the drag.

In this place opportunity may be taken to mention a simple but important point in regard to mule spindles. Formerly mule spindles were made very light, in the hope of saving power, and they answered very well as long as slow speeds were run—about 4,000 revolutions per minute. But now that 6,000 or 7,000 revolutions per minute are demanded, it requires of course a much stronger spindle to resist the vibration caused by carrying the cop round so rapidly, especially when the spindle is full. The strengthening of the spindle alone has made it practicable to run upwards of 7,000 revolutions per minute, but an important mistake has thereby crept in, generally unobserved, leaving the spindle thicker at the top, as shown by *Fig.* 202. The effect of this is a greater vibration of the yarn as it is thrown off the end of the spindle than when made in the form represented by *Fig* 203.

Fig. 202.

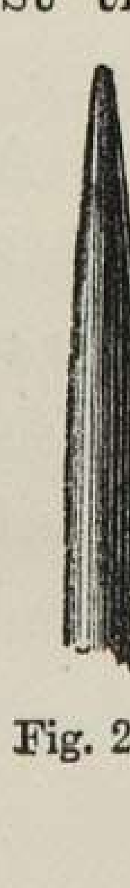


Fig. 203

It is proper, therefore, to have a strong spindle with a *fine* point to keep the thread steady whilst the twist is being thrown in. This matter is so important in mule spinning that a trial of it is urged upon all parties using mules, by having the spindles in a pair or two of their mules ground down to a fine point, as indicated above, when a marked difference will be observed both in the spinning and in the quality of the yarn produced, the latter being less woolly and consequently stronger.

Up to the year 1832 the largest mules did not exceed 30 dozen, or 336 spindles to each mule, the general size being about 24 dozen, or 288 spindles, and the cotton mills from 12 to 16 yards wide. This number of spindles to each mule was quite as many as was found practicable for a hand-mule spinner to spin upon one pair of them, generally right and left hand, as he had to put up the carriages and wind on the yarn by manual labour, the self-acting mule being then in its infancy and practically unknown.

The history of cotton manufacture in Lancashire, like that of the production of the cotton itself in South America, might be written in tears and in blood. This sad state of things arose, however, from very different causes. In America the growth of cotton fostered and perpetuated, if it did not originate, the great evil of negro slavery, and it required no effort of the imagination in an Englishman to associate cotton on its arrival in this country, beautiful and valuable as it appeared, with the story of the sufferings and the sorrows of the negro. But in Lancashire the evils associated with cotton manufacture were originated and perpetrated by the operatives themselves, and from mistaken views of the employment of machinery instead of hand labour. The introduction of nearly all those beautiful and elaborate self-acting machines for the various processes of the manufacture of cotton, the inventions of enterprising men in various grades of life, in many instances struggling with poverty and difficulties, but supported by the energy of their own minds, and cheered by the hope of success, have been signalised by the opposition, and, in many instances, by the violence of the operative classes of the community. Agitations were excited by misguided men; crusades against machinery were preached up by village orators; mobs were collected; mills were wrecked; and, in many instances, lives were lost. Those records will ever remain as indelible blots on the pages of the history of Lancashire. Even in later times *Trades Unions* were instituted for the assumption of power by the employed against the employer, and *Strikes*, as they have been called, for higher wages have often unnecessarily and unreasonably been perpetrated, and have produced the most unhappy consequences. In one of those disputes, in the year 1830, a Mr. Ashton, of Hyde, was shot by the riotous cotton operatives, and the lives of other masters were at the same time attempted. The working classes have ever been slow to learn that the proper price of labour must be regulated by the law of supply and demand, and that there is such an equilibrium of fair and just remuneration between employer and employed which, like water, cannot rise above its natural level except by force, and if that be resorted to, trade will lose its free and healthy action. Any attempt to force the price of labour above this level must end in commercial depression. When trade flourishes all reasonable demands for increase of wages have generally been granted by the employers; for it is only fair that the labourer should share in the prosperity of his master.

In connection with the period just noticed, and also with the subject of improvements in machinery, the writer may be permitted to refer to one of his earliest inventions in the machinery of cotton manufacture, and one which has become universally adopted and of acknowledged importance. Having heard, in the spring of 1832, that an unsuccessful attempt had been made in Scotland to couple mule machines together, he, after much deliberation, resolved to make the experiment in his father's mill. It is unnecessary to detail the opposition and the discouragement met with, or the gradual process by which the result was arrived at; suffice it to say, that in the course of three days two mule machines of 312 spindles each were successfully connected, and to the astonishment of the spinners worked admirably. The start, as arranged, took place just before the usual stopping hour. The water wheel continued to run: the mill hands came together to see the operation, and pronounced it a complete success. Many master spinners afterwards came from various parts of the country, and were soon convinced of the value of the improvement. An incident occurred which led the writer to devise an additional mechanical appliance in this connection. After a second pair of mules had been coupled, the spinner who worked both mules—two on the right hand and two on the left, containing altogether 1,298 spindles—complained of the heavy action of the machines. An effort was made to lighten the action by giving increased speed to the rim and more bevel to the slips, but this not proving satisfactory the "putting-up motion" was invented by the writer,—a simple contrivance by which the spinner could take as much of the moving power, by gentle friction, as he required for the purpose of bringing up the carriages, setting the slips level, and at the same time apply a portion thereof to wind up the yarn while the carriages were going in.

The following is a rough sketch of the author's Putting-up Motion, which has, with modifications, been found to answer every requirement, and completed the process of coupling hand-mule machines in cotton manufacture:—

Fig. 204 shows elevation of hand-mule headstock, looking from behind, in which A is the framing, B, the rim, having fast and loose driving pulleys at C. The loose pulley, C, originally an arm pulley, was supplanted by a box pulley that had its rim beveled off so as to fit into the rim of the fast pulley when pressed against it. A small diagonal shaft, D, having a friction pulley, E, was fixed in the position shown. This shaft worked in a footstep at the bottom, and rested on a swing lever at the top.

It geared by mitre wheels, F, at the bottom with a small horizontal shaft, at the other end of which was the band pulley G, round which was wound the mendoza band that drew out the carriage H. A weighted lever I was fixed in the position shown, one end supported by a stud at K, and the other by the catch L. The action was as follows:—when the spinner was ready to put up and pressed against his knee cushion the catch L was thrust back, allowing the weighted lever J to descend, and being connected with the swing lever at M caused the friction pulley E to press against the loose box pulley C. The moment it came in contact the diagonal shaft was put in motion

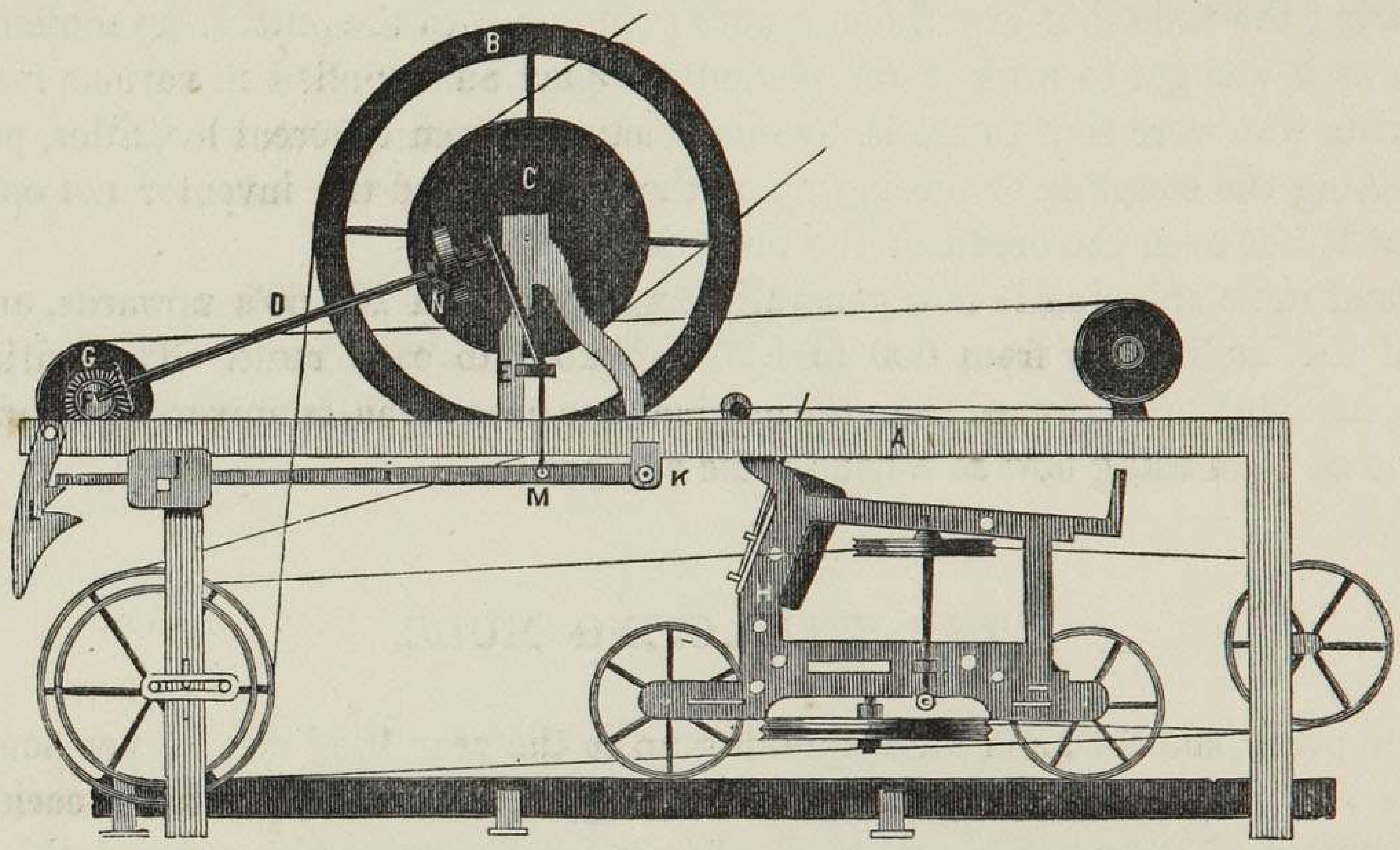


Fig. 204.—The *first* Putting-up Motion, by Evan Leigh.

and began to drag up the carriage, with greater or less force as the friction pulley was set farther from or nearer to the centre of the box pulley, which could be done easily, as the friction pulley was made to slide up or down the shaft, being only held by the set screw N. The degree of winding on was regulated by sliding the weight I^1 up or down the lever I, and as it was held by the same sort of set screw, the spinner could with a small nut key regulate the power he required, as the carriage was coming out, to the greatest nicety, either for winding on or drawing up the carriages. He could so set it as to command only the most gentle pressure, or cause the moving power to take up the whole of the drudgery of dragging up the carriages and winding on, leaving him only to hold back a little in following up.

It has been thought worth while to illustrate this *first* putting-up motion, because it was the beginning of a principle that wrought a speedy and complete revolution in hand-mule spinning. Formerly, instead of coupling, mules were, in some cases, pieced up and turned lengthwise in the mill; but after this time new mills were built of double and treble their former width. Instead of 300 spindles, mules were now built of from 600 to 1,200 spindles in each mule, and the price of spinning was reduced about one half. Singular as it may seem, the operatives also shared in the benefit, for they could earn more money upon the improved machinery with less physical toil; and those who were temporarily thrown out of work by the change were soon absorbed by the rapid extension of the cotton manufacture which took place about this time, partly from the cheapening of production, and partly from other causes.

Through the liberality of the proprietor visitors were constantly coming into the mill during the time that experiments were going on with the putting-up motion; and as soon as it was got to work it was instantly copied and applied in various forms by machinists who were sent to see it, by manufacturers from different localities, prior to undertaking the coupling or piecing up of their mules, and the inventor not only lost the benefit but even the credit of the invention.

Hand mule spinning is now generally employed from No. 60's upwards, and the sizes of the mules vary from 600 to 1,200 spindles to each mule. The putting-up motion, modified or improved from the original one here given, is universally employed. There is no such thing now as a hand mule without it.

THE SELF-ACTING MULE.

The price paid for hand mule spinning up to the year 1832 was 5*d.* per pound for No. 60's twist, on the largest mules then existing, of about 300 spindles in each mule. The invention of the "putting up motion" and coupling of mules reduced this price at once to 2¾*d.* per pound. The widening of mills and piecing up of mules subsequently reduced it still further, because a spinner was able to work three times the number of spindles; which was not only economical as far as his own labour was concerned, but he saved a considerable amount in piecers' wages also, because, whatever the size of his mules, he was obliged to have one big piecer, who could work the mules during his temporary absence, but in other respects was of no more value than a little piecer at half the price; therefore a spinner working on a pair of mules containing 1,800 spindles saved the difference between two big piecers and two little ones, which made about 20*s.* per week in that respect, besides saving the work of two spinners. This sweeping change in the price of hand mule spinning checked considerably the progress of the self-acting mule just then coming into prominent notice.

The exorbitant cost of the spinning process compared with the other departments of a cotton mill drew the attention of ingenious mechanics to the subject, together with the frequent disputes and turnouts continually occurring in England and Scotland. Several attempts had been made, first by Mr. William Kelly, of Lanark Mills, in

Scotland, in 1792, also by De Jong, of Warrington, and others in England, to solve the difficult problem of making this delicate and complex machine self-acting, none of which were practically successful, until Richard Roberts cut the Gordian knot and made the self-actor a *commercial* success.

Mr. Roberts was born in North Wales, on the 22nd of April, 1789, of humble parents. After working some time in Staffordshire as a pattern maker, he obtained work as a cabinet turner in Manchester, as a lathe and tool maker in Salford, and as iron turner in Messrs. Maudsley and Co's establishment, London. He afterwards returned to Manchester and commenced business on his own account as a lathe and

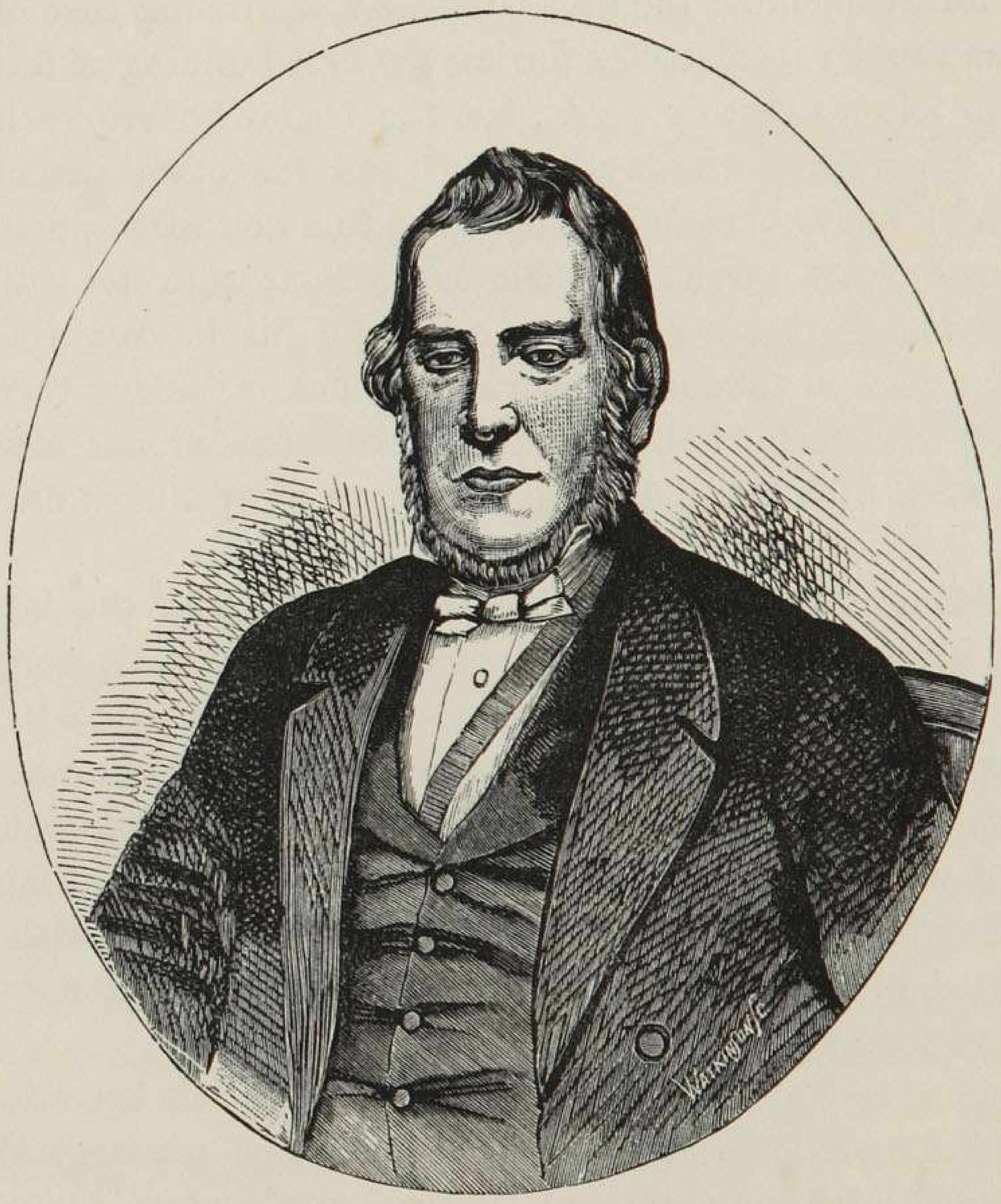


Fig. 205.– Portrait of Richard Roberts.—[*Engraved, by permission, from Messrs. Thos. Agnew & Sons' Engraving.*]

tool maker, cabinet turner, &c. He was in partnership with Mr. Thomas Sharp, from 1823 till 1843, when that gentleman died, after which he carried on business at the Globe Works under the title of Richard Roberts and Co. He was afterwards joined by Messrs. B. Fothergill and J. Dobinson until 1849. For three years after this he carried on the machine business again as Richard Roberts and Co., retiring from it in 1852; after which he went to London and practised as a consulting engineer until he died, in great poverty, a few years ago. Government subsequently allowed his daughter £300 per annum, but she did not live long to enjoy it.

Mr. Roberts was a man of versatile genius. He obtained about thirty English patents for as many different scientific inventions. Human life is too short for any man to work out successfully so many inventions; therefore they become burthensome rather than profitable to himself, and others reap the reward of his discoveries. Hence Mr. Roberts' ill success in life. He persevered, however, with his self-acting mule, and made money by it, especially after he brought out his beautiful "quadrant motion;" which is now adopted in all self-actors and universally allowed to be the best contrivance for overcoming the great difficulty of winding yarn on a bare spindle, which increases so rapidly in diameter during the first building of the cop.

Poor Roberts left no earthly goods, but the legacy he bequeathed to society in his unsurpassed "quadrant winding motion" and his other inventions have been productive of untold wealth, and fully entitle him to a well-earned niche in the Temple of Fame. He was a brave warrior, but his contentions were not with hostile armies dealing out death and destruction to each other, for his lot was differently cast, and his happier battles were in subduing natural laws and organising them for the use of mankind, in which warfare he fought manfully until he fell, not covered with glory, so called, nor crowned with laurel wreath, but borne away almost unrecognised to an humble grave.

The annexed figures show Roberts' self-acting mule, after the introduction of the quadrant motion, according to his patent, dated July 1st, 1830, from which time its success may be dated. For a full description see *Blue Book*, No. 5,949 Patent.

After the expiration of Roberts' patents the self-acting mule was brought to still greater perfection by successive detailed improvements by different machinists, the most successful of which were the patents taken out at different times by the firm of Messrs. Curtis, Parr, and Madeley, of Manchester, whose mule, with latest improvements, is illustrated in Plate XXXVII., for full description of which the reader is referred to their various specifications.

Other makers also may be mentioned as successful labourers in the same field, whose respective improvements will be noticed further on, amongst whom are Messrs. P. and J. Mc.Gregor, who have adapted Roberts' quadrant to Smith's mule. From this firm the author has just received the following interesting communication:—

"Falcon Works, Poland Street, Oldham Road,
"Manchester, May 10th, 1872.

"Evan Leigh, Esq.—Dear Sir,—

"We make two sorts of self-acting mules, viz., one on Smith's, of Deanston, principle, and one on Sharp and Roberts' principle, as modified by Parr and Curtis, with our own improvements. With regard to Smith's mule we perhaps know more about it than any other party in the country, seeing we were brought up under Mr. Smith, at Deanston, and have been makers of the mule, or employed as workmen in making it, from its commencement, in 1834,

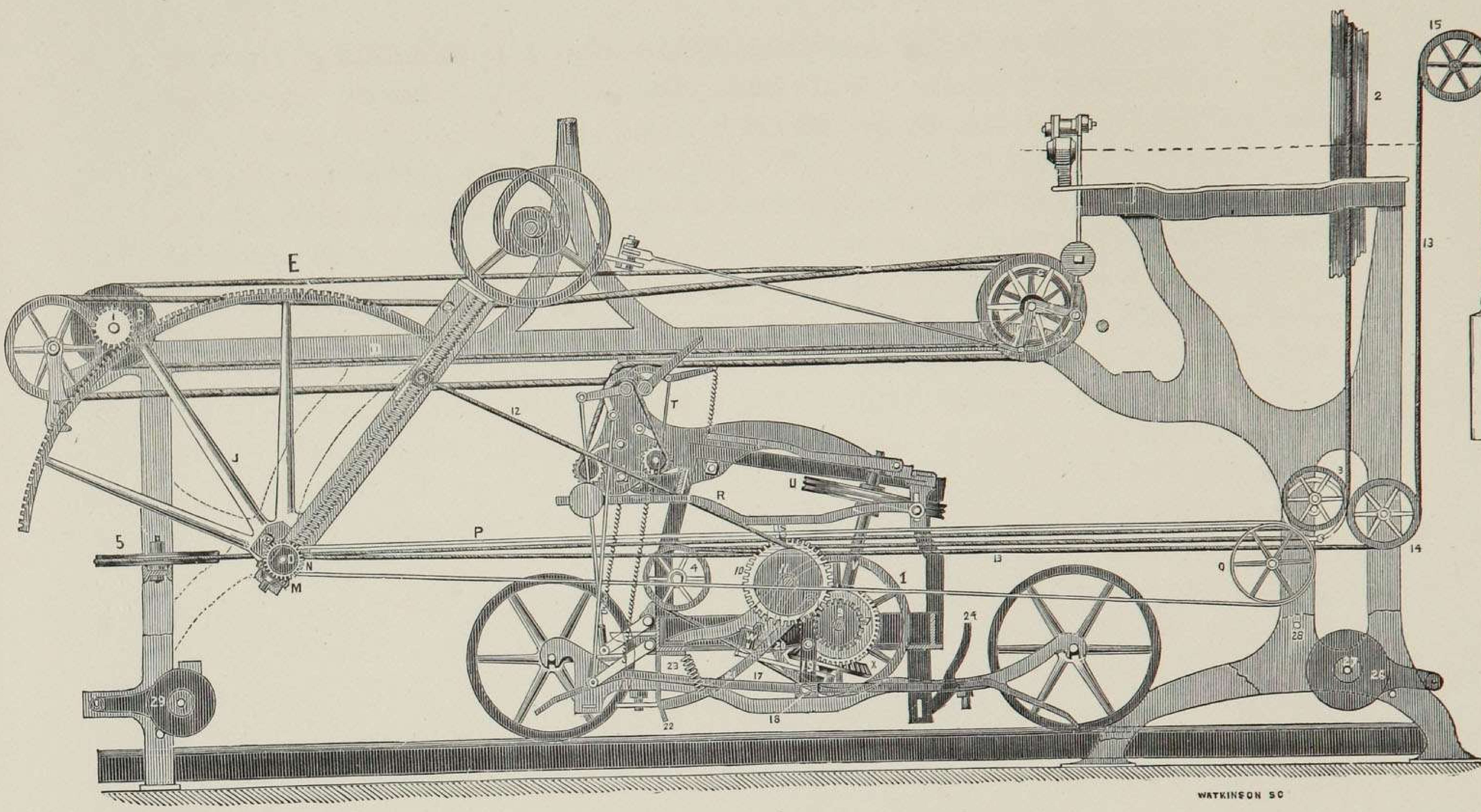


Fig. 206.—Roberts's Self-acting Mule (Side Elevation).

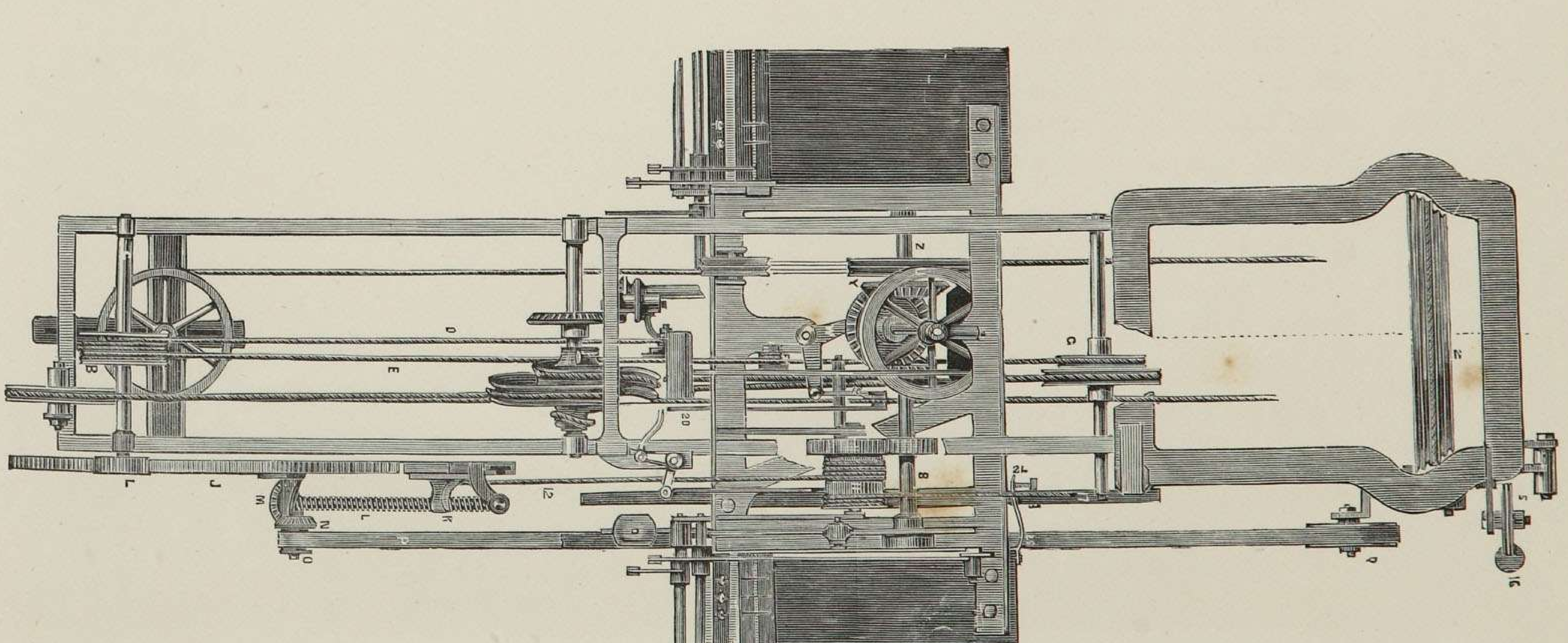


Fig. 207.—Roberts's Self-acting Mule (Plan).

PLATE, XXXVII.

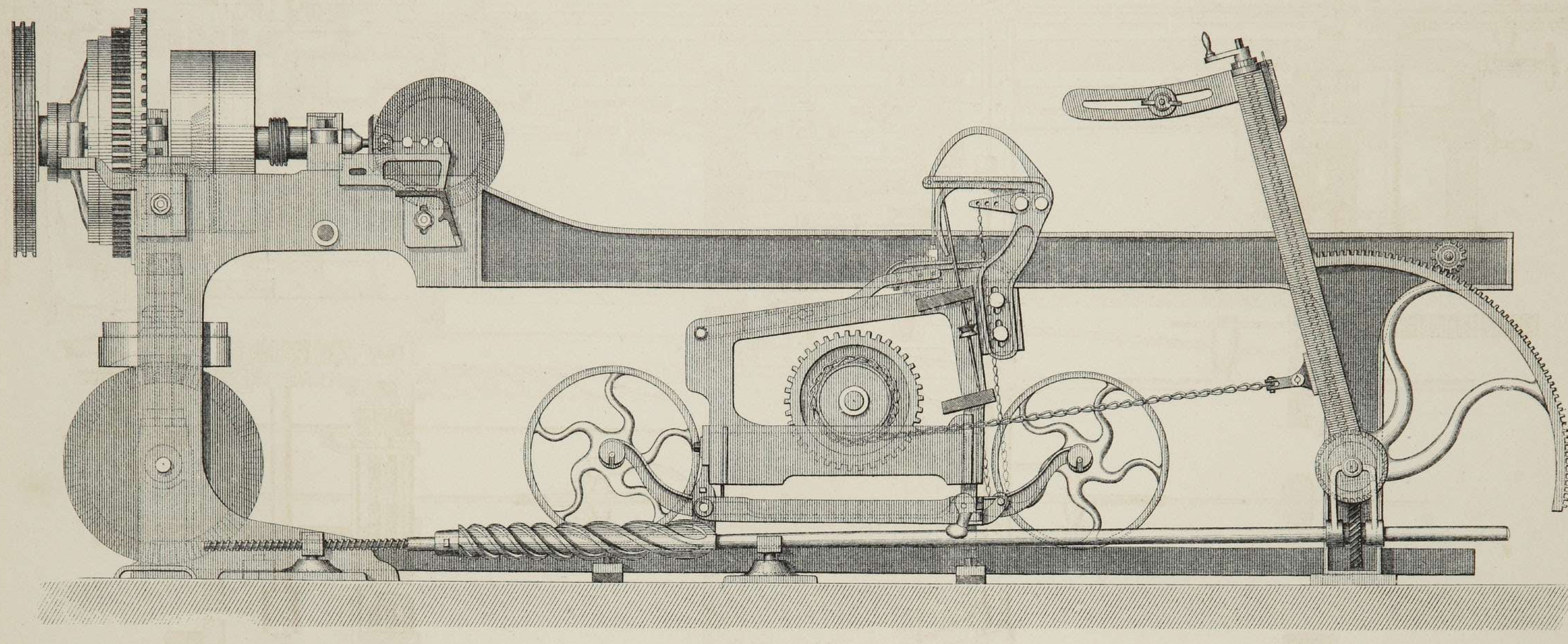
SELF-ACTING MULE,

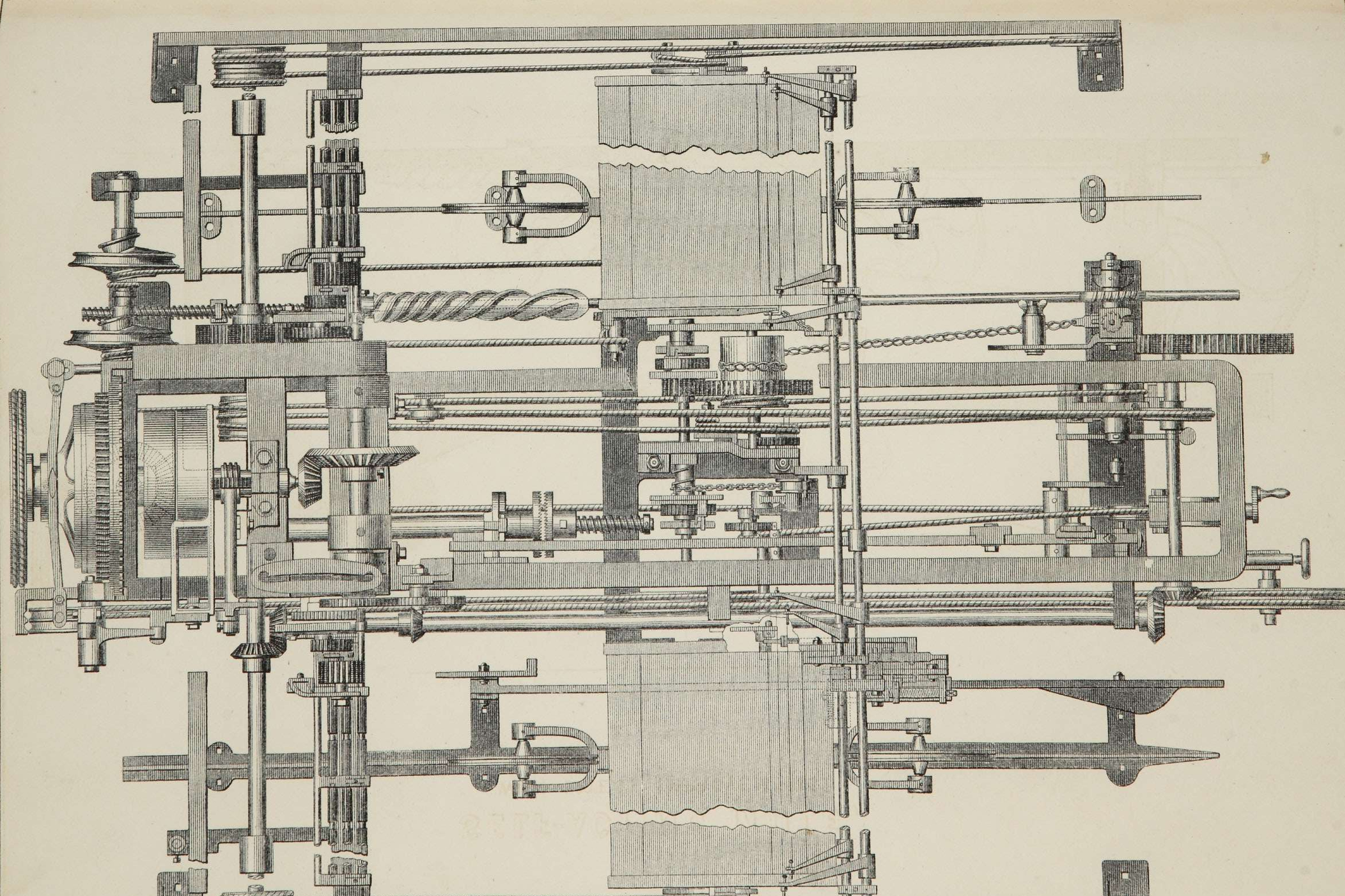
WITH LATEST IMPROVEMENTS.

AS MADE BY MESSRS PARR, CURTIS & Co

SCALE OF FEET.

0 1 2 3 4 5 6 7 8 0 1 2 3 Feet

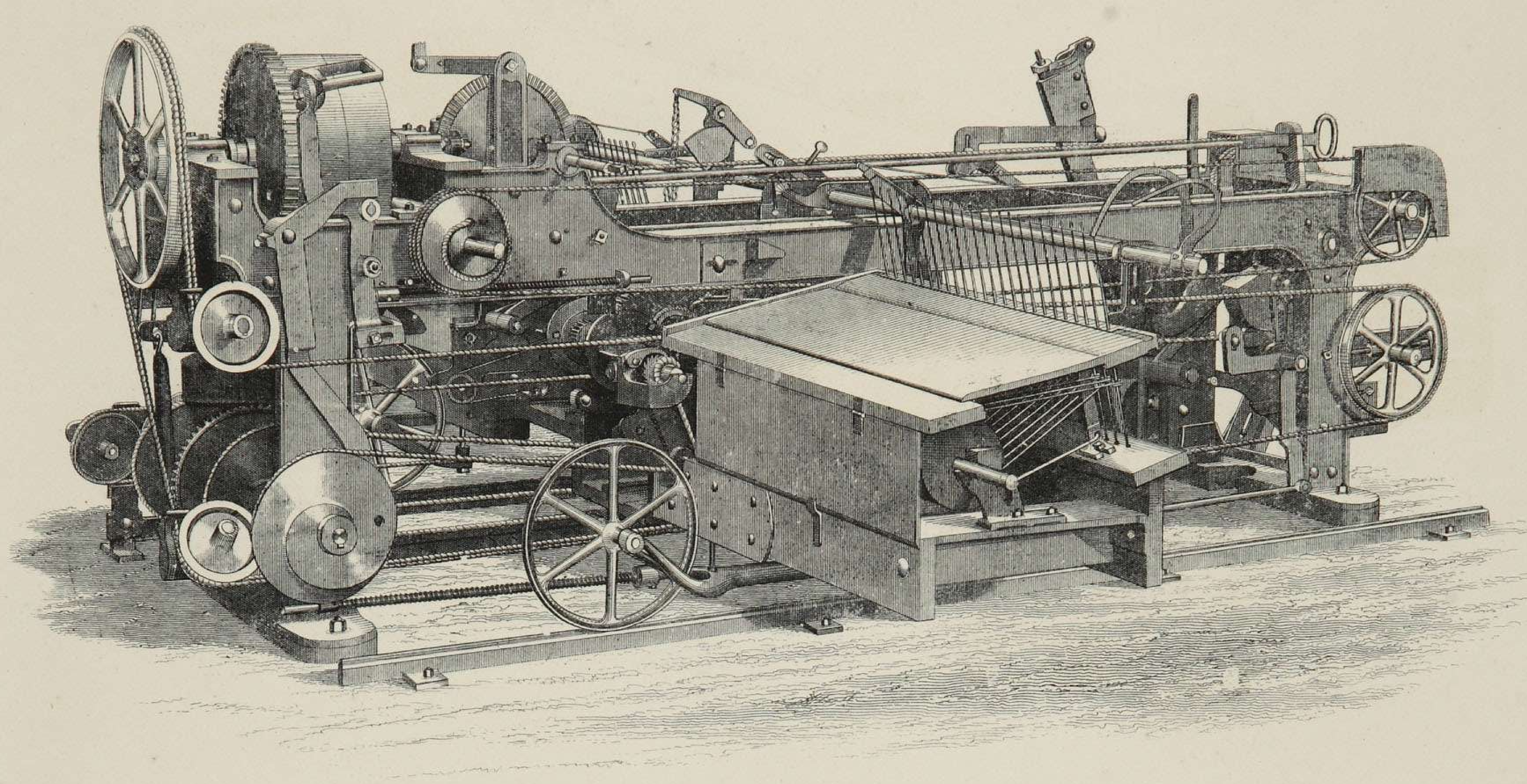


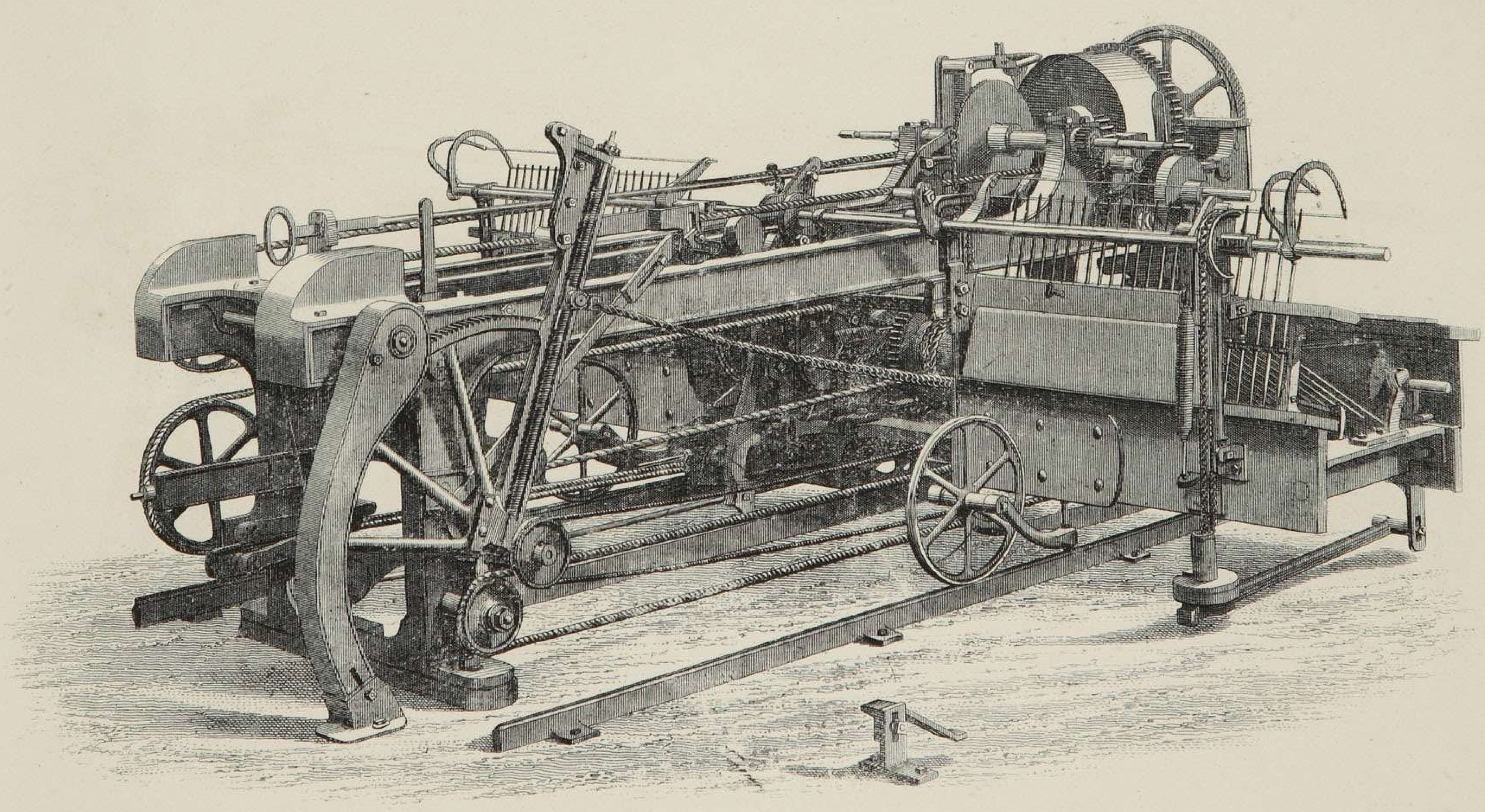


J. GALLOWAY, LITH. MANCHESTER.

SELF-ACTING MULE

AS MADE BY P & J. M^c GREGOR, MANCHESTER





J. GALLOWAY, LITH. MANCHESTER.

till now. This mule, from the simplicity of its movements, the carriage being moved in and out by the mangle wheel motion, thereby dispensing with bands for working the carriage, and the coils of yarn being thrown off the spindle by a stripping motion instead of backing off, (this latter part being the invention of the late John Robertson, of Crofthead, near Glasgow), made the mule headstock and carriage square very simple, and capable of running at high speed, and was well adapted for spinning wefts up to 40's or 50's, and twist up to 30's, or any yarns where all the twist could be put on whilst the carriage was coming out, or without twist at the head; and to this day no mule can produce the same quantity of yarn of the counts mentioned, and with so little wear and tear or expense, as Smith's mule, as made by us with all latest improvements.

"This mule had originally a friction winding on motion of great ingenuity, the invention of Mr. Smith, but Roberts' winding on was much superior to it, and on the expiry of Roberts' patent we adapted the latter to Smith's mule, and Smith's mule has always been made since then (by all the makers of the mule) with Roberts' winding on as applied by us.

"It is the only self-acting mule that has been able to maintain a position in the trade along with Roberts' mule; but the motions of the latter being more like the hand mule is better adapted for spinning a greater range of counts of yarn. The backing off motion being better adapted for fine yarns than a stripping motion to keep out snicks or snarls, and a twisting at the head motion, and a separate taking-in motion for the carriage (none of which had ever been applied successfully to Smith's mule) gave Roberts' mule a decided advantage over Smith's mule for counts above 30's twist or 50's weft. Hence the more general introduction of Roberts' mule into the trade. We have made mules on Roberts' principle to spin as fine as 160's, and to do it better than on the hand mule. Roberts' mule is essentially the same now (as made by all the principal machinists in Lancashire) as it was when it left the hands of Mr. Roberts. The out-taking and in-taking motions, backing off motion, winding on motion, motion for regulating the winding on from the counter faller are all Roberts' inventions, and all the innumerable patents taken out since Roberts' patents expired have not made any very material improvement in the above motions, which are the essential motions of a self-acting mule.

"The improvements we have introduced to the mule, and especially as applied to Roberts' mule, are, 1st, the regulating of the twist from the tin roller or drum shaft in the carriage. I refer you to my patent, No. 1,554, 23rd May, 1862, for a description of the principle. It is the only true way of regulating the twist of a mule, as in the event of the rim band slipping the twist in the yarn would still be correct, as the tin roller or drum shaft must make its correct revolution every draw. 2nd. The wear and tear of scroll bands for taking in the carriage has been a serious item of expense in Roberts' mule. Two scrolls with separate bands have been used for a long time to take in the carriage to remedy the above, and although it was impossible to get these two bands to act in perfect unison, as one band would almost be certain to do all the work, still if one band broke the other kept the mule going and prevented further accidents. We introduced a lever, as explained in my patent, 1,013, 23rd April, 1863, Fig. 6. To one end of a lever attached by a stud in the centre to the carriage square we attached one of the in-taking scroll bands, and to the other end of the same lever the other in-taking scroll band. By this simple arrangement both in-taking scroll bands act in perfect unison, and the scroll bands last very much longer.

"Our other improvement has reference to the winding on motion. Roberts' winding on motion was not, as left by him, completely self-acting from the beginning to the end of a cop. His plan for regulating the winding on at the beginning of a set of cops, on the bare spindle till the cone is formed, has not been materially improved since his day, as his "strapping motion," as it is called in the trade, (but with a band instead of a strap), is the simplest plan and just as efficient as any yet made for that purpose, and when properly set is completely self-acting. But as the mule spindle is made to taper, the point being less than one-half the diameter at the top of the spindle than it is just above the collar, it is evident that the winding on motion should be gradually increased in speed as the cop lengthens on the spindle, at the part where at the smallest point of the cone of the cop nose the yarn is wound on to the spindle, and that is when winding on the last few inches each draw, and before the mule carriage lights in at the beam. Roberts put a stud at the end of his radial arm, called in the trade the 'nose pin,' which, when the mule was just going into the beam, impinged on the winding on chain just as the mule carriage was going into the beam, and thereby gave the necessary increased motion to the winding on at that point. This stud or 'nose pin' required to be adjusted by the winder or piecer as the cops filled up, and was often neglected; and when such was the case the winding on would be slack, make soft cop noses, and otherwise make bad work. This was the only part of the self-acting mule that had to be regulated by hand, and I have made it now completely self-acting. The principle of the plan as now applied is explained in the last patent mentioned, Fig. 9, and when properly set we can begin and finish a set of cops without the slightest assistance of the minder or piecer. The principle of the application may be explained in a few words, viz.: I attach the nose pin to a lever on the top end of the radial arm. This lever is connected by a rod to a stud on a lever attached to the framing of the headstock. The amount of impingement on the winding on chain depends on the position of the stud in the lever attached to the framing, and the position of this stud is shifted by the builder as it drops to lengthen the cop. This regulating from, or by, the dropping of the builder is the essence of the invention, as without that it could not be completely self-acting. You will see from the accompanying photographs this motion is now used by us, and which acts perfectly, and which has made the self-actor completely self-acting.

"We have introduced a number of other smaller improvements into the self-acting mule, but nothing worth special attention in a work such as yours. "Yours truly,

"PETER Mc.GREGOR,
"P. & J. Mc.GREGOR."

SMITH'S SELF-ACTING MULE.

At page 110 Mr. Smith's mule was honourably mentioned as an invention which had lasting properties. However opinions may differ as to the true value of the principles upon which Smith's mule is constructed, it has, at any rate, the merit of simplicity, and nobody can question the saving of time and power effected by stripping the spindles by the upheaving of the under-faller instead of backing off; but this is only applicable, practically, to low numbers, and for all counts under 30's it is undoubtedly an excellent mule, both for quantity and economy of production, when made with Roberts's winding motion. The woodcuts, *Figs.* 208, 209, showing side elevation and plan, will give the reader an idea of its construction and appearance. All other mules have practically succumbed to Roberts's and Smith's, the former being made almost exclusively, except as above stated.

Plate XXXVIII. shows right and left side elevation of Roberts's mule by Mc.Gregor. There are now many excellent makers of self-acting mules upon Roberts's principle; the selections made are done impartially, and given as a fair specimen of the whole. They differ only in small details one from another.

Self-acting mules for fine spinning require something more than those for low and medium counts, in consequence of the longer after-draught, more turns at the head, and delicate nature of the thread. Messrs. Dobson & Barlow, of Bolton, appear to have given greater attention to the latter than other makers.

THE TRIANGULAR MULE.

In the year 1845 some interesting experiments were tried at the works of the old and respectable firm of Messrs. William Higgins & Sons (late Cocker & Higgins), of Salford, on a spinning machine of strikingly novel construction.

A patent was taken out, No. 10,584, in the names of James Higgins and Thomas Schofield Whitworth, in which were claimed "two sets of drawing rollers, delivering to spindles set back to back, and rollers to traverse to or from the spindles or the spindles to or from the rollers, in segments of a circle, or in oblique or vertical direction." This was followed in 1849 by another patent in the same names, No. 12,755, in

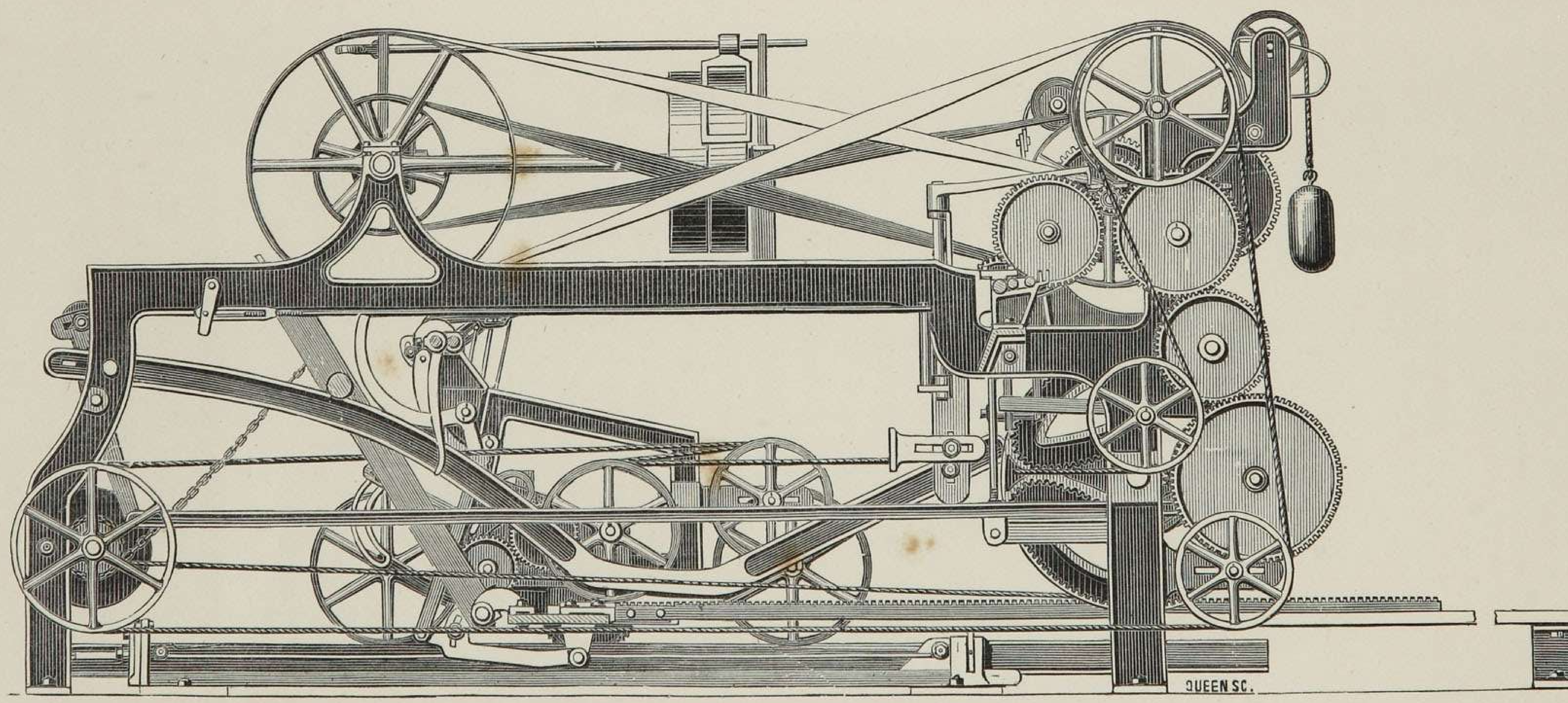


Fig. 208.—Improved Smith's Self-acting Mule (Side Elevation).

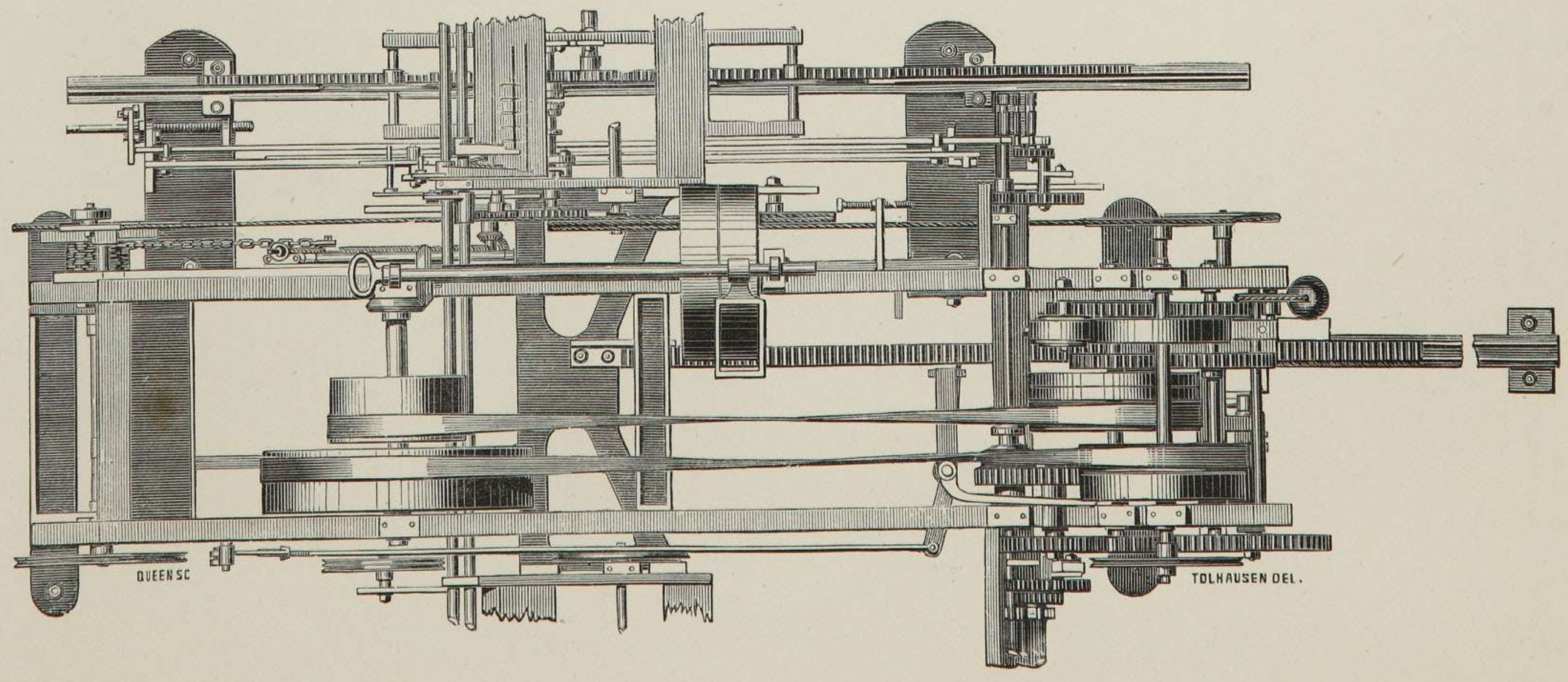


Fig. 209.—Improved Smith's Self-acting Mule (Plan).

which the claims were "a double self-acting mule in which the roller beams and spindle rails counterbalance, approach, and recede from each other, the spindles moving in the segment of a circle." In 1852 a further patent appeared, by the same parties, No. 14,203, in which the principal claim was for "the roller beams moving in a vertical direction, and carriages to traverse at a right angle thereto." All these various patents show the earnestness with which the Messrs. Higgins pursued this

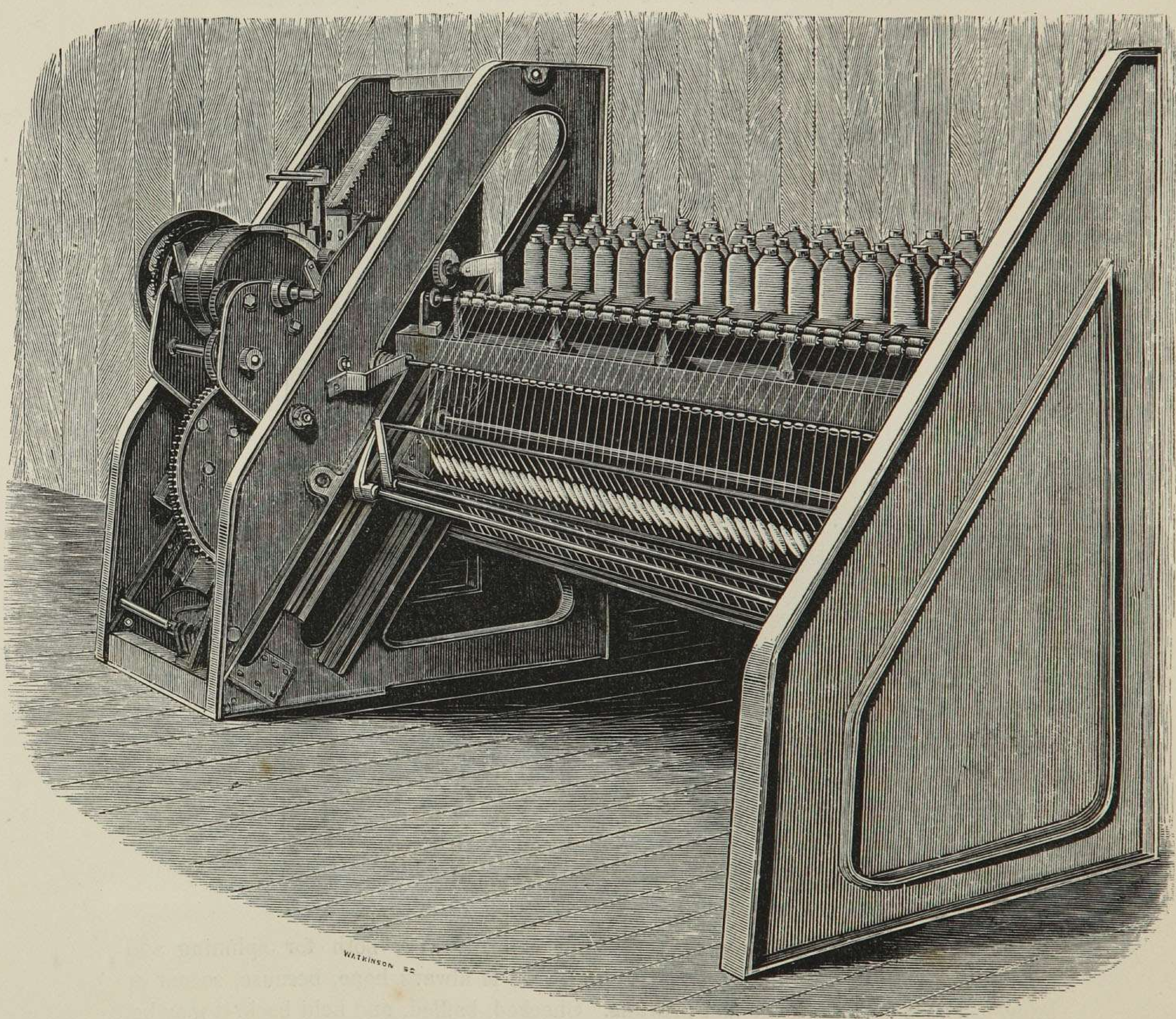


Fig. 210.—Rhodes' Triangular Mule (Bird's-eye View).

important invention, that undoubtedly had its origin at their works in 1845; but notwithstanding their protracted efforts, they do not appear to have been sufficiently satisfied with the result, as they never brought it publicly foward or recommended it to their customers.

The principle involved in this machine was worth contending for, and it is to be regretted that Messrs. Higgins did not succeed in bringing it to a practical result, because it is highly probable from what has been done by another machinist that the

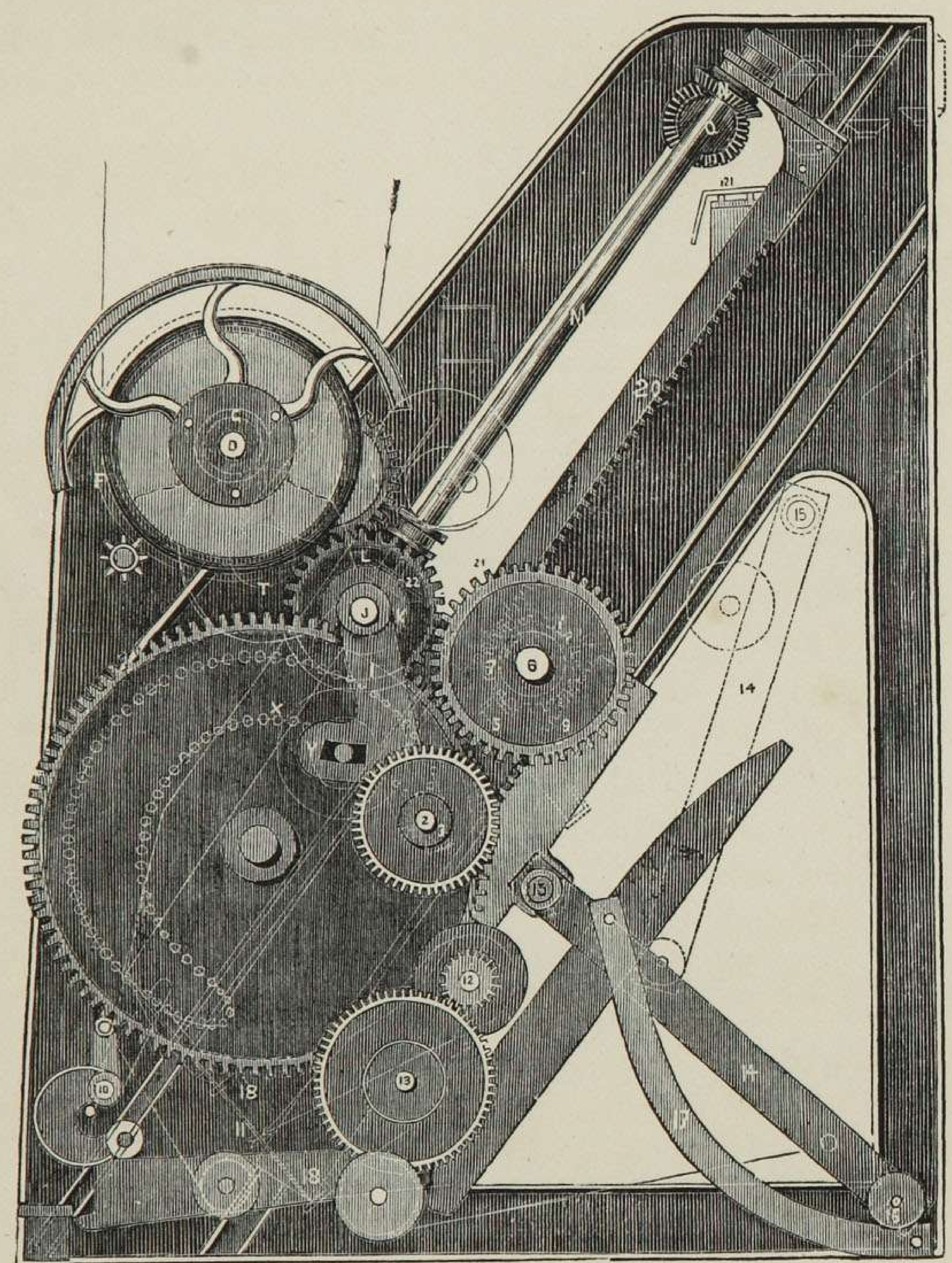


Fig. 211.—Rhodes' Mule (Side Elevation).

Triangular Mule may ultimately come into extensive use both for spinning and doubling. Where mechanical truth exists there is always hope, because, sooner or later, it comes to the surface and prevails. Checked, baffled, and held back, it may be, by untoward circumstances,—prejudice and difficulties may impede its way,—but in the end all these impediments are surmounted, and it rides on triumphantly over them.

Pursuing the history of this singular looking and very ingenious machine;—it made its next appearance at Chemnitz, in Saxony. An experienced English mechanic, named Rhodes, the same person who, together with Mr. Lakin, when in the employ of Messrs. Parr, Curtis, and Madeley, patented some important improvements in the construction of Roberts's mule. Rhodes subsequently emigrated to Saxony. No doubt this practical mechanic had been favourably impressed with the principle of the machine Messrs. Higgins had so long been contending for; and after mentally working it out in his own way, he persuaded a merchant of the name of Zwanziger to join him in taking out a patent for it. Thoroughly understanding Roberts's principle, he applied it to this form of mule in a simple and practical manner, and an experimental machine of 96 spindles was built. To his great surprise, however, although the copping and other motions acted perfectly, the ends could not be kept up properly, which was most discouraging, and the whole thing was near being given up in despair. It is highly probable that Messrs. Higgins had been baffled in the same way, and gave it up in consequence. On minutely examining the cause of the bad spinning, Rhodes found that it arose from the diagonal position of the thread causing great vibration at the top of the spindle, which increased with its weight as the distance augmented between the spindles and the rollers by receding one from the other. This defect was so serious that it seemed to strike at the very root and principle of the machine. A very simple remedy was tried, almost without hope, but it proved eminently

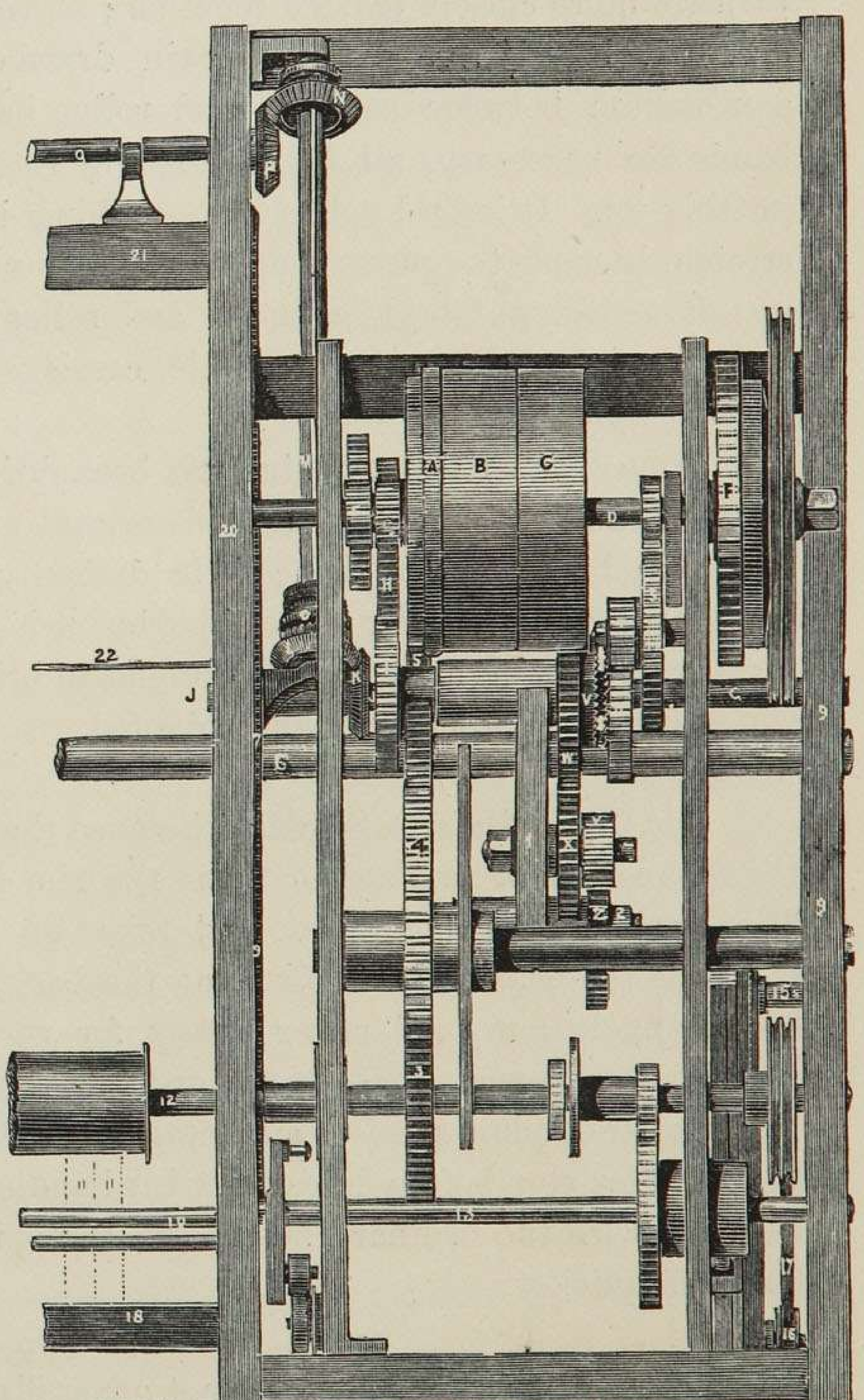


Fig. 212.—Rhodes' Mule (Front Elevation).

successful; for after its application the mule of 96 spindles spun for 45 minutes without breaking a thread! This remedy was merely a wire stretched across the mule to support the ends half-way between the spindles and the roller beam. The length of stretch being 50 inches, the support is only 25 inches from the top of the spindles, and the like distance from the rollers when the carriage is out. In the engravings, *Figs.* 210, 211, and 212, representing bird's-eye view, side and front elevation, of Rhodes's machine, it will be seen that both carriage and rollers move on the same inclined plane.

The advantages claimed for this machine over the ordinary mule are:—firstly, a saving of about one-half the room; secondly, from the shorter stretch the fibres of the yarn are more closely twisted together; thirdly, it can be minded by cheaper labour; fourthly, it requires less power in drawing out and putting up from the exact equilibrium between carriage and roller beam; and, fifthly, no scroll or squaring bands are necessary, all being done by rack and pinion, both in drawing out and putting up. It is said not to lose anything in quantity from the comparatively short stretch, because the putting up is effected more rapidly by the converging together, simultaneously, of both carriage and roller beam, each having to traverse only 25 inches, whilst the ordinary mule carriage has to go about 64 inches at every putting up.

From Saxony this machine was brought to Oldham, where the writer saw it and watched its operations for half-an-hour, but no thread was broken during that time.

It is believed that some little difficulty about the patent prevented the thing being pushed forward for some time, but it is now in the hands of a first-class machine-making firm in Manchester, who intend to bring it out shortly for doubling yarns, for which it is said to be admirably adapted.

Box Organ Mules.—So called because the rim shaft is fixed upon the carriage, and the spinner when putting up turns the rim handle after the manner of a box organ. This arrangement looks neat, and takes up less room than the ordinary mule head-stock, as the gearing is all fixed at the back, near the creels. This kind of mule is seldom made now, and never except for very fine yarns. It never was capable of producing as much work as the ordinary kind of hand mule, because the physical power of the spinner is less advantageously employed, and he is obliged to wait until the spindles stop before he can put his handle in gear for backing off and winding on; whereas, with the ordinary headstock, the spinner can catch hold of his handle and back off quicker.

Double Speeds are often, but not generally, used. The meaning of this term is an extra speed given to the spindles after the carriage is drawn out, and it is, no doubt, beneficial on the whole when properly applied. Like many other things about cotton spinning its merits are disputed. It is sometimes employed in spinning No. 60's as soon as the carriage has got about a foot out from the rollers, when the double speed comes on, and, as a matter of course, produces a larger amount of yarn in a given time. This is not advisable where the yarn is tender and subject to breakage. Double speed is more generally put on at the head, but is only applicable for fine counts where there are many turns at the head.

Letting-off Motion.—This is used with advantage in the finer description of yarns; also in wefts of all numbers; and consists in turning the rollers a little during the putting up of the carriage, so as to give out about three inches, a superabundance of twist having been given at the head, which is immediately absorbed. This is equal to a longer stretch, and adds about five or six per cent to productiveness when properly applied. It can only be said to be fairly applicable to weft yarns, as the harder kind of warp yarns would twist down and break too much at the head if applied to them, unless applied in a smaller degree, when it improves the spinning a little by causing fewer threads to break during the putting up of the carriage, as the strain is not always thrown on the nip of the rollers at the same point.

Mr. Lockwood, of Lewiston, State of Maine, an extensive manufacturer of great experience and reputation, states, in reference to the letting-off motion, that he introduced it into one of his mills when his mules were inadequate to supply the looms by about six per cent, and by this simple application he not only gained so much extra in production, but improved the quality of the yarn thereby at the same time, so that the looms again demanded more yarn from better weaving.

Iron Carriages have been much thought of and speculated in, but no construction of that kind has hitherto been practically introduced. What is wanted, in a mule carriage, is rigidity combined with lightness; and in the present state of mechanism, nothing exceeds good dry deal timber,—clumsy it may be, and inconvenient for export, but that inconvenience must be endured. Deal boards of $1\frac{1}{4}$ inch in thickness are quite strong enough for the framework of carriages, when properly put together. Anything stronger adds unnecessary weight, and acquires a great momentum in putting up quickly, the checking of which throws a great strain upon the bands and gearing, with loss of power, and wear and tear.

Drum Bands are not much used now except in hand mules for fine spinning, having been in a great measure supplanted by a tin roller of about 5 inches diameter running the whole length of the mule; still there are some spinners who prefer them to the latter. Where they are used, however, it is better to run them open than crossed, as, in the crossed bands, every alternate drum must have crossed spindle bands, which not only cause much waste when a band breaks from its getting entangled with the others, but the twist is not so regular as when they are all open.

Twist.—Montgomery, in his work on Cotton Spinning, published about forty years ago, gives the following

RULE.—Multiply the square root of any given numbers of yarn by $3\frac{3}{4}$, if for twist or warp yarns; and if for weft by $3\frac{1}{4}$: thus, if the number be 36's twist—

	6 the square root.	Wefts	6
Multiply by	$3\frac{3}{4}$	Multiply by	$3\frac{1}{4}$
	$22\frac{1}{2}$ turns per inch.		$19\frac{1}{2}$ turns per inch.

And so on for any number. As a fundamental principle, this rule is correct; circumstances, however, alter cases, and, with the great variety of cottons now used, the intelligent spinner will be guided by discretion. This rule or principle, however, is safe to rely upon, in changing from one number to another, to avoid waste.

There are certain hard-twisted yarns, commonly called Wig Yarn, spun upon throstles for the Turkish market, and also "Mock Water Twist," spun upon mules, which must be excepted from the above rule. In these, as much twist as can be got in is required, so as to give the yarn curl and elasticity.

Tin Rollers.—Although we consider these preferable on the whole to drum bands, especially for coarse numbers, still there is the formidable objection of being obliged to drive the spindles from them by half-cross bands, as in a throstle, which is a loss of power, from the bands rubbing against the edge of the wharves. Now, the bottom of the wharves being of smaller diameter than the flanges, the latter are driven through more space than the rate at which the spindle-band is travelling; hence there is a rubbing where they touch, which not only wears the band but causes a loss of power. Smaller tin rollers are necessary to obviate this, as the bands come on the spindle at a less angle thereby; but there are insuperable objections to the tin rollers being very small in diameter, as in that case a very high speed of spindle cannot be got up without a small diameter of spindle wharve, which does not answer, as it requires tight bands, which are apt to slip in a very great speed in the tin rollers, and are also otherwise objectionable. Tin rollers have again a little advantage in the facility of putting on a new spindle band when one breaks, as a sharp piecer can do it without stopping the mule; but a band will last longer when driven from an upright drum, simply because the drum being of larger diameter admits of the spindle wharve being larger also, therefore the band runs through *more space*, will consequently work slacker, and take less power. It has also the advantage of coming direct upon the bottom of the wharve. But then, again, drum bands are very undesirable, because they are apt to get slack, come off, and occasionally break.

To retain the advantages of the upright drum, and avoid the disagreeable drum band, drums are now frequently driven by gear. In this case there is the rattling of the bevel wheels and the oiling of the shaft to contend against; but when neatly applied, it is much better than drum bands. It is thought this might be improved, and a noiseless way of driving drums attained by right angle ox-tooth wheels. This has never yet been tried, but, mechanically speaking, it is very likely to answer the purpose, and would run quite smooth and noiseless.

Remarks.—Having now given the advantages and disadvantages of each system, the intelligent spinner will select that mode of driving best suited to his case. If he be a fine spinner, the vertical drum may be best suited to his purpose. If a coarse spinner, the tin roller will enable him to get off a little more work, with all its defects. Tin rollers ought to be placed at as great a distance from the spindles as practicable, and to have good long bearings, barreled a little to retain the oil, and projecting inside the drum. A smaller diameter of tin roller, say about four inches, having steel gudgeons well polished and slightly barreled would be a saving of bands, as it might be set a little further back, and the angle of the band would be less acute. A more perfect system of driving mule spindles is much to be desired. Skew bevels have been tried, like a roving frame, also skew frictional wheels, but these methods have been abandoned again on account of the great speed and wear and tear.

YARN DOUBLING.

THE doubling of cotton yarn is carried on to a great extent, as doubled yarn is used for a variety of purposes, such as thread, hosiery, fancy goods, &c.

As yarns are sometimes doubled two, three, four, or more folds, and again redoubled into four, six, or nine cord, from a large range of numbers variously twisted in the single state before doubling, an exact knowledge of the way to proceed in giving the proper quantity of twist at each change from one number to another, and from one sort of yarn to another, is very essential. The writer is not aware that any law or rule has hitherto been laid down to govern these changes, but certain it is that a large amount of work is daily spoiled in guessing at the proper twist, even by experienced managers of doubling mills, when circumstances require them to make changes which they have not been accustomed to.

It requires no profound knowledge of arithmetic to make any of these varied changes from one extreme to another without spoiling an inch of yarn, but simply a familiarity in extracting the *square root* of any given number. As every manager may not be familiar with this, it may be necessary to mention that the square root of any given number is that figure which multiplied by itself gives the number of the yarn of which the square root is sought. Example: Suppose the yarn be 36's of which the square root is sought, then 6 is the square root, because $6 \times 6 = 36$. If the yarn be 120's, then 10·96 is the square root, because $10{\cdot}96 \times 10{\cdot}96 = 120$; and so on, 11 being the square root of 122's yarn, 12 of 144's, 12½ of 150's, &c. Every manager of a doubling mill should not only have a knowledge of extracting the square root, but he should have an *expert* knowledge of doing it, because, as will shortly be shown, it is the mainspring of success in managing all doubling operations. Example: Suppose the single yarn to be doubled is 120's twist, and it is required to be doubled twice over for thread purposes, the first doubling to be two-fold, and the next three-fold; the first doubling would reduce the thread to No. 60's, the square root of which is 7·76:

	7·76
which being multiplied by	3·75
	3880
	5432
	2328
	29·1000

This gives (say) 29 twists to the inch for the first doubling *in the opposite direction.* The next doubling being threefold, would reduce the numbers to 20's, the square root of which is 4·50 × $3\frac{6}{8}$ = 17 nearly, which must be the number of turns given to it, *again in the opposite direction*, or the same way that the single yarn was twisted.

If the single yarn be 120's soft weft, and the doubled yarn be wanted for warps, or to be used up in fancy goods of soft texture, then the square root of the doubled number must be multiplied by $3\frac{1}{4}$, instead of $3\frac{6}{8}$, to ascertain the amount of twist that will make the doubled yarn *lie straight*, or produce what may be termed the *latent* state. Add to this a given percentage in all cases, to produce the amount of curl required.

Sometimes single yarns are doubled many folds at one doubling, for hosiery or other purposes, being first wound three or four fold upon bobbins, and two of these doubled together. Suppose the single yarn to be No. 32's soft weft, and it is required to be doubled eight-fold; this would reduce the numbers to 4's, the square root of which is 2, which, multiplied by $3\frac{1}{4}$, gives $6\frac{1}{2}$ turns to the inch as the proper twist, *to make the doubled yarn lie straight.* If more or less than this be given, the yarn will have a tendency to curl. About twenty per cent more is generally given, as a tendency to curl is preferred, and with it the yarn is stronger, except in hosiery and other fancy yarns, which must be altogether excepted from the above rule.

In this manner all numbers, from the highest to the lowest, may be accurately doubled, without making waste.

THE TWINER.

The difference between yarn doubled by the twiner is about the same as yarn spun upon the mule to that of the throstle,—it is softer, and of more woolly texture. It is not adapted for thread or lace purposes, but for selvages and warps for certain kinds of goods, and bundled yarns for export. The twiner resembles a mule in which the carriage containing the spindles is stationary and fixed on the floor the reverse way of a mule carriage, but set in the same place as the roller beam and creels of the latter. It is furnished with another light carriage, which runs in and out on elevated slips. This latter carriage carries a step rail and a small creel. The step rail carries the cops to be doubled, in a vertical direction, upon steel skewers, from which the weft is drawn endwise until the yarn gets near the bottom, when, in order to save waste, the skewers are removed to the light creel, in which they have a rotary motion. In the meantime fresh cops are set in the fixed position, ready to piece up as the others come off. The yarn is drawn from the cops as the light carriage comes out, and it first passes over a board covered with flannel, and then through water in a zinc trough, or, in lieu thereof, under a wet flannel laid upon the other, which lays the ooze or standing-out fibres. After this it passes under small lead weights covered with flannel, and then through the "slide" or clasp. In the meantime two ends have been doubled together, and being pieced up to the doubled end from the spindles of the stationary carriage, receive twist after passing under the small lead weights. As soon as the light carriage has been drawn out to the full extent, the strap which actuates the machine is thrown upon the loose pulley, the operative seizes the rim handle, puts down the slide which locks the yarn fast, then takes hold of another handle that actuates the faller with his left hand, and winds the yarn upon the spindles of the stationary carriage as he pushes up the light creel carriage. This is the operation with hand twiners, but they are now nearly all made self-acting by somewhat similar mechanism to the mule.

The Twiner has its useful properties and its defects. Amongst the former may be mentioned that it takes much less power than the throstle doubler; and the doubled yarn being wound upon a bare spindle in the form of a large cop no bobbins are required; and it can be packed in skips for the home market without reeling; or it may be reeled for export without wear and tear of bobbins. To set against these advantages, its value is much less than the same yarn doubled upon the throstle doubler, because from being more woolly it is not so strong as the latter, and by no means adapted to thread purposes. It is also more liable to have weak places, arising from the snicks and snarls more or less found in the weft not having the same chance of being straightened out, because the motions of the twiner are intermittent, whilst those of the throstle doubler are continuous. In all doubling operations a gentle strain should be put upon the single yarn when the two threads are coming together; and there is a much better chance of doing this effectually in the continuous motion of the throstle doubler than in the intermittent motion of the twiner. If this is not done properly, not only are the snarls and twitters taken in without being stretched out, which leaves a weak place, but the doubled yarn is apt to be *corkscrewed*, which arises from one thread going in slacker than the other. Corkscrew may be produced from one thread of the weft being thicker than the other; likewise from a cop twisted weftwise being doubled with another that has been spun twistwise.

The production of the twiner, per spindle, is about double that of the mule, working the same number of hours per week.

Mules are sometimes converted into twiners by taking away the rollers and using the lead weights in place thereof, and placing a twiner creel at the back for fine yarns, or winding the yarn two-fold upon bobbins for coarser yarns.

THE THROSTLE DOUBLER.

This is a machine exactly like a throstle spinning frame, only that instead of drawing rollers a single pair of rollers of larger diameter are used in place thereof. These rollers are covered with brass for wet doubling, and the yarn is passed through a zinc trough filled with water, and then through the rollers to the spindle and bobbin, receiving its twist in the opposite direction immediately on passing the rollers. The legs of the flyers are drilled upwards and have each a brass wire curl soldered in the holes, which can be changed when the curls are worn out.

THE RING AND TRAVELLER DOUBLER.

The ring spinning frame has already been fully illustrated and explained, therefore it is only necessary to say that the rest of the machine is precisely like the throstle doubler, likewise explained.

The success of this machine in doubling cotton yarns has been so marked that it is making rapid progress, especially for dry doubling. Wet or moist doubling may likewise be done upon this frame for warp purposes, and as a first doubler for thread or lace; but it is better to use the flyer frame for the second doubling for lace, thread, or gased yarns, as the fibres can be more closely laid by the latter frame. It has been shown that rings of any size can be made and travellers of any weight used, so that it becomes a convenient frame for regulating the drag when three, four, or more folds are wound upon a bobbin by a winding machine with stopping motions.

GASING AND POLISHING.

Gasing is a process by which doubled yarns are singed in winding from one bobbin to another, when the thread passes through a small jet of gas.

In this operation it is of the utmost importance for good and regular work that the frame be worked at a uniform speed, otherwise threads may be burned in some places and not sufficiently singed in others. By an ingenious arrangement the gas flame for every thread is pushed aside when a thread breaks or a bobbin is run off, and comes on again when the running is recommenced.

Polishing is a process by which doubled yarns, or even single yarns of good quality, are thoroughly stretched out and somewhat elongated by a machine, shown in *Fig.* 213, and at the same time a size composed of bees-wax and other ingredients is applied. The yarn is first reeled in hank and put upon two small cylinders, in front, which are gradually forced asunder while the thread is being polished; and when it comes out it has a beautiful silky gloss, and at the same time gains in weight and length.

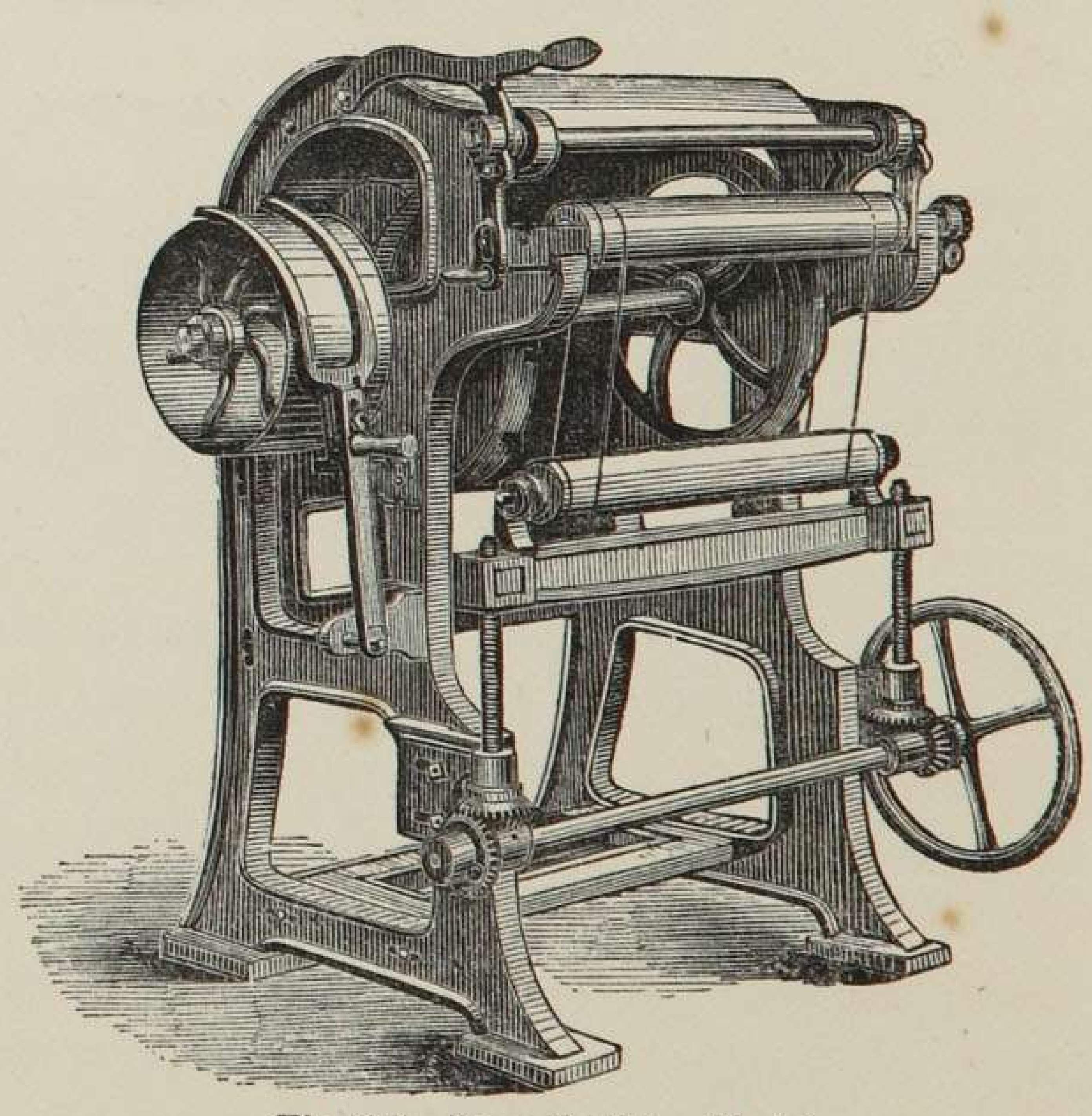


Fig. 213.—Yarn Polishing Machine.

SPOOLING.

Doubled yarns, if for sewing purposes, after being gased and polished are wound from the hank upon large bobbins and taken to the spooling machine. (*Fig.* 214.)

This interesting machine, the invention of Mr. William Wield, of Manchester, is almost entirely automatic. The small spools being placed in readiness, the machine takes them in upon horizontal spindles, fills them each with an exact length of thread, when it stops winding, cuts the thread, and also a small slit in the end of each bobbin, into which it fixes the loose end; then by another change it throws out the full spools, takes in fresh empty ones, which are placed in position by the minder, goes on again and repeats the operation! All these changes are effected by the machine itself, through a system of cam motions, with the greatest regularity, leaving the minder nothing to do but place the empty bobbins and gum tickets upon the ends of the full ones.

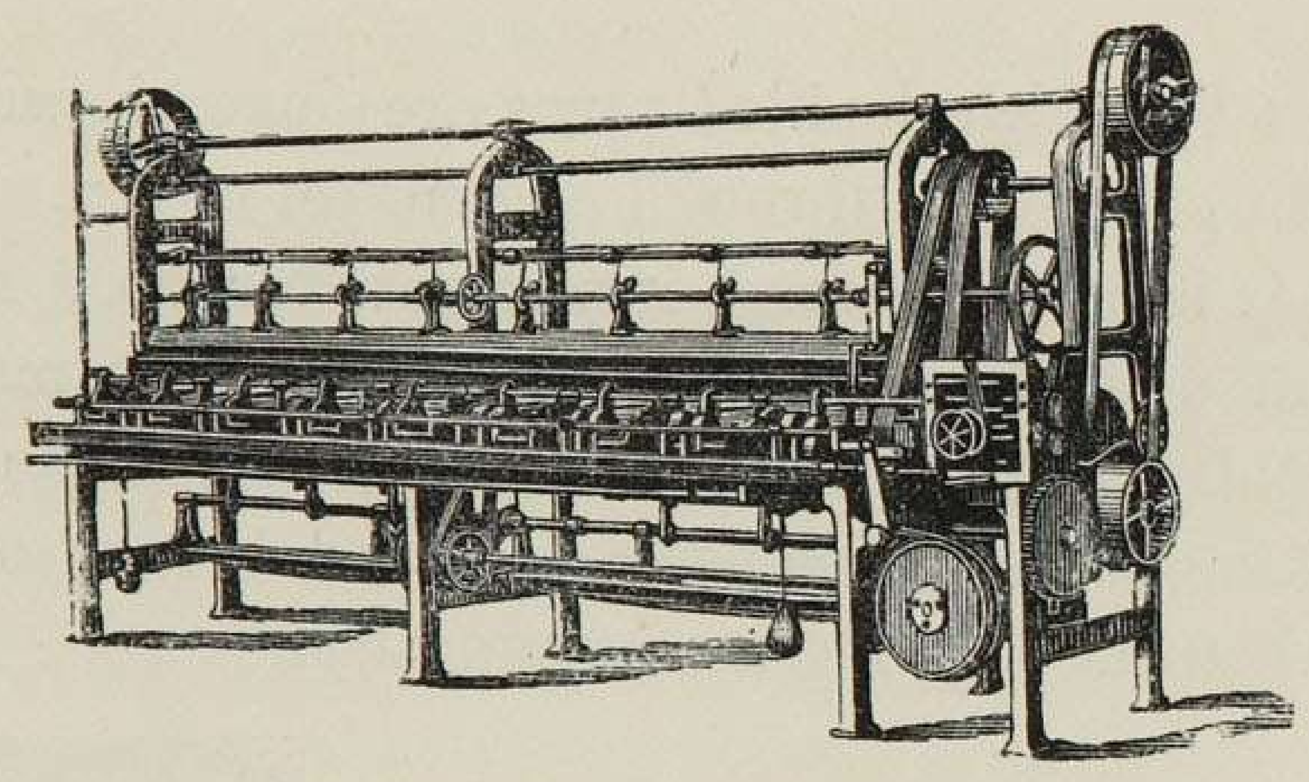


Fig. 214.—Wield's Spooling Machine.

STEAM BOILERS AND STEAM ENGINES.

HOW to generate, and how to use steam, is now becoming a serious question, from the steadily advancing price of fuel. It is to be regretted that the casualties arising from explosion are still numerous. Had it not been for the efforts of the "Manchester Steam Users' Association," and other similar societies, formed for the periodical inspection of steam boilers, the annual losses of life and property would have been very great ere this; but the labours of these societies not only prevent accidents, but teach economy. From the reports issued by these associations in 1871, it appears that there were 70 boiler explosions during the year 1870, which caused the deaths of 85 and injuries to 135 persons; whilst only 66 explosions, 66 deaths, and 113 cases of injury are reported as having occurred during 1871. In the annual reports full particulars, with illustrations, are given of each accident, which show the cause of explosion, and enable manufacturers and boiler-makers to guard against them. It appears that only two or three of these explosions occurred at cotton factories. A few examples are selected from these publications, the first of which, *Fig.* 215, is that of a boiler crushed in by external pressure, a cause of accident very frequent in the days of low-pressure steam, but now of extremely rare occurrence; yet this took place at Bury, in Lancashire, so lately as 1865. In this case the pressure on the boiler had been allowed to get below the atmospheric pressure, and a partial vacuum was formed inside, as was often the case when steam was used merely as a condensing medium. The early explosions were so palpably due to the weakness of the boilers, which, compared with those of the present day, were badly constructed, principally of the wagon shape (*Fig.* 216), but some of them were provided with vacuum valves, to prevent accidents like those just noticed.

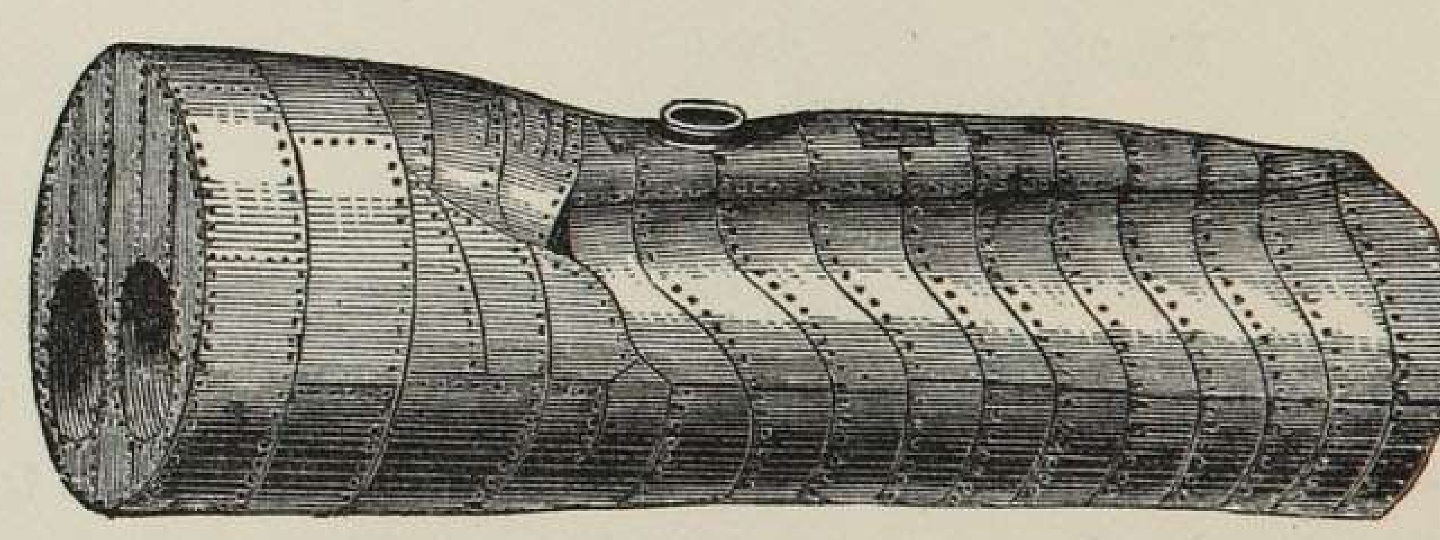


Fig. 215.—Boiler crushed by atmospheric pressure.

When the advantages of high-pressure steam became recognised, the old wagon-shaped boiler was discarded, and succeeded by the Butterley boiler, which was cylindrical, with a flue enlarged at the firing end, and having the bottom part cut away the length of the fire bars. This boiler had a great run, as it would stand a pressure up to 20lbs. to the inch, but was seldom worked at more than 10 to 15lbs. *Fig.* 217 shows a Butterley boiler which exploded at Walsall in 1866, injuring two persons. It was 26ft. 6in. long and 9ft. diameter; the wagon-shaped top to the fire-place was 8ft. 6in. long, and attached to the bell mouth of the internal tube, which then continued circular to the back of the boiler. The tube was 3ft. 6in. diameter. All the plates were about 7/16ths of an inch thick, and although the boiler was an old one, they were nowhere reduced in thickness by wear. The usual pressure of steam was 18lbs.; and a self-registering gauge showed that at the time of the explosion it did not exceed 20lbs.

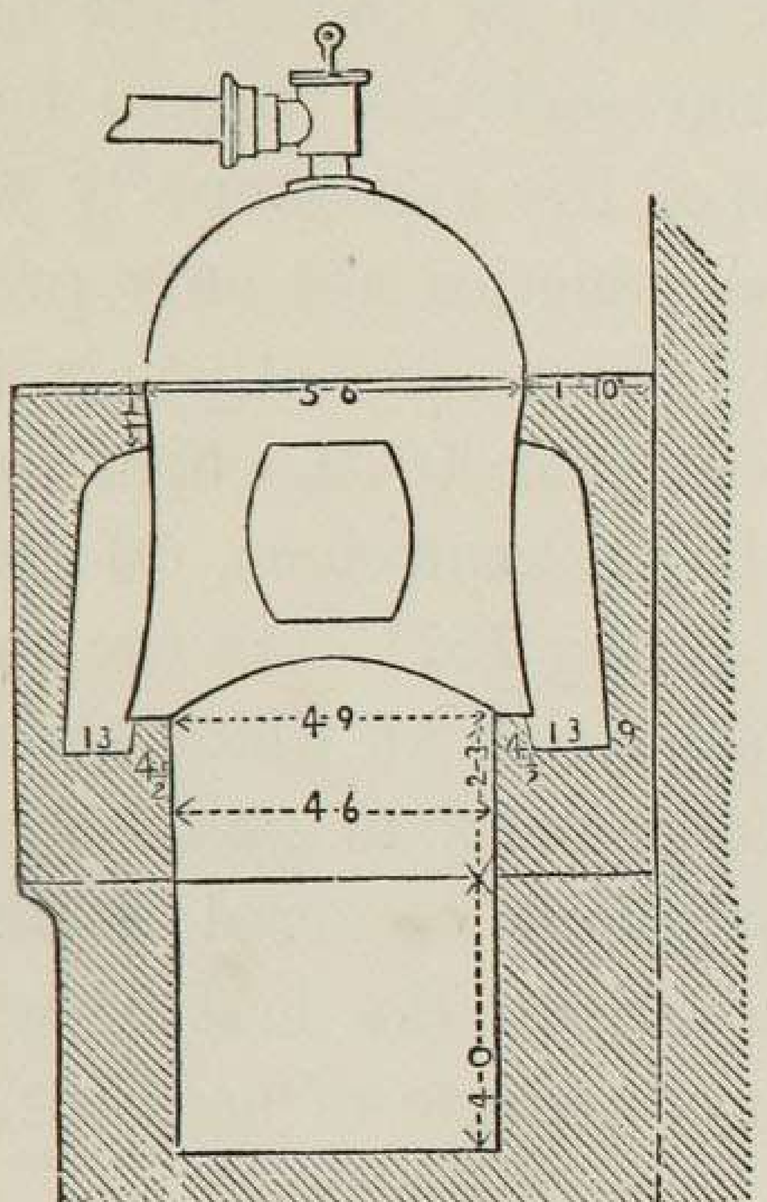


Fig. 216.—Boulton & Watt's Wagon Boiler.

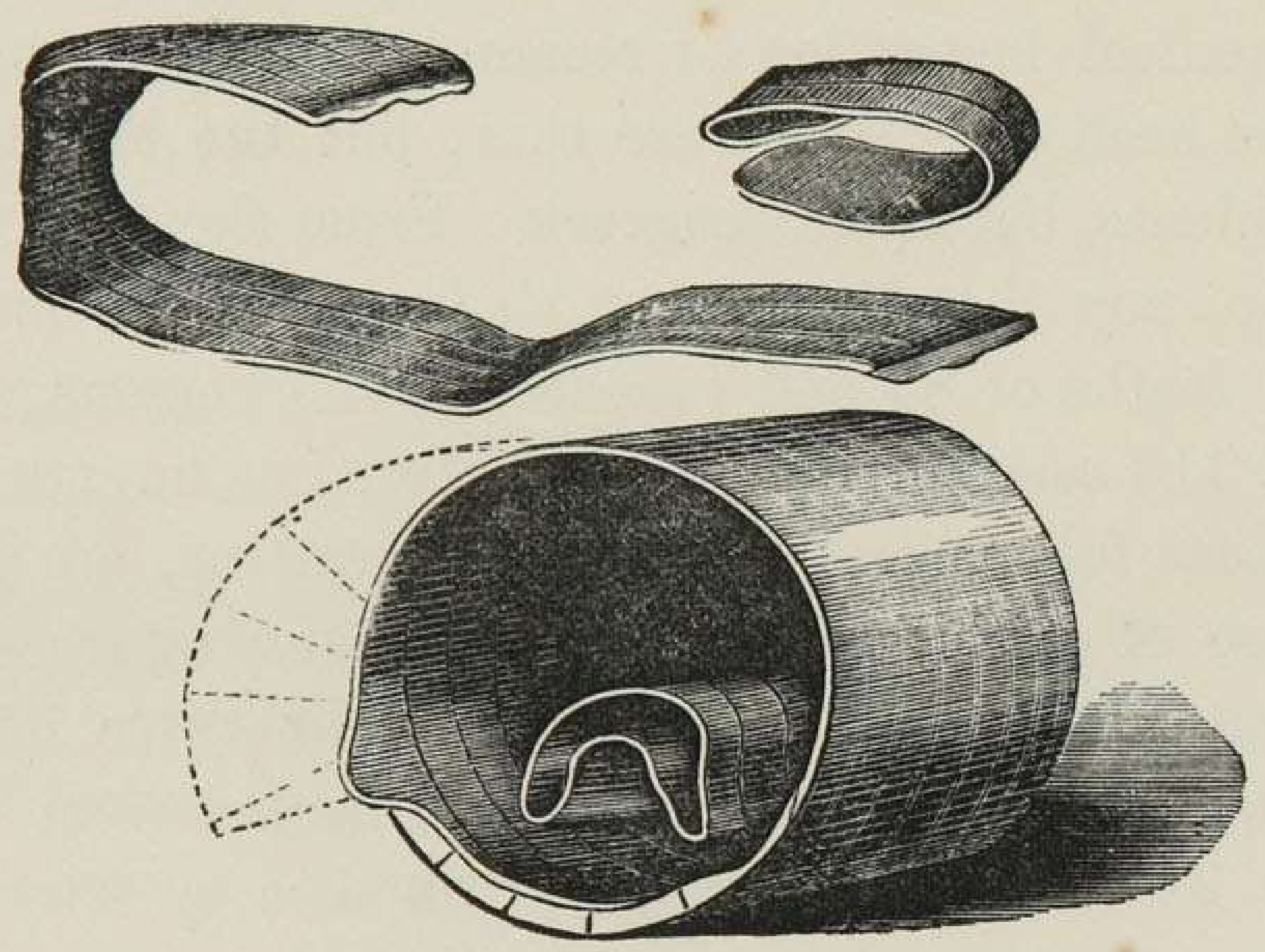


Fig. 217.—Exploded Butterley Boiler.

The top of the fire-grate on the right side was rent longitudinally; and the upper part of the shell, consisting of four rings of plates, and the top of the fire-place were opened out and blown away to a considerable distance. The front end was also blown away, the bell mouth of the tube was driven to the front, and the tube which remained in the back part of the shell collapsed upwards. The cause of the explosion was most likely the intrinsic weakness of boilers of this shape, especially over the fire-place, where the top is only retained in its shape by numerous stays. The boiler had been very frequently repaired at this the weakest place, and its strength had thus been so reduced as to render it unable to bear even a few pounds more than the ordinary working pressure. The whistle was found to have been gagged with hemp.

After steam began to be used at a higher pressure, the tremendous havoc caused by an explosion led many to think that something more must be requisite than the expansive force of the steam to produce such an effect, and many persons attributed to steam, under certain conditions, a detonating force, or a sudden access of expansive power that overcame all resistance. To support this somewhat natural impression, it was asserted that the steam became partly decomposed into its constituent gases, forming an explosive mixture within the boiler. This idea is not yet quite abandoned. A little reflection, however, will show that when water, under pressure, is heated to above 212 degrees of temperature, if suddenly set at liberty, it flashes off into steam, and occupies above a thousand times more space than when restrained, pushing everything aside with a force or energy exactly in proportion to the pressure in the boiler at the time of the explosion. Water, in a vessel strong enough, may be heated to such a degree that when it bursts the vessel the explosion will be equal to or even greater than that of gunpowder, and the greater the quantity of water thus heated the greater will be the destructive effects, precisely as the difference between exploding a small barrel of powder or a large one.

A long time elapsed before spinners ventured to use steam at a higher pressure than could be safely carried by the Butterley form of boiler, but when they did so the Cornish or Lancashire boiler, with one or two flues, with the firing inside, became general, and steam was carried to a pressure of 50 or 60 lbs. to the square inch, and was used by compound high and low pressure engines, or else cut off early in the same cylinder. Sometimes boilers of this description exploded from neglected corrosion, after having worked safely for a number of years.

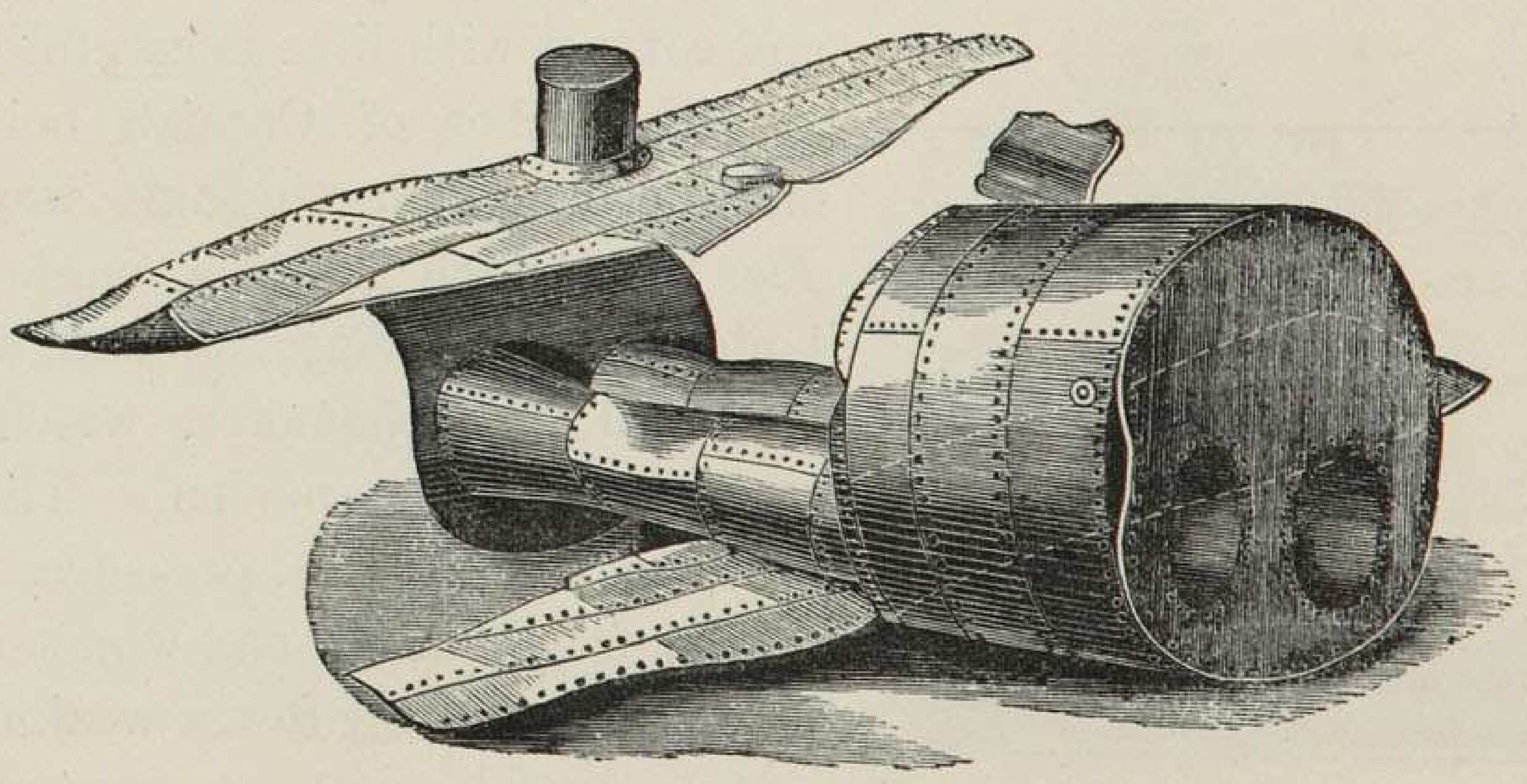


Fig. 218. Cornish Boiler, exploded from neglected corrosion.

An example of this kind is shown in *Fig.* 218, by which two persons were killed and thirty injured. It was a two-tube Lancashire boiler, 22 feet long, 7 feet 6 inches diameter, with tubes 3 feet diameter, 7/16th in. plates, carrying 60 lbs. steam pressure. Some rents took place on the underside of the shell, allowing the central portion to open out and blow away. The portion containing the dome was thrown to the left, and the other to the right. The front end, with three rings of the shell, also the tubes and back end, were but little moved from their original position. The tubes were dented in on the top and bottom, by the fall of some large coping stones upon them, but the crowns of the furnace were uninjured, and there were no signs of shortness of water or overheating. Extensive corrosion on the underside of the shell, where it had rested on the brickwork, had so reduced the strength that it was unable to bear the working pressure. In the sketch the fragments are drawn so as to show their position when in the boiler.

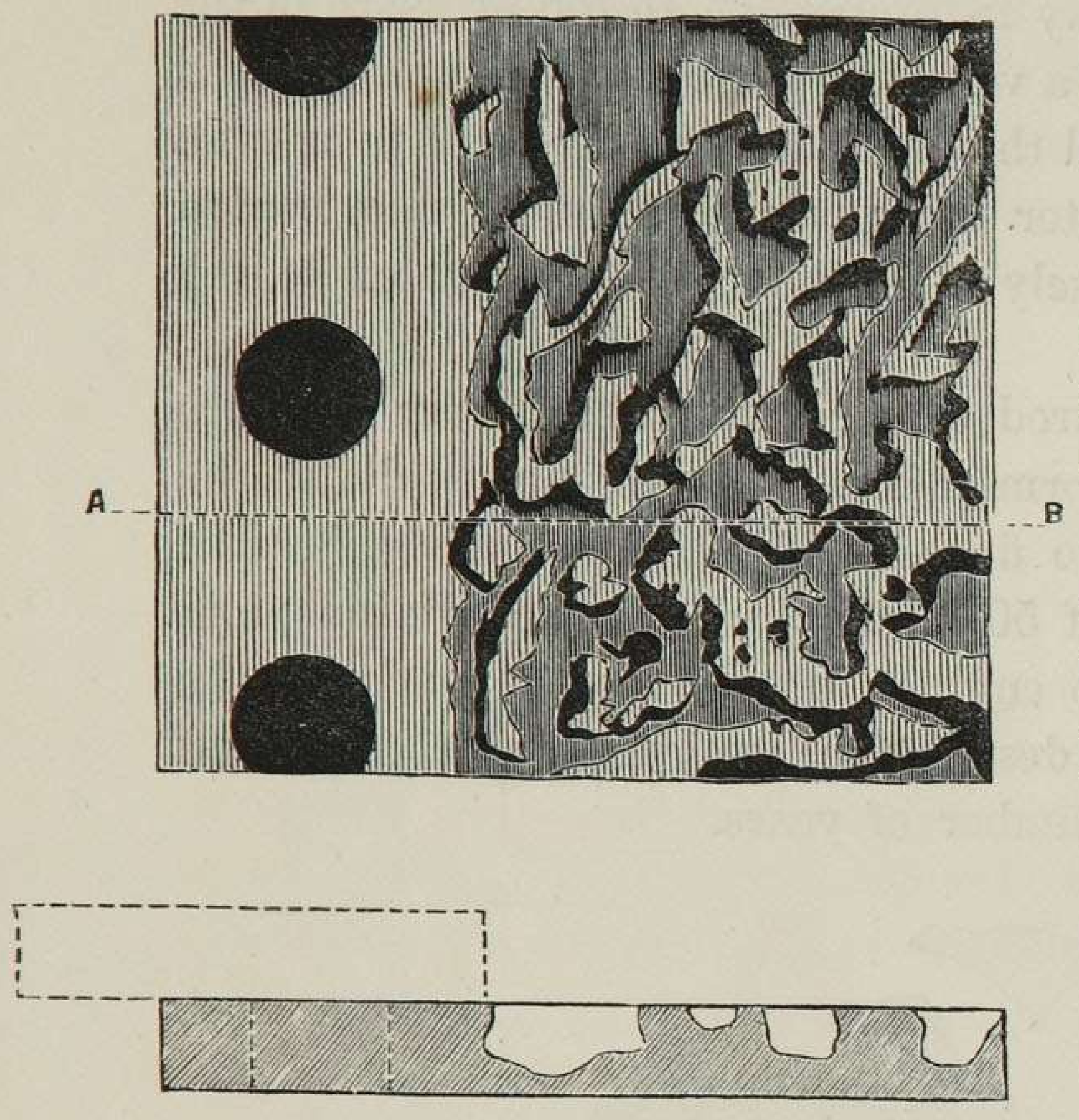


Fig. 219.—Corroded Plate.

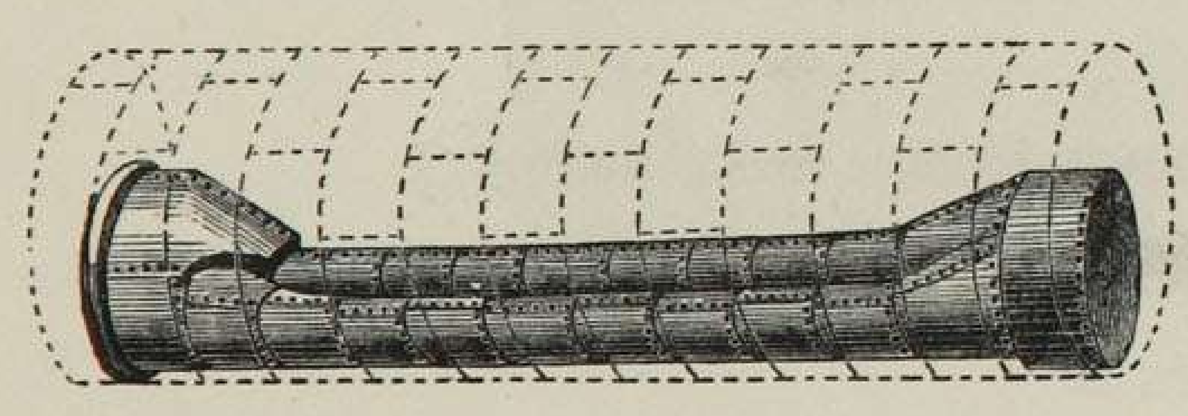


Fig. 220.—Boiler Flue, crushed in through weakness.

Referring to the effects of corrosion of boilers set upon brickwork, it generally takes place from leakage under the boiler where it rests upon the brickwork, and cannot well be seen. In the setting of boilers, formerly, lime mortar was used, and where the leakage came in contact with the mortar the boiler plates were insidiously pitted and eaten away, as in *Fig.* 219, which exhibits plan and section cut through at A B of a corroded plate. This has been the unsuspected cause of many explosions, where everything else was kept in perfect order. Blocks made from firebrick clay are now generally used to rest boilers upon, and contact with lime is carefully avoided.

The tubes of Cornish boilers are very often crushed in through weakness, as in *Fig.* 220, which shows a single tube Cornish boiler, 26 feet long, 6½ feet diameter, tube 3 feet 9 inch diameter, which exploded in 1868, killing one person. The plates were 3/8th in. thick, 15lbs. pressure. The tube collapsed from end to end whilst the steam was being raised, owing to the weakness of so large a tube, made without strengthening rings. The dotted line shows outside shell of boiler.

The deposit of hard stony scale on the inner surface of boilers has also been a prolific source of explosion. Such deposit, being a bad conductor of heat, the plates have got overheated, and gradually weakened from being burnt away in places where the deposit has been the thickest. In certain districts where the water has contained too much lime, the scaling has been most troublesome.

Multitubular Boilers were tried and found to be good and rapid steam generators, but were given up on account of the scaling of the tubes and inner shell of the boiler, which could neither be cleaned nor prevented at the time they were in vogue for manufacturing purposes. If they were tried again now, with surface condensers, distilled water might be used, and a more satisfactory result arrived at.

With increase of pressure there has been a steady diminution in the consumption of fuel; and boilers now, for manufacturing purposes, are all made cylindrical, with one or two flues through them, and with the fire-bars inside. Some are made of Bessemer steel plates throughout, of less thickness, with flanged flues, which are more costly at first, but they are reported to work well and last longer.

The Galloway Boiler (Fig. 221) has been extensively used. It has an advantage in better circulation of the water and increased

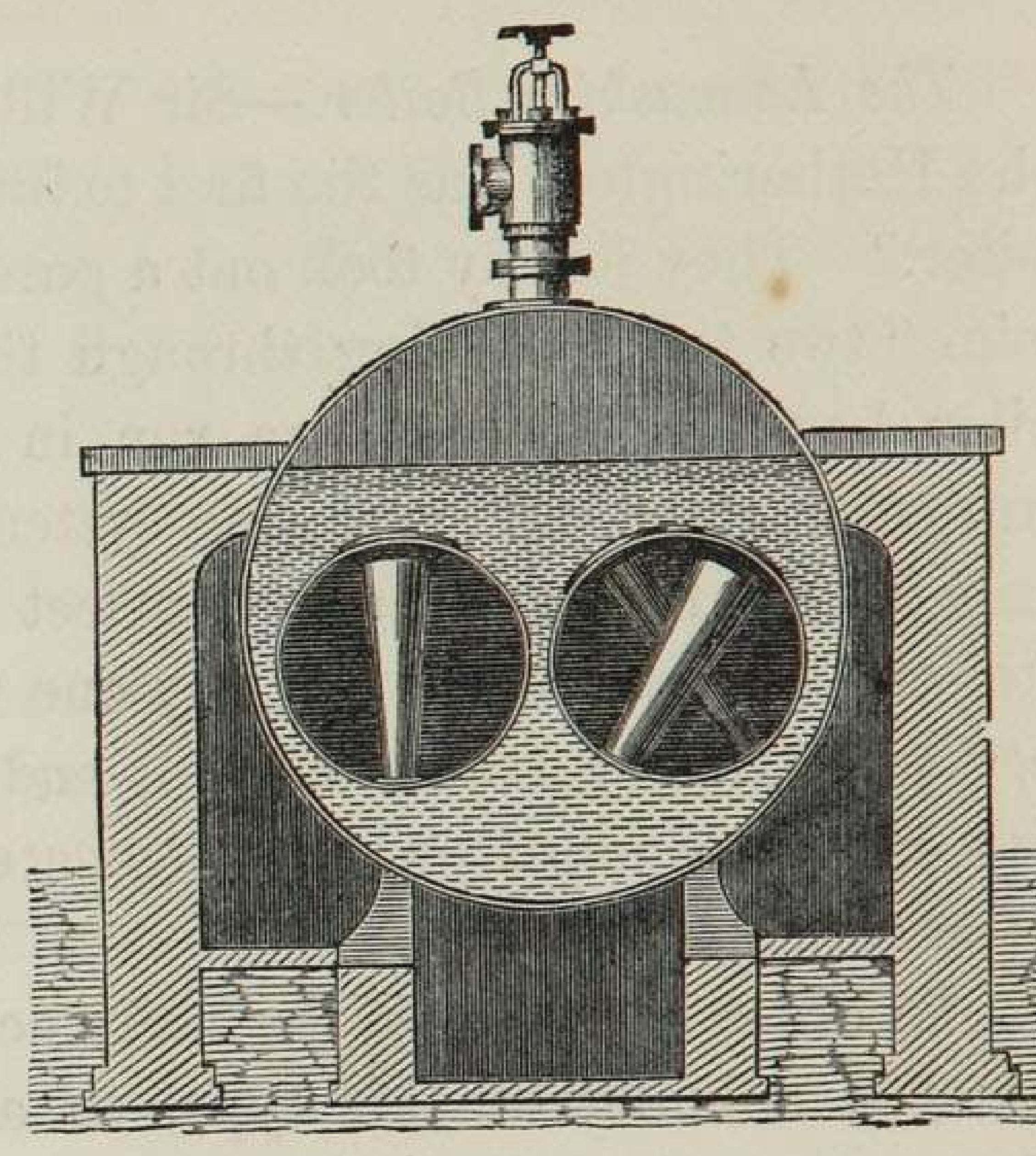


Fig. 221.—The Galloway Boiler.

Fig. 222.

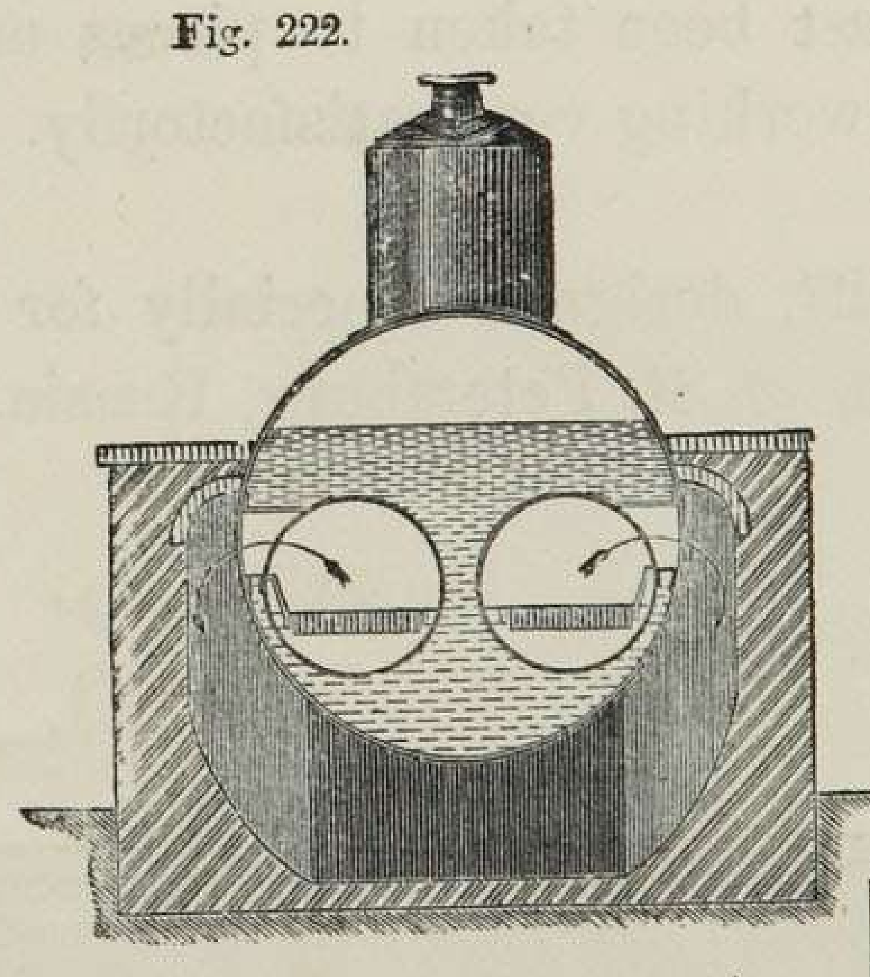
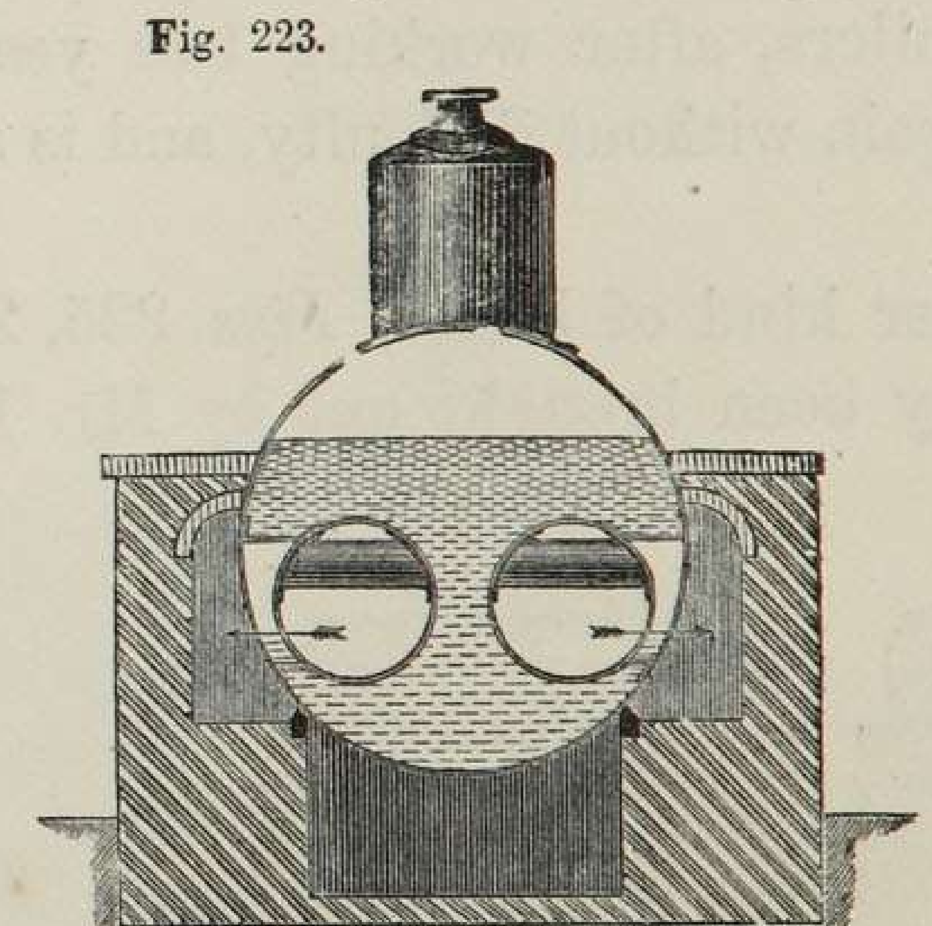


Fig. 223.



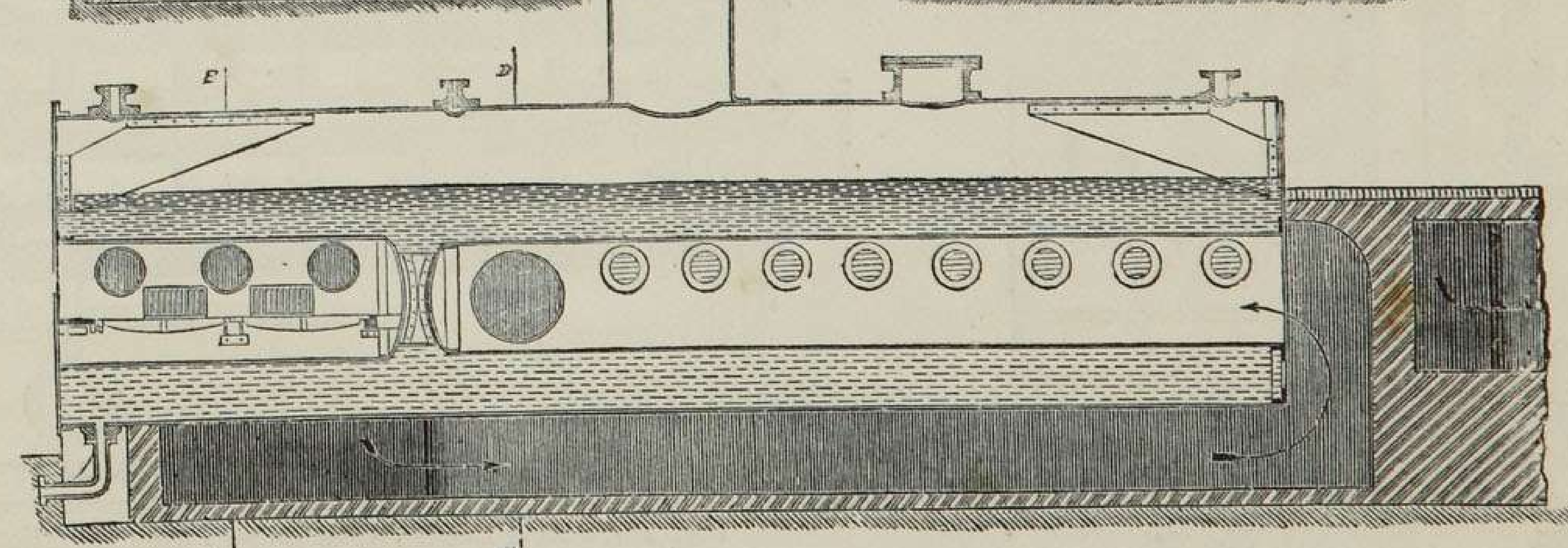


Fig. 224.—Edge's Patent Boiler.

heating surface, but a defect common to the plain two-flued boiler, in the unequal expansion of the flues to the outer shell, which sometimes causes leakage at the ends. *Edge's Patent Boiler (Figs.* 222, 223, and 224) avoids the latter defect by dividing the flues, as shown. It has also a good circulation, and is said to work well so far as it has been tried, being quite a recent invention. It is sometimes made with one flue only.

The Lancashire Boiler.—Sir William Fairbairn, Bart., together with the late Mr. John Hetherington, was the first to introduce what is generally called the "Lancashire Boiler." They jointly took out a patent in the year 1844, No. 10,166, in which they claim "two tubes passing through the water, each of which contains a fire." This boiler has had an immense run in the manufacturing districts. It was a great improvement upon the existing system when it came out, and so long as it was well made by the inventors, gave perfect satisfaction; but, like many other good things, after the patent ran out and any one was at liberty to construct it, many boilers were very indifferently manufactured, and occasionally casualties occurred with them, as with others, especially where the water was bad and formed a thick scale, difficult to get at under the flues.

In order to remedy the evils occasioned by deposit, Sir William has recently patented a boiler of this type, so arranged that the flues can be unscrewed and taken out, so that all the internal parts of the boiler can be thoroughly cleaned. One of these boilers, after working two years, has just been taken to pieces and put together again without difficulty, and is said to be working very satisfactorily.

Another kind of boiler, *Figs.* 225, 226, and 227, designed especially for safety, has recently been brought out by Mr. Levi Leigh, of St. Petersburg, Russia. It is

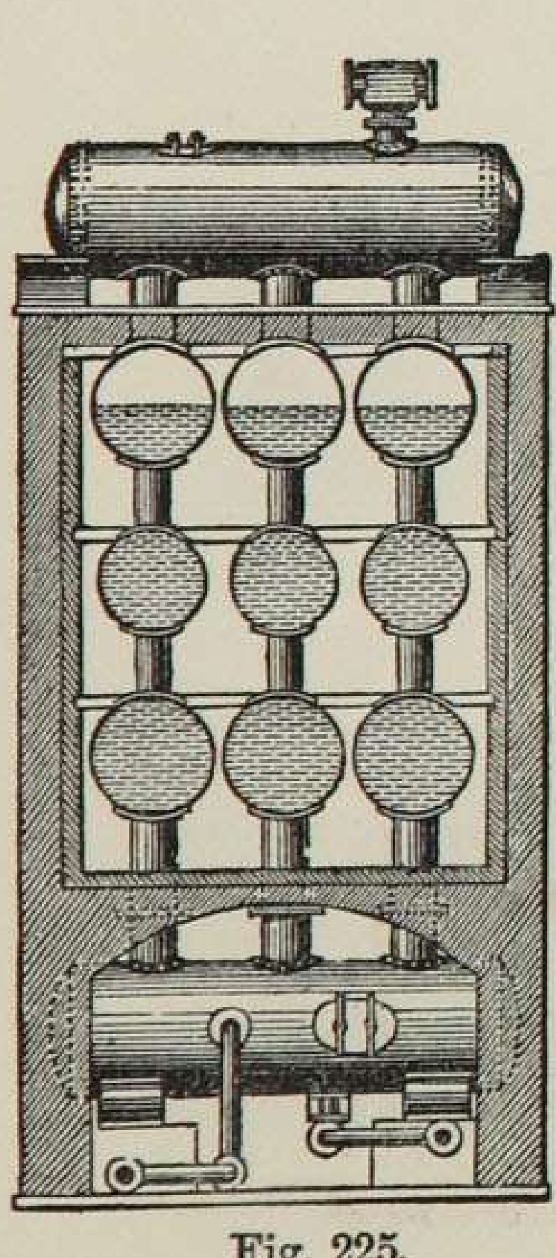


Fig. 225.

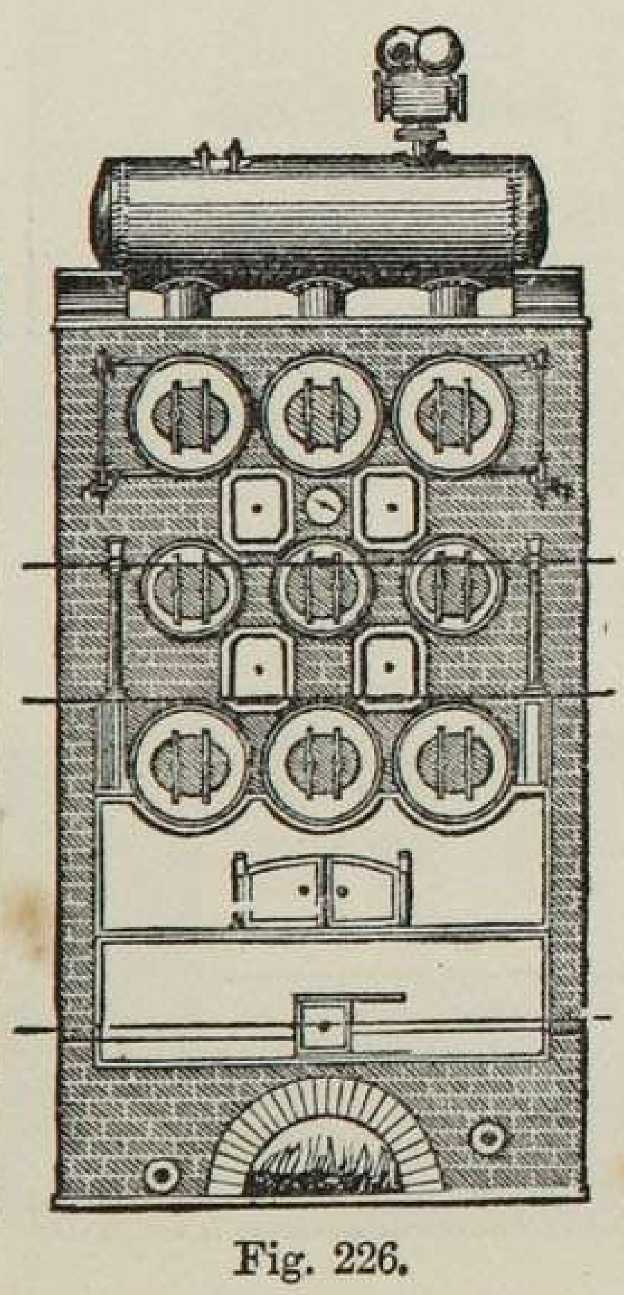


Fig. 226.

Levi Leigh's Boiler: Front Elevation and Section. (Scale ⅛in. = 1 foot.)

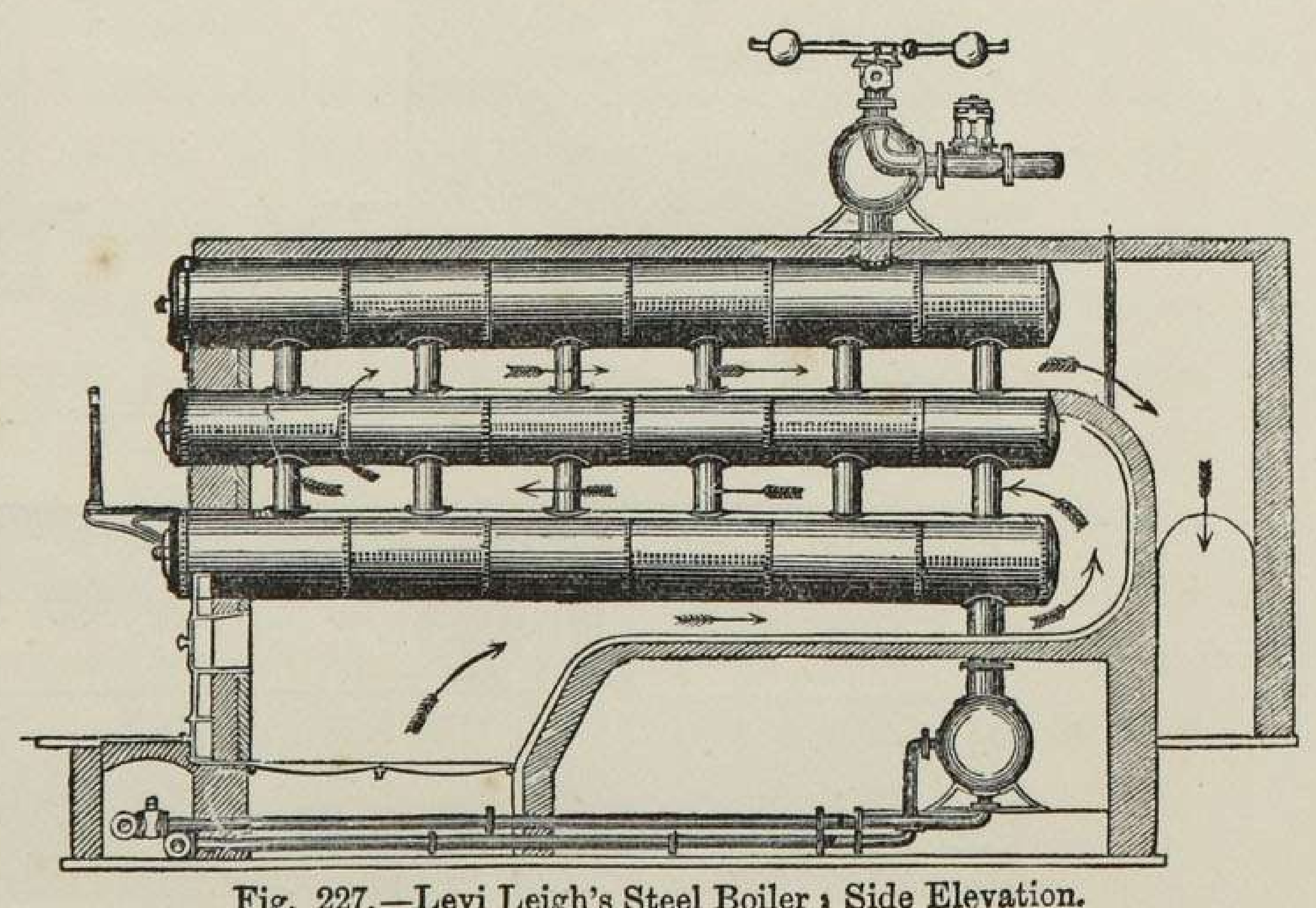


Fig. 227.—Levi Leigh's Steel Boiler: Side Elevation. (Scale ⅛in. = 1 foot.)

manufactured by Messrs. Musgrave & Sons, of Bolton, entirely from steel plates, 5/16ths of an inch thick, and carries a working pressure of 150lbs. to the square inch, The engravings show the fire-place arranged for burning wood. When coal is used the fire bars are raised to come nearer to the bottom of the boiler. The heating surface is 1,400 square feet, steam space 200 cubic feet, and the working quantity of water 751 cubic feet.

Water Tube Boilers are now becoming much used, and when properly manufactured possess undoubted advantages both in safety and economy. They have not, as yet, been extensively adopted for cotton mills, but where they have been tried, of good manufacture, they have proved satisfactory. There are several good varieties of this kind of boiler now in the market, such as *Fig.* 228, manufactured by Messrs. Howard, of Bedford; and *Fig.* 229, called the "Root Boiler," made by the "Safe and Sure Boiler Company," of Birmingham.

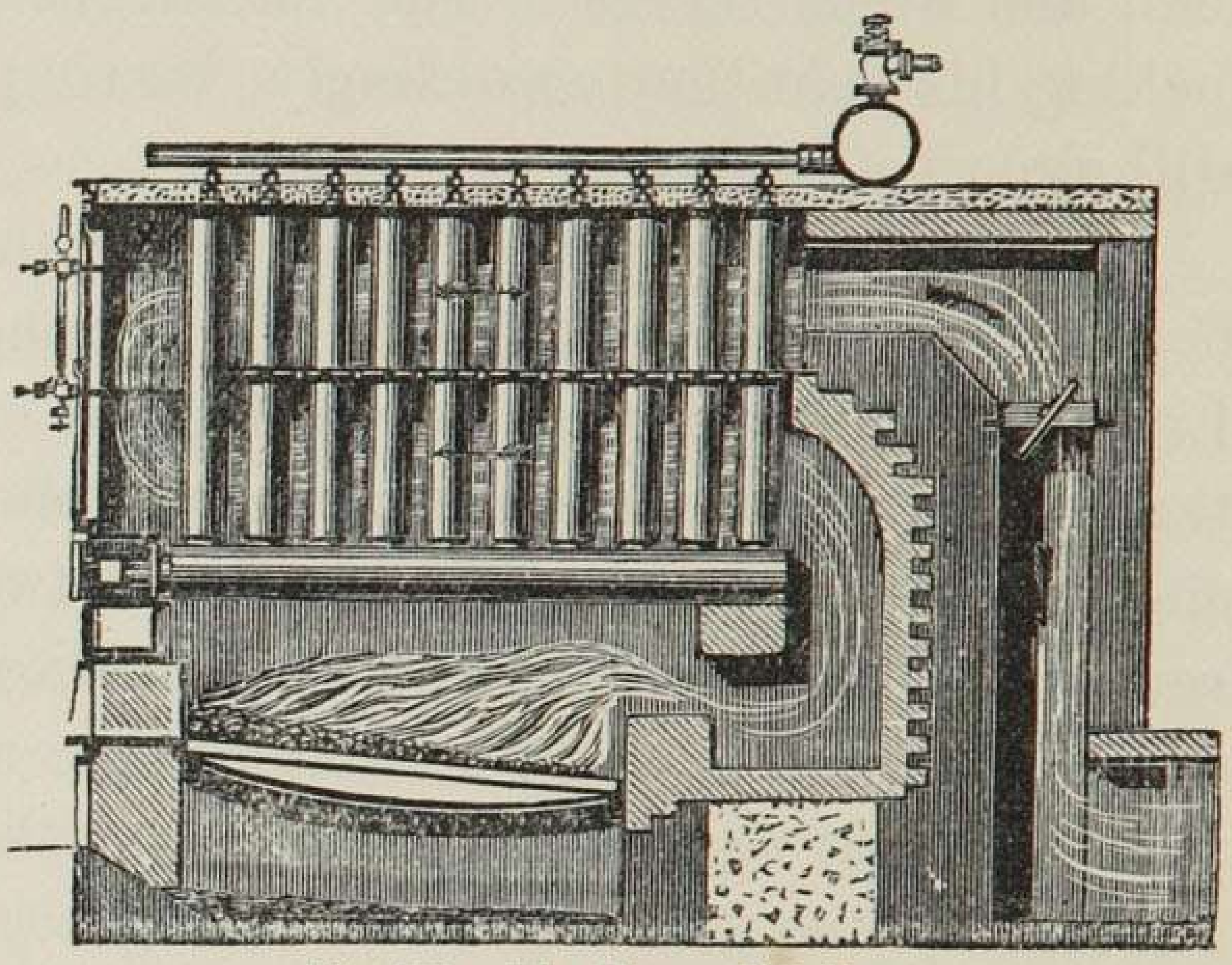


Fig. 228.—The Howard Boiler.

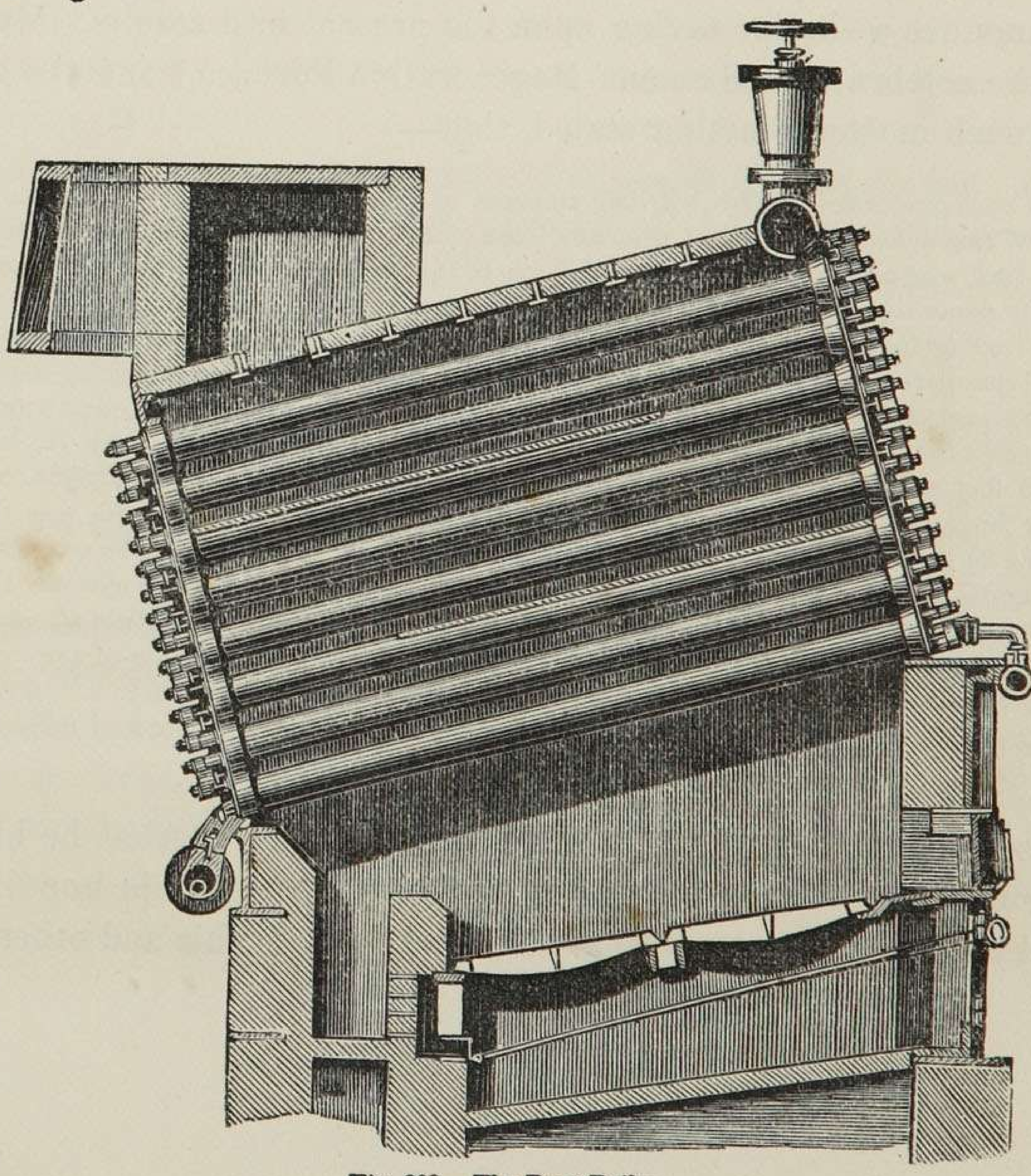


Fig. 229.—The Root Boiler.

A hundred other varieties of boiler might be shown, some of them probably better in some particulars, than those illustrated; but the object is more to point out the direction that steam generation is taking than to perplex the reader with profuse illustrations or to recommend any particular boiler. The fact is, that what will suit one locality, or kind of work, will not suit another, from the difference in the water, fuel, and other things. The intelligent manufacturer will therefore be guided in making his selection accordingly, bearing steadily in mind that the waste of fuel is still almost incredible.

It was stated by the President of the Institution of Mechanical Engineers, Mr. C. W. Siemens, D.C.L., F.R.S., in his inaugural address at the annual meeting held in Liverpool this year, that the heat given off in the combustion of ¼lb. of coal is more than sufficient to work a horse power one hour, if it could all be utilised! It was shown that the average consumption of twelve of the best modern steam ships, having compound engines, was 2·03lbs. per indicated horse power per hour, the lowest being 1·70, and the highest 2·85. These were not merely experimental trial trips, but the result of long voyages. It was stated that when the Mechanical Engineers met in Liverpool, nine years ago, the average consumption of the then best steamships was 4·51bs. per indicated horse power, so that a saving of over 50 per cent had been effected during that time; and it was predicted that Mr. Siemens' successor in the presidential chair, when they met again in Liverpool, nine or ten years hence, would be able to announce a similar saving upon the present best results. Mr. Siemens, the inventor of the celebrated "Siemens' Regenerative Furnace," and the greatest living authority on such matters, further stated, that—

"The annual coal production in Great Britain amounts at present to 120,000,000 tons, which, if taken at ten shillings per ton of coal delivered, represent a money value of £60,000,000. It would not be difficult to prove that in all the uses of fuel, whether to the production of force, to the smelting and re-heating of iron, steel, copper, and other metals, or to domestic purposes, fully one-half of this enormous consumption might be saved by the general adoption of improved appliances which are within the range of our actual knowledge, without entering the domain of purely theoretical speculation, which latter would lead us to the expectation of accomplishing our ends with only one-eighth or one-tenth part of the actual expenditure, as may readily be seen from the following figures :—One pound of ordinary coal develops in its combustion 12,000 units of heat, which in their turn represent 12,000 multiplied by 772, making 9,264,000 foot pounds or units of force, which represent a consumption of barely ¼ lb. of coal per indicated horse power per hour, whereas few engines produce the indicated horse power with less than ten times that expenditure, or say 2½ lbs. of fuel. In taking credit, however, for only 50 per cent of the actual average expenditure, we arrive at an annual money saving of £30,000,000 per annum, a sum equal to nearly one-half the national income! Nor does this enormous waste indicate all the advantages that might be realised by strict attention to appliances for saving fuel, which are, generally speaking, also appliances for improving the quality of the work produced. In a national point of view it is of great importance that our coal deposits should be made to last as long as possible; and, regarding public health and comfort, the smoke nuisance is only another name for waste of fuel—smoke, indeed, being nothing more or less than unconsumed coal."

There is no doubt that Mr. Siemens is quite correct in what he has here stated, and that the margin for improvement is still very large. It is humiliating to think that after all the experience engineers have had, both in this and other countries, and the thousands of inventions patented and unpatented to arrest this waste of an article that is becoming more precious every day, we should yet have the mortification to witness so much of the useful results of each pound of coal dissipated. Yet so it is; nobody seems to grasp the subject fairly; all improvements appear to be only in detail. Yet the theory of generating steam has long since been well understood. For ages it has been known that water is a bad conductor of heat, and that to convert it into steam it is far the best to separate it into thin sheets or films, instead of firing away at a great bulk, and thus allowing nearly all the heat disengaged from the coal to escape up the chimney.

What appears to be wanted is, firstly, a perfect combustion of the coal, and then, with the heated gases, to generate the steam with perfect safety in small quantities as it is wanted. A practical means has been found in the surface condenser of suddenly changing steam into water in small quantities. Why, therefore, not change water into steam by reversing the operation?—turning on the heated gases and water just in the quantities required, instead of keeping a large explosive mine upon the premises in the shape of steam boilers that have taken tons of coal to charge them up to a dangerous point, before any use is made of them. Then, again, why not arrest the heat that is escaping away up the chimney, and bring it back to the fires again? This is already partially done in Green's Economiser, by which the hot escaping gases are made to heat the feed water. The same thing might be done to heat the fresh air which supplies the fires. But if all the heat was re-absorbed, there would be no draught in the chimney; therefore, pursuing rigid economy, it becomes a question whether to allow sufficient heat to escape to produce a draught by chimney, or to do away with it almost entirely, and perform the necessary circulation of the air and gases by the assistance of a fan. The interest of the money necessary to erect a large chimney would probably be more than sufficient to drive a fan to assist a small one after nearly the whole of the heat was abstracted and turned back into the closed ash-pits; the heat being carried along by the fresh air that has come through a sort of tubular boiler, and the heated gases *from* the fire drawn through the tubes by the fan and thus passed away into the atmosphere.

Much may be done by a better circulation of the water in boilers. A locomotive was exhibited to the Mechanical Engineers, at their recent meeting in Liverpool, having a coil of gas pipe in the smoke box, through which air was drawn and forced into the bottom of the boiler by a small pump. The waste heat from the furnace imparted a higher temperature to the air passing through the pipe into the boiler than the water in the boiler, which it also agitated by the bubbles of air entering through a perforated pipe along the bottom. The effect was said to be a saving of about 26 per cent in fuel, or, in other words, the locomotive consumed 39lbs. of coal per hour, without the apparatus, and only 28lbs. with it, drawing the same load over the same ground. This is a very significant fact. It would be interesting to know how much of this large saving was due to the escaping heat arrested and turned into the boiler, and how much to the agitation of the water. If much of the saving was due to the latter, mechanical agitators might advantageously be fixed to ordinary boilers for condensing engines.

Much loss is also occasioned by the present mode of hand firing, the frequent opening of the fire doors lets in large quantities of cold air. This, as well as the smoke nuisance, might all be prevented by the adoption of a good system of mechanical firing. Several plans of doing this are already known to be working economically, but mechanical science might be advantageously turned in this direction for boilers of all kinds.

Another source of loss is by radiation of heat, through neglect of covering all exposed parts of boilers, steam pipes, cylinders, &c., with some good non-conductor, such as sawdust, hair felt, or "Leroy's Patent Non-conducting Composition," which is put on as plaster, and is highly spoken of. This is a duty which should not be neglected by steam users. If nothing more perfect should be used on the plea of expenditure, sawdust is cheap enough, and answers very well.

STEAM ENGINES WITH LATEST IMPROVEMENTS.

After having generated steam in the most economical manner, the next question is, "How to use it to the best advantage?"

The nature and properties of steam are now well understood. Steam is no longer used in engines merely as a condensing medium, but in the best engines its high-pressure properties are first turned to account by expansion, and then it is condensed to form a vacuum. This double application, combined with higher piston speed, has completely upset the old method of estimating the power of an engine, as settled by Watt; and engineers are suggesting other modes as a standard of power, seeing that in actual practice the best made engines, worked expansively at a quick speed, give off an indicated power seven or eight times that of the nominal, by the old rule. Nevertheless no more convenient rule can be devised for universal application, to estimate cost, than that established by Watt; for speed has nothing to do with the cost, neither has the pressure of the steam. It is only a question of quality of construction; and a few extras, such as expansion valves, &c., or a guarantee given that under certain conditions of piston speed and steam pressure in boiler, the engine will indicate so many horses' power above the nominal.

A ready method of estimating the nominal power of an engine, according to Watt, is as follows: viz.,—

If the steam cylinder of a condensing engine be 30 inches in diam., it is 30 HP.
Therefore, if doubled to 60 inches diam., it would have four times the area, and be - - - - - - - - 120 HP.
If doubled again to 120 inches diam., it would have sixteen times the area, and be - - - - - - - - 480 HP.
Going downwards from 30 inches diam. to 15 inches, we get - - $7\frac{1}{2}$ HP.
If the cylinder is increased one-half larger in diameter, the power is doubled; thus, if 30 inches be 30 horse power, 45 inches will be - 60 HP.

And so on, by adding or diminishing, any intermediate power may be mentally arrived at without employing a formidable array of figures.

Assuming that quick running, direct-acting engines will for the future be exclusively employed in driving cotton machinery, and that the steam used will always be at high pressure, it is an open question whether to use one cylinder or two to each engine. Some engineers prefer to expand the steam in one cylinder by an early cut off, and others recommend two. When two engines are connected together and run at a high speed, one cylinder has the advantage of greater simplicity and answers best for cotton mills up to about 60lbs. pressure on the square inch. When steam is used at a higher pressure—say from 60lbs. to 150lbs. on the square inch—it is better to compound the engines by having a high-pressure cylinder of smaller dimensions to take the steam first and discharge it into a larger cylinder, through a vessel where it can be reheated before passing into the larger cylinder. This reheating may be accomplished by the steam as it comes from the boiler to the high-pressure cylinder through a tubular vessel.

It is a fact that expansion produces cold; and unless steam be superheated before it leaves the boiler or reaches the cylinder, it loses much more of its pressure than it otherwise would by the first expansion, as it becomes then too moist. The superheating takes up this moisture, and to some extent prevents it losing pressure. When only one cylinder is used to each engine and the cut off is made early—say at one-tenth of the stroke—the steam requires rather more superheating, as there is some chill produced by its being open to the condenser alternately at each stroke, the loss from which is greater in a single cylinder engine, because the temperature of the steam at full pressure is much higher than it would be if already expanded in a high-pressure cylinder, and the shock on the piston is much greater at the commencement of the stroke. This shock is best taken up by a heavy piston and connecting rod, which acts as a sort of anvil for the steam to strike against, and prevents to a considerable extent the thump upon the crank pin.

How to work Engines with $1\frac{1}{2}$*lbs. of coal per indicated horse power per hour.*—It was intended to illustrate the compound engines of Her Majesty's ship *Briton*,—those engines which have actually been worked with a consumption of 1·3lb. of coal per indicated horse power; but as the engines may, for manufacturing purposes, be improved upon, a description of them, and the circumstances under which so low a consumption of fuel was attained, may suffice and be useful.

The engines of H.M.S. *Briton* are made in the following manner: The smallest cylinder is 57 inches diameter, and the larger 100 inches diameter; the stroke of piston in both is 2 feet 9 inches. The smaller cylinder is fitted with a sliding expansion valve, to cut off at from one-third to one-fifth of the stroke; but in order to have the advantage of the cranks of the two cylinders being at right angles to one another, the steam is not discharged direct from one cylinder into the other, but there is an intermediate chamber, or reservoir, between the two cylinders, into which the steam is received from the small cylinder and discharged into the larger. This chamber is made of copper and brass, and reheats the steam within by means of a steam jacket.

On the official trial of these engines, the pressure of steam in the boilers was about 60lbs. to the square inch, and the vacuum in condenser from 27 to 28 inches. Under these conditions it was found that the power developed by each of the two cylinders was practically identical, and the same pressures were exerted at half-stroke when working "full power." The power obtained at "full power" was 2,148 horses, when the consumption of coal was a shade under 2lbs. per horse power per hour; but at a slower speed the consumption was 1·515lb., the engines indicating 1,100 horses' power, and at a still slower speed 1·3lb. per horse power per hour, the engines indicating 660 horses' power, or twice the nominal power. These trials were each of six hours' duration; the coal was accurately weighed in bags at the dockyards, the number of bags carefully counted, the stoke-hole cleared up before and after each trial, and the fires placed in the same state at the commencement and completion of the different runs; two sets of indicator figures were taken from both cylinders at each and every half-hour, and the revolutions of the engines were taken with a mechanical counter.

There can be no doubt that these trials were accurately made, and they teach an impressive lesson in showing: (1) That true economy lies in having engines and boilers of sufficient capacity, so that they can do their work with entire ease; (2) That when one compound engine is used for steam at 60lbs. pressure, it is better to have the high pressure cylinder of about one-third the capacity of the low pressure cylinder, and set the cranks at right angles, having a jacketed receiver between, where the steam may be slightly reheated; (3) That the engine should be able to do its work easily when the steam is cut off at one-fifth of the stroke in the high pressure cylinder, and then expanded into the low pressure cylinder of three times the capacity, making a total expansion of about fifteen times.

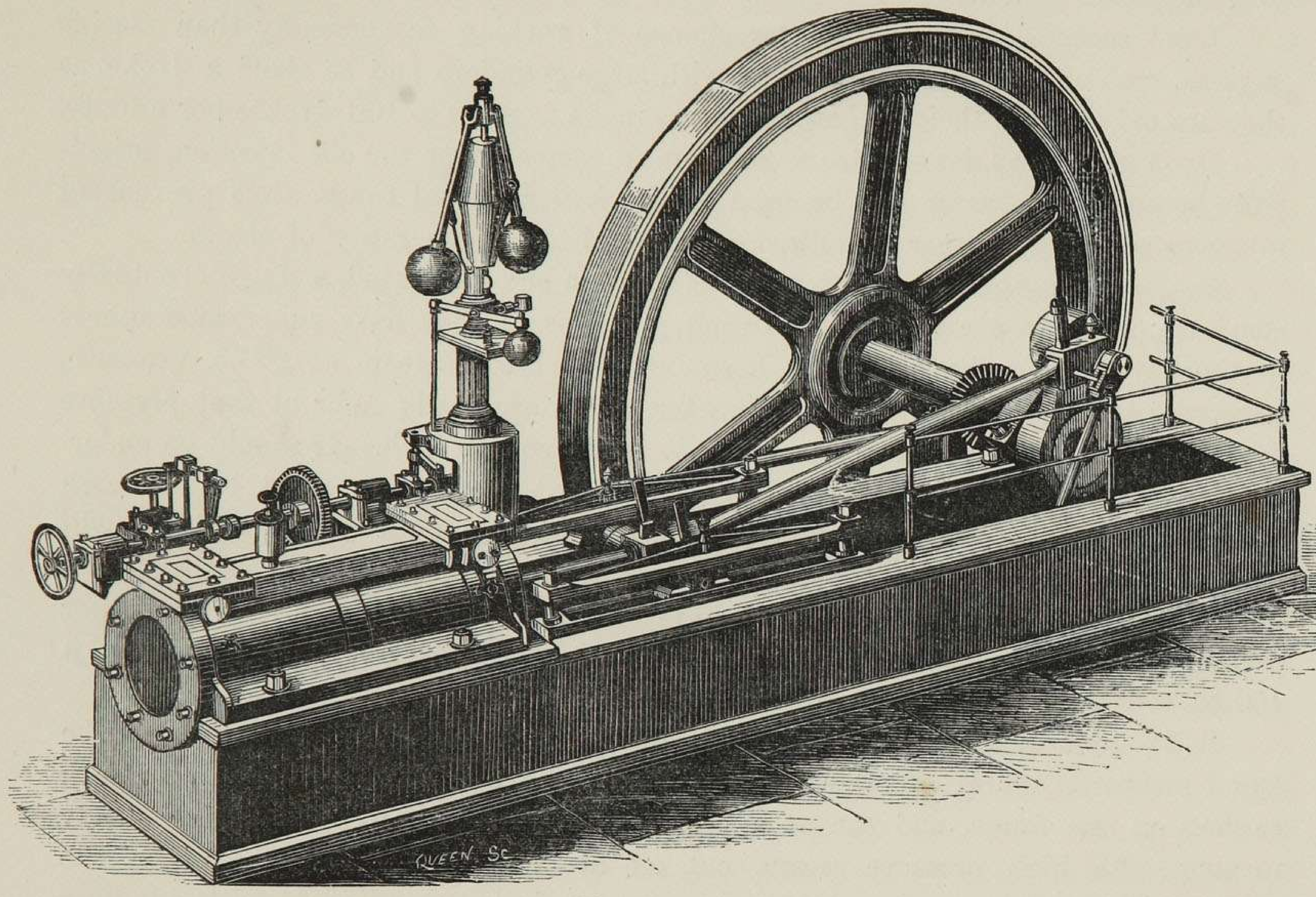
When a pair of compound engines are worked together, with the cranks, at right angles, it does not appear to be of much consequence, so far as economy is concerned, whether there be a receiver between the high and low pressure cylinders, or that the steam goes direct from one cylinder to the other. But when there is only one compound engine, a receiver is imperative, so that the cranks may be set at right angles. Both high and low pressure cylinders should be steam jacketed, and felted over the steam jackets.

Land engines have a far better chance of working economically than marine engines, such as those described above, with large cylinders and so short a stroke, as they are too often on their centres, having to make from 60 to 100 strokes per minute.

Good surface condensers are a great improvement over the old injection, principally because pure water can be used in the boilers at all times, thus preventing injurious scaling and other deposit so detrimental to the generation of steam.

Oscillating engines work with less friction than any other kind, and will eventually come as much into use for manufacturing purposes as they have superseded others in the navy. They have already been introduced with steam at 200lb. pressure, generated in steel boilers, of small diameter, which are really safer at that pressure than the old Butterley boilers were at 20lb. to the square inch. It should be understood that the higher the pressure of steam used the smaller must be the high pressure cylinder of the compound engine, so that the power of one cylinder will balance the other at half stroke. If a consumption of less than $1\frac{1}{2}$lb. per indicated horse power per hour has been attained in marine engines, with only 60lbs. boiler pressure, surely a much less consumption is attainable in land engines with steam at 150lbs. to 200lbs. pressure.

Self-contained, direct acting engines, working at a high piston speed, will be found most economical in every respect for driving cotton mills. A pair of such engines on one frame, and run at a high speed, will work well, and give steady turning, with high pressure steam, cut off at one-tenth to one-fifteenth of the stroke, without compounding, if they have steam jacketed cylinders with felt over them, and the condenser not too near the cylinders. The principal difficulty with such engines has hitherto been the liability of the valves getting out of order, but this is now completely obviated by Messrs. Edge & Co., of Bolton, who, some years ago, patented a new grid valve and cut-off motion. This valve only makes a short throw, opening the port to the full extent and cutting it off again, however early the cut-off may be required. A movement which effects so many desirable things, arranged, too, so that the governors can act upon it, is necessarily complicated, as will be seen from the sketch of Messrs. Edges' engine, *Fig.* 230. This engine has four sliding grid valves, two for steam and two for the exhaust, working transversely to the piston, and cutting off close to the cylinder, thereby saving steam passages. These valves are worked by cams placed on two small shafts, which are driven by eccentric wheels, thereby receiving an intermittent fast and slow motion. The upper cam shaft, which acts upon the steam valves, is made to slide by the action of the governor, and has curved cams upon it to regulate the cut-off. Although these engines are uncouth looking, they are said to work exceedingly well, and the valves keep in good order.



No. 230.—Edge's Patent Steam Engine.

A very neat improvement upon the Corliss valve gear has been effected by Messrs. John and Edward Wood, engineers, of Bolton, who have also dispensed with the piston rod slides, by introducing a parallel motion to their horizontal engines. The valve gear is worked by three eccentrics, one for each of the steam ports, and one for the exhaust. The steam port valves are thus opened suddenly when the eccentrics are at their full throw; and being acted upon by springs, the steam is cut off instantaneously, when the catches are liberated by coming in contact with notches placed farther or nearer by the action of the governor.

SHAFTING, SOLID AND HOLLOW; COUPLINGS, BEARINGS, AND STEPS.

SHAFTING.

FIFTY years ago, the shafting employed in cotton factories was nearly all square, and turned only at the journals; the drums fixed thereon for driving machinery were formed of cast iron rings and lagged with timber on their peripheries. The rings had square holes, larger than the shafts, so as to admit taper wedges of different thicknesses on all the four sides to set the drums true, after which lead was run in to keep the wedges in their places. When the lags had been put on, the drums were turned up true from the bearings, and wood ends put in, the drums extending generally, from bearing to bearing, about 8 or 9 feet. The heavy portion of the shafting was of cast iron, with clumsy iron box or claw couplings, fastened on with wedges and lead. The speed of such shafting was necessarily slow, and break-downs frequent, the operations becoming more uncertain as higher speeds were demanded.

Messrs. Fairbairn and Lillie were the first to introduce into the cotton manufacturing districts a new system of round wrought-iron shafting, with iron drums, which they ran at about three times the former speed, thereby effecting a wonderful improvement in lightness and safety. Nearly fifty years have elapsed since then, and there has been no material alteration, except that half-lap couplings have been dispensed with; and all shafting is now turned and polished throughout, so that drums will fit anywhere on the same shaft, as they are previously bored and turned, and easily fixed with a single key or with conical wedges.

The time has now arrived for another innovation in the transmission of power; and with our present knowledge of materials and the laws of motion, there is room for a change as great, economical, and complete, as that invented by Messrs. Fairbairn and Lillie, although it has held the position, then taken up, for nearly half a century. So far as the British cotton manufacturer is concerned, the question of transmission by shafting has long been considered settled; and Fairbairn's principle, like Watt's beam engine, has had a profound and undisturbed reign of nearly half a century. The speed of shafting is certainly too slow; and there is now a better material—steel—than iron, and at a sufficiently cheap rate.

With steel shafting run at a rapid speed, power may be transmitted even more economically than at present. There will be several savings effected, namely—one half the capital, less friction, less oil, less chance of loss from break-down and engine repair. Light shafting, with quick speed, involves small drums, small coupling boxes, steps, &c., and general simplicity. Of course, it is out of the question to put light shafting to span from beam to beam without a bearing, as is the case in the present system; an altogether different principle of support must be adopted by running a girder from end to end. This girder need only be of the simplest possible construction, of rolled iron, and of the I form. The top flange is fixed to the beams, and the bottom flange is planed, with bevelled edges for the hangers to slide upon it, and be firmly fixed with a key, as shown in *Fig.* 231, which represents a section through the girder, hanger, pedestal, and shaft. The inside of the hanger is turned or bored out to a gauge, and the pedestals are cast, three together, in a ring turned to the same diameter as the inner flange of the hanger before being cut off. After the hangers are bored out they are planed or shaped at the top from the same maundril, so as to be exactly alike. If the girders be fixed and coupled together with fish-plates, in a true line, the shafting is sure to be level throughout, and any number of bearings may be put up.

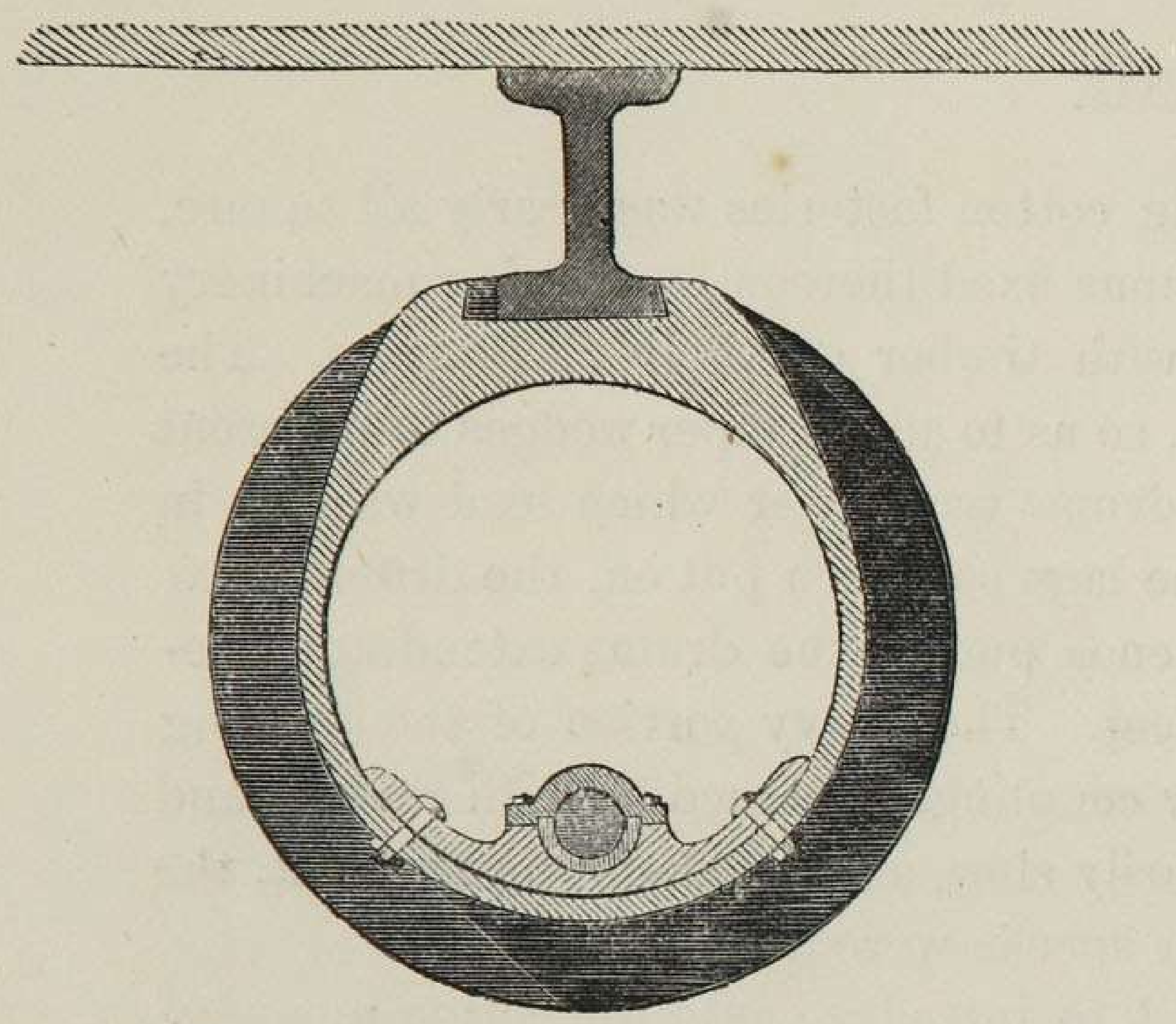


Fig. 231.—Section of Girder, Hanger, Pedestal, and Shaft.

COUPLINGS.

With quick-running steel shafts no elaborate couplings need be made, nor any swell left on the shaft, which is a great advantage, as the pulleys can then be bored out to fit the shaft anywhere, with one key, hollowed out to the shaft on the underside, and fitting a groove in the pulley on the upper side. The shaft couplings may be made of cast iron, in diameter about twice that of the shaft, and the length four diameters of the shaft. They should be accurately bored, and have the holes polished inside with an emery stick, the box chucked and run at a rapid speed for that purpose. After the polishing it should just fit the shaft rather tightly. It ought then to be grooved nearly parallel all through, and have the bottom and sides of the slot scraped to an exact gauge. The ends of the shafts, fastened together by a temporary coupling open at the top, have slightly sunk key-beds cut in them, the bottoms of which should also be scraped to a template, so as to be both exactly alike. A steel key, having the underside first prepared upon a surface plate, fitted first to the grooves in the shaft ends, and then to the box after it is put on, by filing and scraping the top side only, which has a little taper, until the key touches both shafts and box equally all along.

If the couplings are made carefully in this manner, they will never give any trouble. The keys need not be fitted in too tightly, the principal thing to observe is that they touch both shafts and box along the whole surface. The groove in the box should not have more than 1/32-in. taper over its whole length, and the top of the key the same; the key should be oiled when finally put in, so that it may be driven out easily when required without straining the shaft or burring the end of the key.

If the coupling boxes are prepared in this manner, and polished out to a Whitworth template for their respective sizes, they may be made cheaply in large quantities; and if the ends of the shafts be formed by cylindrical templates, they will fit anywhere, and a mill may be accurately shafted at comparatively small expense, and the whole shafting will run as true at the couplings as elsewhere.

BEARINGS.

The steps of the bearings may be of cast iron, or Babbett metal, 2¼ diameters of the shaft in length; and after two steps are cramped together, may be bored out of the solid, and polished to Whitworth's templates. The ends of the holes, countersunk or bell-mouthed, for about one-eighth of an inch on each side, will prevent the oil from running off the bearings, as the countersink creates a sort of capillary attraction, that holds the oil to the bearings. This singular property of a bell-mouthed hole to retain the oil upon its bearing was discovered by the writer when trying experiments with the loose-boss roller, and may be understood from *Fig.* 232, in which *a* represents a round shaft hollowed in the middle at *b*; a drop of oil having been put on at *b*, falls to the underside, and is seen at *d*. If more oil is put on at *b*, it will fall down and drop off at *d*, still leaving one drop suspended, which is held in its place by the gravitation from the two inclines pulling at it with equal force. Now, if a boss be bell-mouthed, the curved line thereby formed represents an incline which pulls at the oil, that has a tendency to run off the bearing along the shaft; and the contention between the two forces prevents, as in the case above, the oil from running away until the angle formed between the boss and the shaft is filled up, as

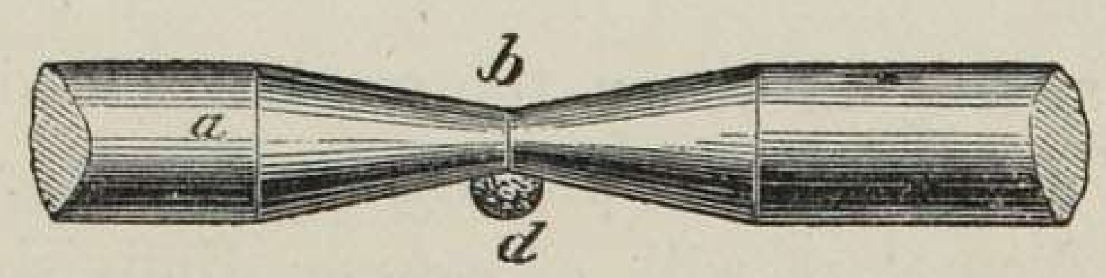


Fig. 232.

here shown (*Fig.* 233), in which *a* represents the shaft, *b* the bottom step, *b*1 the top step, and *cc* the angles in which the oil gathers when the shaft is at rest, but when working it is drawn inward and diffused over the bearing. When the boss *b* is left with sharp edges, there is no such angle, and the oil runs away. So it is with the steps of shafting.

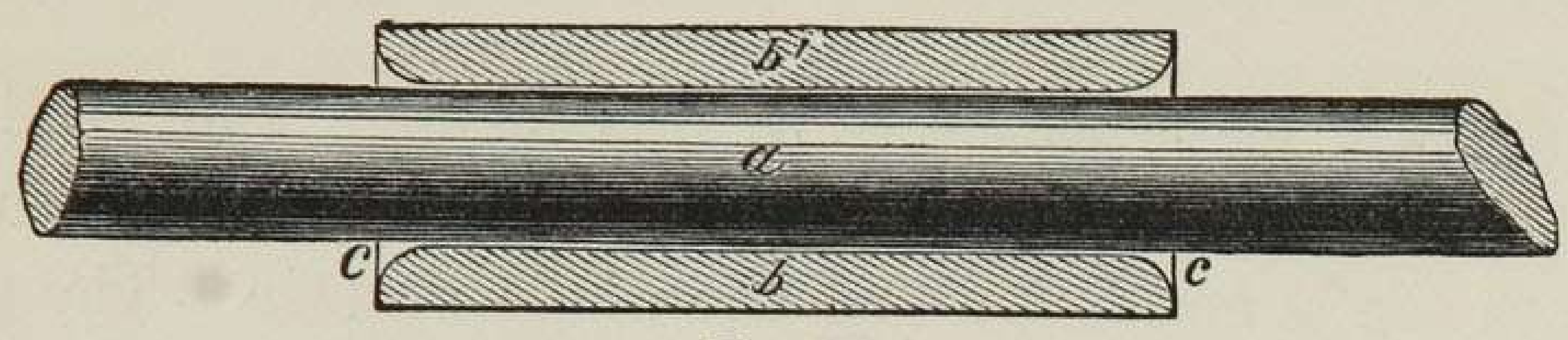


Fig. 233.

If steel shafting be run at 400 revolutions per minute, and well supported in a straight line, very small diameters are sufficient to drive an enormous power, so far as torsion is concerned; as at that speed a shaft of 1-inch diameter would drive over 50 horse-power, and one of 2-inch diameter over 400 horse-power, without twisting permanently; therefore the diameter need only be limited by the spring of the shaft.

If the shaft be of great length, and the power intermittent, the spring of a thin shaft becomes inconvenient. A slight elasticity in shafting is beneficial rather than otherwise; and for turning throstles, or any other constant frames, a considerable spring is not felt. Supposing very light shafting exists in a mill, and it is required to drive mules, looms, or other intermittent machinery, its elasticity may be neutralised by connecting three or four lines together by straps and pulleys placed near the ends. If the pulleys be 3 feet in diameter, well balanced, and the shafts run 400 revolutions per minute, the speed of the connecting straps will go nearly 3,800 feet per minute. and will run for years, giving no trouble whatever in either piecing or tightening Although steel shafts, at 400 revolutions per minute, would absolutely drive the powei above named before breaking or twisting, if kept in a straight line and well supported, it is not recommended, in practice, to exceed one-eighth of a shaft's capabilities, and in no case to put in small diameter shafts without plenty of bearings, which, however numerous, do not add to friction. High-speed shafts diminish friction, because all the belts can be run through more space, with larger pulleys on the machines, and thereby work slacker, which effects an important saving in less piecing and greater durability of straps. With very long shafts the diameters will, of course, diminish as the work is performed.

HOLLOW SHAFTING.

Hollow shafts, made from lap-welded tubes, 4 inches diameter, with solid ends, may be advantageously used in all cotton mills; and if properly coupled and run at 400 revolutions per minute, all the machines, except the scutchers, roving frames, and throstles, may be driven direct from the bare shaft, which is both neat and simple. After such shafting is turned and polished it should be balanced from the centres, then bored and chased, as shown in *Fig.* 234, if intended to be turned to the right, as shafting is generally run. A solid steel bearing, similarly chased at the ends, will couple them together and be self-tightening. Of course, if it be imperative that a

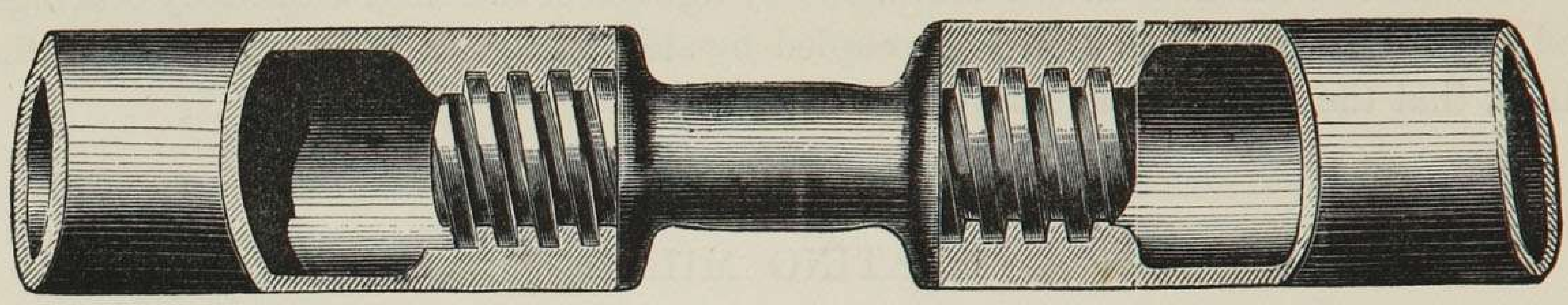


Fig. 234.—Coupling for Hollow Shafting.

shaft should run to the *left* the screws must be reversed. If these bearings are carefully turned from dead centres, so as to be perfectly round and slightly barreled to retain the oil, the shafts will run with exceedingly little friction, require but little oil to lubricate and power to drive them. The diameter of the gudgeon must be regulated by the power each shaft has to drive, and the whole will make a neat, rigid, and effective job. The rigidity of such tubular shafts against the pull of the belts is greater than that of solid iron of the same diameter; and if the belts are arranged to pull against each other, there will be the least possible amount of friction. In some cases, shafts of this description can be made to drive machinery in the room above, upwards as well as downwards.

In America, hollow shafting made from gas-piping, coupled with right and left-hand screws, is said to have been at work in the Georgia Mill, Providence, R.I., for seventeen years without repair. In this mill there are three principal lines of hollow shafting, extending through the whole length of a room 250 by 70 feet, working all the cards, drawing and fly frames for 15,000 spindles, and also about 250 looms on a floor above. The machinery is driven from the bare shafts only $2\frac{3}{4}$ inches diameter. running at a speed of 600 revolutions per minute.

A plan of coupling hollow shafts with a steel gudgeon or rod of $1\frac{1}{4}$in. diameter and 12 inches long, with threads of a screw cut on each end, and screwed into holes tapped into the ends of the hollow shafts, has likewise been brought into operation in America by Mr. Andrew Robeson. This plan is perfectly correct in principle; but it is better to proceed as first mentioned, by turning and balancing the hollow shafts before boring them, and by chasing out the internal screws to a gauge. This makes a truer and better job than tapping. The steel centres should be slightly thickened at the ends, where the screws are cut, so as to leave the screwed part the same strength as the other, and have collars for the shafts to screw against.

The necessity for an improvement in the transmission of power, from the motor to the machines, has become more imperative from the widening of the bays in cotton mills, from 8 or 9 feet to over 10 feet. This difference between the supports is very material, and demands a much heavier solid shaft than formerly; this, of course, adds to the expense, and occasions loss of power in transmission.

Of the two methods shown above, one by light steel shafting, with many bearings, and the other with hollow shafting, coupled by steel gudgeons, it is concluded, on the whole, that the latter is the simplest and best.

HEATING MILLS.

A new plan of heating mills by steam has recently been adopted, and is said to work exceedingly well. Instead of having cast-iron pipes of about 3 or 4 inches diameter, common gas pipes are used of about 1 to 2 inches diameter. These pipes are nowhere open to the atmosphere, but simply connected with the top and bottom of a steam boiler, so that the water arising from condensation is driven back into the boiler.

BELTING.

When steam or other power has been put down in the most economical manner, the next thing to be regarded is its transmission to the various machines with as little loss as possible. In a previous article the advantages of driving all the shafts by quick-running belts was pointed out. It was then stated that the transmission of power in all, or nearly all, the best factories in America was by *double* leather belting sewn together. A better plan of making a broad belt has since come to the writer's notice, illustrated in *Fig.* 235. This belt can be made with the greatest ease, of any

Fig. 235.—Patent Driving Belt, same on both sides.

thickness or width, perfectly equal in texture throughout, and alike on both sides. It is made by cutting up the hides into strips of the width of the intended thickness of the belt, and setting them on edge. These strips, *Fig.* 237, have holes punched through them about one-eighth of an inch diameter, and one inch apart. Nails made of round wire, clenched up at one end for a head, and flattened at the other, *Fig.* 236, are used, as shown in *Fig.* 238, for fastening the leather strips together. Each nail is half the width of the intended belt; and after the strips are all built upon the nails, the ends of the nails are turned down and

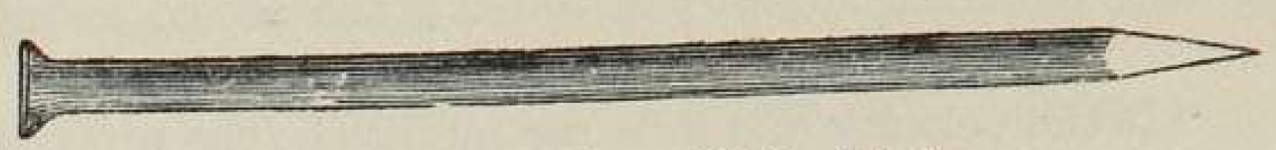
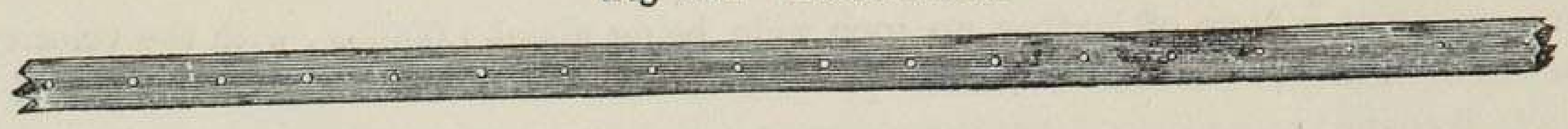


Fig. 236.—Round Wire Nail.

Fig 237.—Leather Strip.



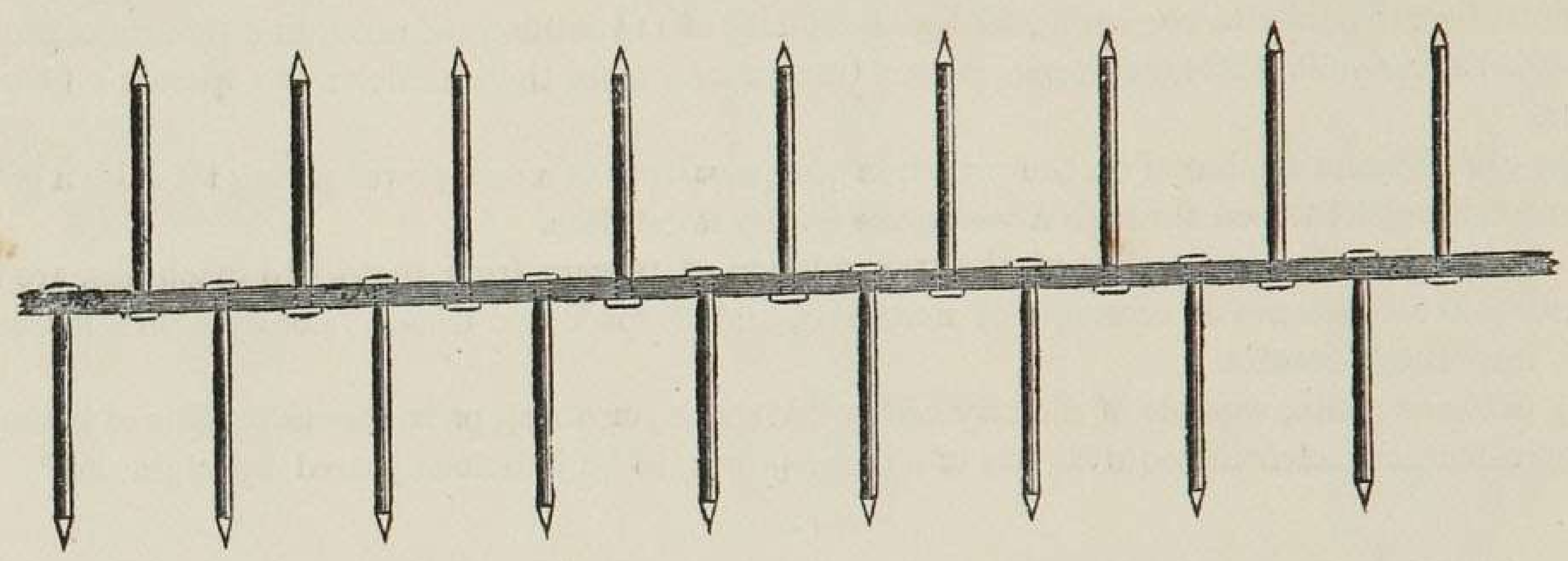


Fig. 238.—Nails, as put through Central Leather Strip.

driven into the leather, thus making a firm strap without any kind of cement or splicings. When the strap is required to be tightened, it is only necessary to take it asunder, where the step lines are shown in *Fig.* 239, cut off from one end of the strap at each step what is required, and piece up again with wire nails, or laces, going entirely through the strap.

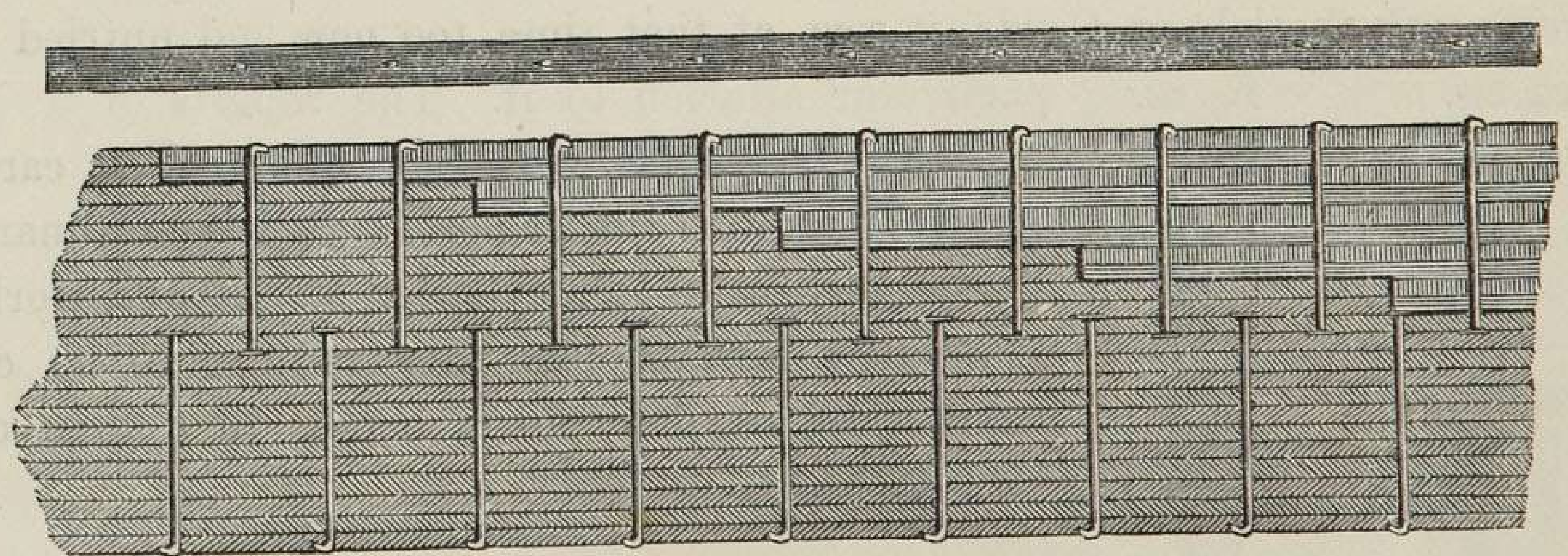


Fig. 239.—Section through Belt, showing Piecing.

In an interesting paper on this subject, read by Zechariah Allen, Esq., at a meeting of the New England Cotton Manufacturers' Association, he gave the following "Theoretical Rule for calculating the Tension necessary to be imposed on a Belt for transmitting a Horse-power:"—

"The standard of 'a horse power,' generally adopted, is the measure of force that is sufficient to raise 33,000lbs. 1 foot high, in a minute, or 1lb. 33,000 feet high in a minute.

"It is only necessary to divide this standard measure of 33,000lbs. by the number of feet velocity per minute, of the belt, and the quotient will indicate the actual tension (in lbs.) required to be imposed on the belt to transmit one horse power.

"If the velocity of a mile per minute be the proposed speed of the belt, then 33,000 ÷ 5,280 = the number of feet in a mile, shows 6¼lbs. tension on the belt, requisite to transmit *one* horse power.

"If 80 horse power is required to be transmitted, then 80 × 6¼ = 500lbs. tension will be imposed on this belt. If the belt be made 6 inches wide, the tension will be 83lbs. to each inch of width.

"If 6,000 feet be the proposed velocity, the tension will be reduced to 5½lbs. to the horse power; and with a tension of 1lb., and velocity of 33,000 feet per minute, a thread, strong enough to sustain a pound weight, might serve to transmit a horse power to a distance.

"The ultimate strength of a strip of leather, an inch wide, being about 1,000lbs., with the velocity of a mile per minute its ultimate strength might transmit 200 horse power before breaking, and with the velocity of 33,000 feet per minute, might serve to transmit more than 1,000 horse power. But if the velocity could be increased to the speed of the transmission of solar power to the earth, with the velocity of 11½ millions of miles in a minute, a pack thread would be strong enough to transmit 1,824,000 horse power, being much more than sufficient to operate all the machinery in Great Britain.

"All these calculations are based on the principle of equivalents of a less power acting through a greater extent of space, and a greater weight raised through a less space in the same time.

"In this choice of means and modes of the transmission of powers from motors to machines, are available most important incidental advantages of economy of materials, and of space and time; velocity with a feeble power accomplishing most important results.

"A costly cable or chain, capable of directly lifting 33,000lbs., or cheap pack thread capable of lifting only 1lb., are, under different velocities, scientific equivalents of a horse power, to be judiciously used by engineers."

LATEST IMPROVEMENTS IN MACHINERY, &c.

So far as cotton-spinning machinery is concerned, the writer is not aware of anything of marked importance having been introduced during the last two years, excepting *Ashworth's Patent Flattened Wire Cards.* Although aware of this invention when writing the article on Cards, it was, at that time, too new and untried to make particular allusion to it. The reports of its working appear to be, so far, very favourable. The cards keep sharp for a much longer period than the ordinary round wire cards, make less cylinder strips, and work better generally; nevertheless they require to be carefully ground up, at first, for a longer time than ordinary wire cards.

Improvements in detail are always going on; amongst which may be mentioned *Booth's Patent Steps,* for slubbing, intermediate, and roving frames, throstles, &c., which are said to work very satisfactorily. *Figs.* 240 and 241, annexed, show their form.

Fig. 240.

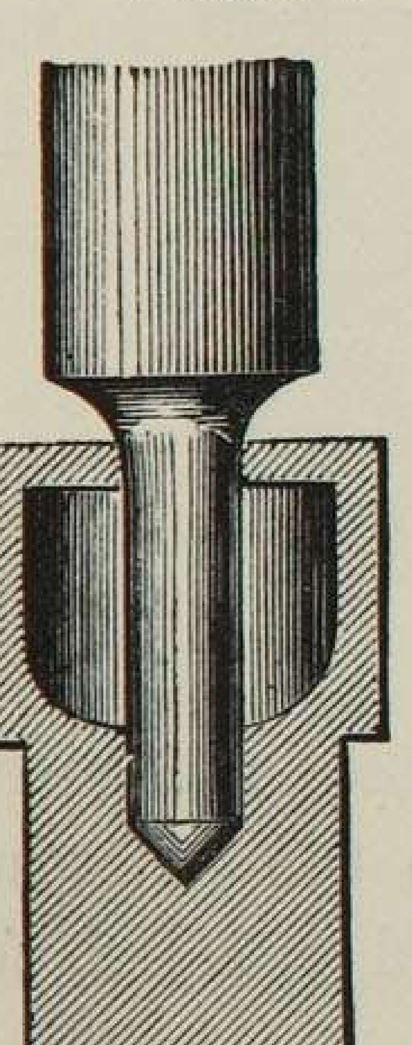
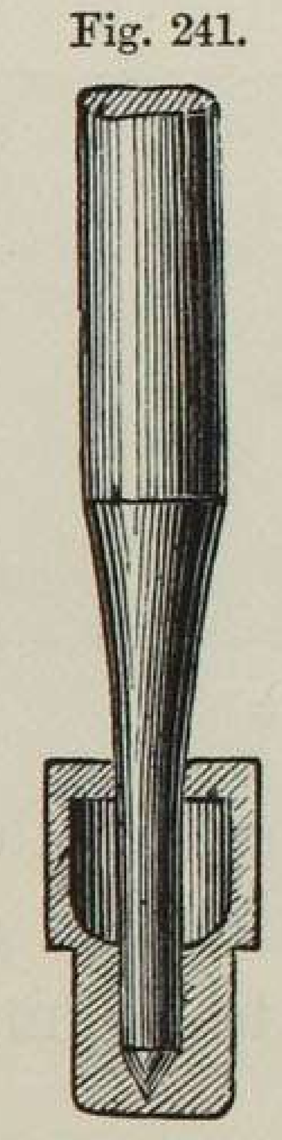


Fig. 241.



Booth's Patent Steps.

An improved form of *Bolster* for similar frames, shown in *Figs.* 242, 243, 244, was patented some time ago by Messrs. Curtis, Parr, & Madeley. This bolster has been extensively adopted, and is said to work well. *Fig.* 242 represents the stationary bush, and bobbin wheel, as commonly used. *Fig.* 243 shows the patent loose revolving bush, which rotates freely in the stationary bush (fig. 242), and is made to revolve by means of a pin under the flange, which enters a small hole in the top of the bobbin wheel. *Fig.* 244 is a section of the stationary and revolving bushes, bobbin wheel,

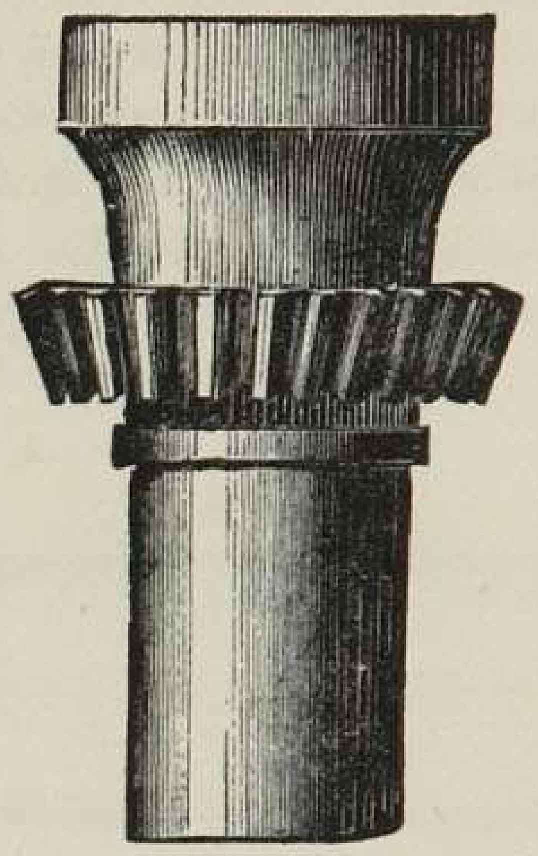


Fig. 242.

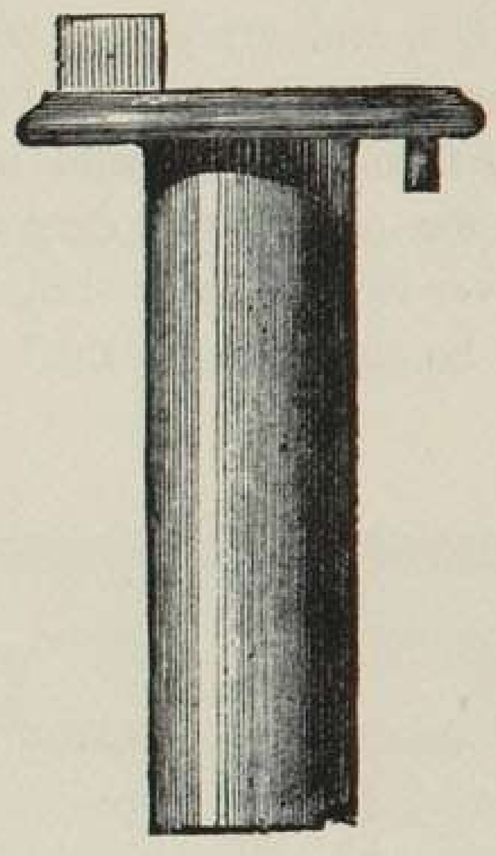


Fig. 243.

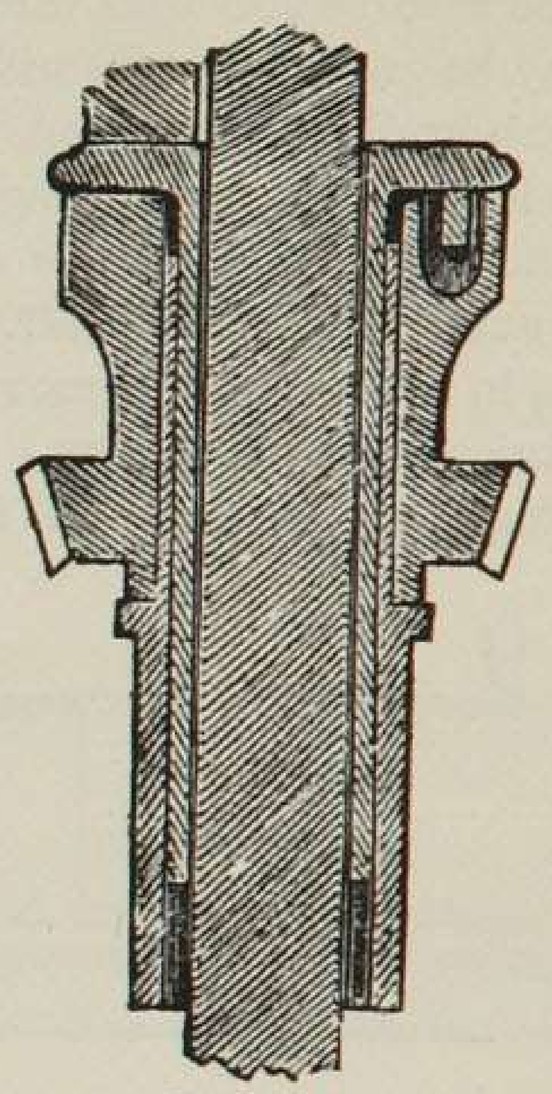


Fig. 244.

and spindle. The advantages obtained by this form of bolster are: (1) The spindles, by revolving in the patent bushes, are prevented from wearing, because they and the revolving bushes rotate in the same direction; and from experience it is found that they have no tendency to wear unround, even when the flyer is out of balance. (2) The spindles not wearing or becoming unround, their highest speed can be retained for a longer period. (3) A saving of oil and power; the bushes being made of polished cast iron, and working in the same position during the lifting of the bobbin rail, whereby the oil is retained on the working surfaces. (4) They only require lubricating three times per week, which is easily performed by lifting the loose bush by the flange. (5) The flange of the revolving bush forms a cover for the working parts, and prevents the oil getting on the bobbins.

An Improved Method of Grinding the Cylinders of Carding Engines has been brought out by Messrs. Dronsfield Brothers, of Oldham. A sketch and description are given below, (*Figs.* 245, 246, 247):—

"The Improved Apparatus illustrated above is specially designed to effect the grinding of Carding Cylinders and Doffers in a more thoroughly and efficient manner than when the ordinary apparatus, or an emery roller or strickle, is employed for the purpose. The Apparatus and the method of application are illustrated in the above drawings, wherein *Fig.* 245 represents a front view; *Fig.* 246 a cross section; and *Fig.* 247 an end view of the Apparatus, shown as when grinding the surface of the main cylinder of a Carding Engine. The grinding is, in this case, effected by means of a circular flat plate *a* instead of by the ordinary strickle or roller. This plate is fitted with a steel shaft, which revolves in bearings formed in the frame *b*; and on the said shaft is fixed a bevel wheel *c*, which gears with the bevel wheel *d*, which latter bevel wheel is mounted to slide on the screw shaft *e*, and is fitted with a fast key which enters a groove in the said shaft. The shaft *e* is mounted in bearings formed on the circular end plates *f f*, and is cut with both a right hand and a left hand thread, the frame *b* being fitted with a shunting key, which works in each of the two threads alternately, so that when the screw shaft is caused to revolve, by means of the strap pulley *g*, the frame *b*, together with the circular plate, will be traversed to and fro across the surface of the cylinder, and, at the same time, the grinding plate will be caused to revolve rapidly by means of the above-mentioned bevel wheels. These combined motions of the grinding plate produce a very uniform effect over the whole surface of the cylinder, and the peculiar action of the circular plate, by reason of the constant changing of the direction of motion of the particles of emery as they pass over the wires, cause each wire to be rapidly ground to a round and sharp point. In order that the ends of the cylinder may be ground equally with the central portion, means are employed whereby the grinding plate is caused to make a slight dwell on arriving at either end of its traverse. The end plates *f f* are each formed with a projecting piece, to fit in the ordinary bearings or brackets *h h*, and are connected together by the cylindrical cover *i*, and by the rod *k*, on which slides a bracket *m* attached to the frame *b*, in order to prevent the rotation of the traversing frame *b*, around the axis of the screw shaft. The bearing formed in the said bracket is fitted at each end with stuffing boxes. The stuffing in the said boxes preventing the access of grit and dust to the said bearing, and keeping the rod *k* clean and well lubricated. A portion *l* of the said cover is made as a sliding door, by means of which access may be had to the traversing frame in order that the same may be cleaned or oiled."

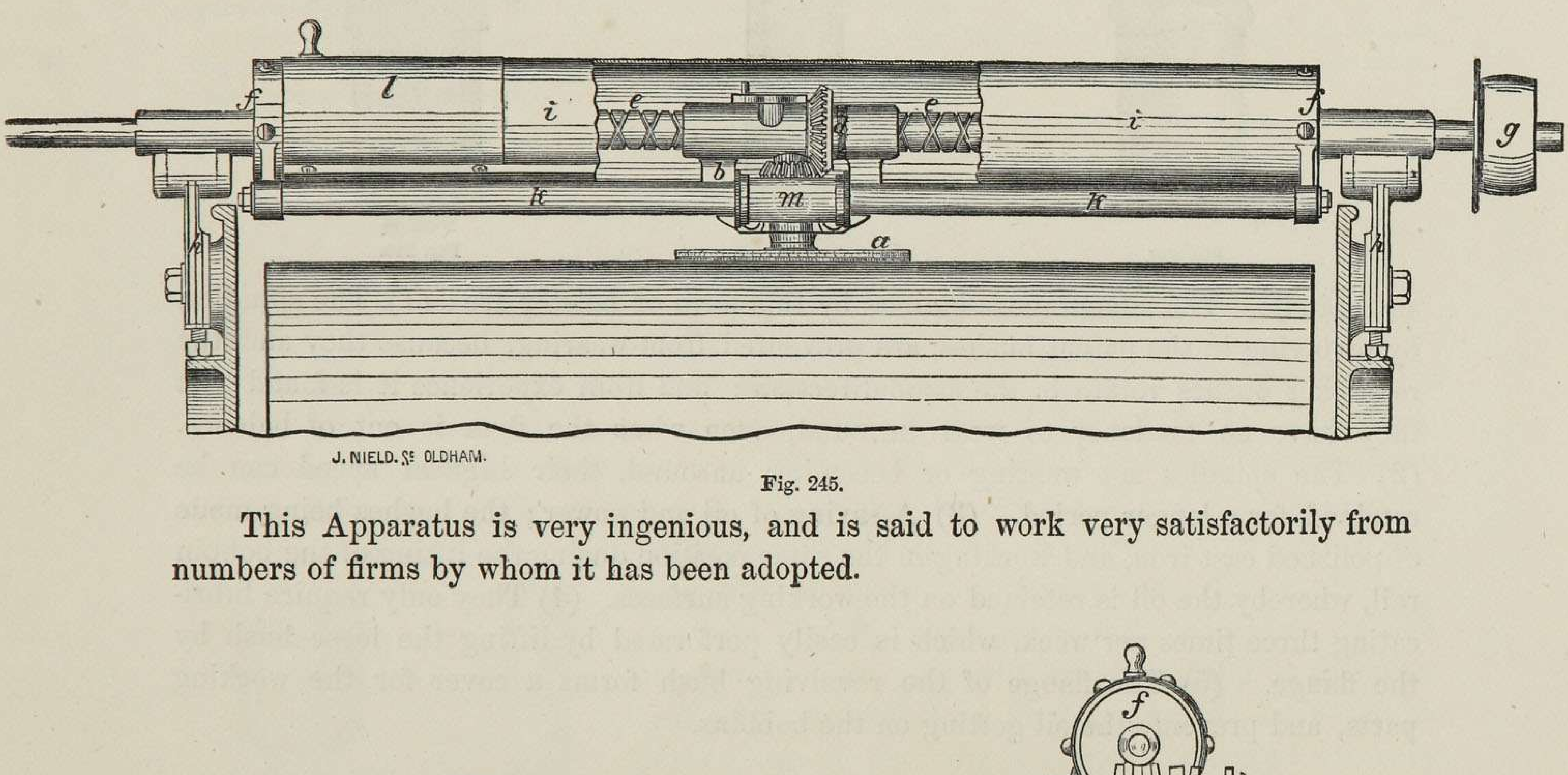


Fig. 245.

This Apparatus is very ingenious, and is said to work very satisfactorily from numbers of firms by whom it has been adopted.

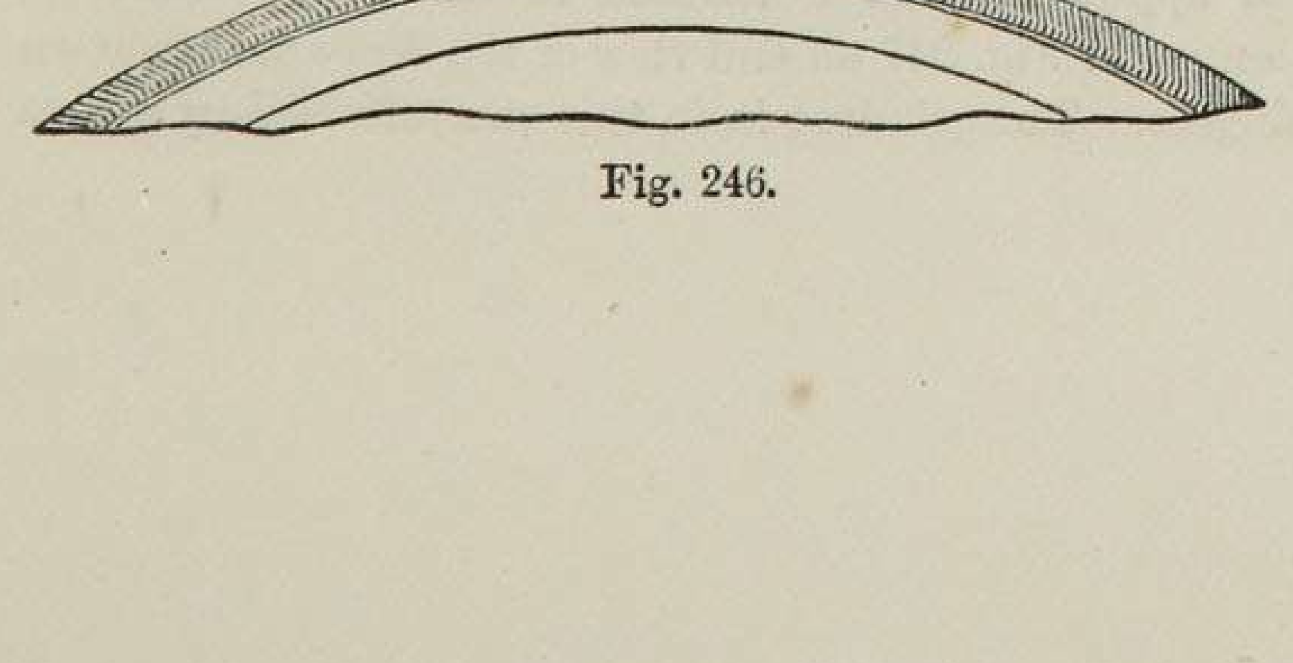


Fig. 246.

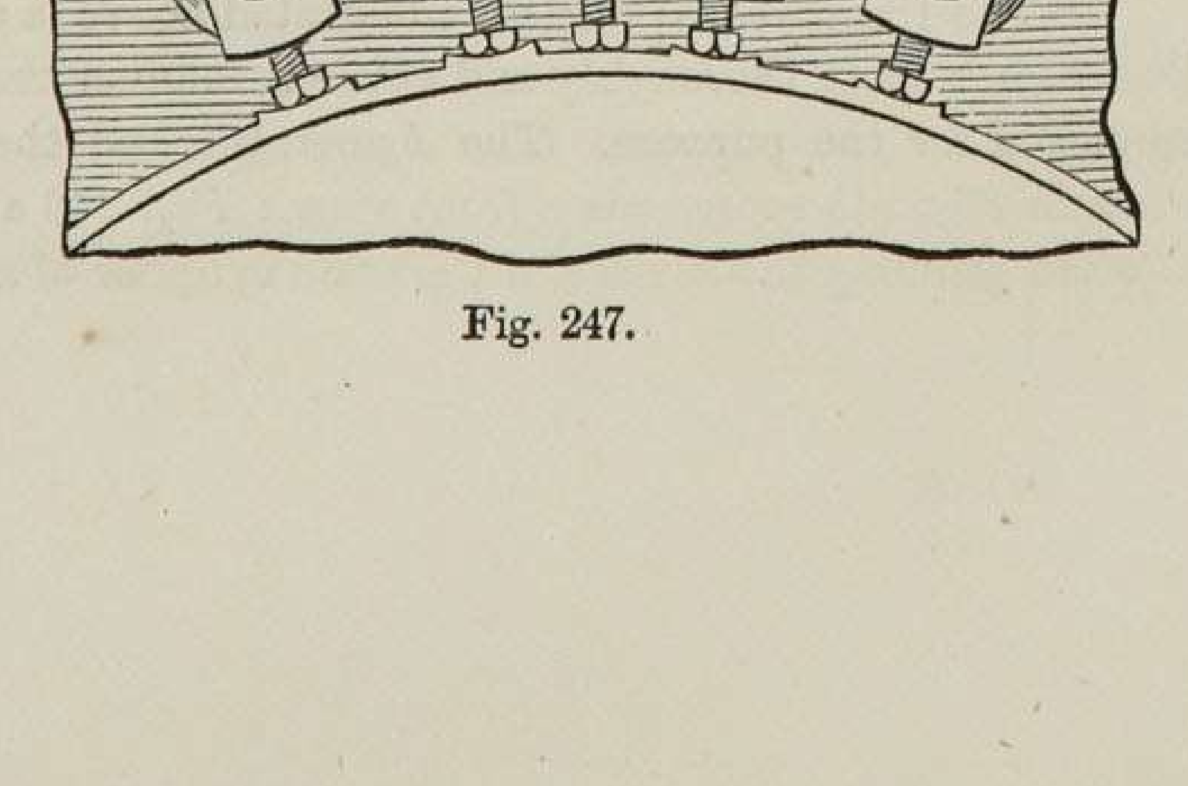


Fig. 247.

An Improvement in Slubbing and Roving Frames has just been effected by Mr. John Elce, of this city, by which the bolster and step rails and the driving of the spindles are better arranged. The bottom cone is suspended upon levers, and the cone strap tightened or slackened at pleasure by a screw with a handle upon it. Instead of the usual train of spur wheels connecting the ascending and descending shafts which drive the bobbins, and lose their direct action by the bending of the arm, thus making a difference of many teeth in transmitting the differential motion between the top and bottom of the lift, this is accomplished by a short swinging shaft and bevel wheels. The bottom bevel has a heavy boss, and slides up the shaft, by a sunken key, in order to effect the necessary lengthening and shortening of the arm. One shaft only is used in driving both bobbins and spindles. The bevels gear on opposite sides of the swinging shaft, and thus compensate each other for the loss or gain in moving up or down.

Heilmann's Combing Machine is now becoming extensively used; and, in addition to the original makers, Messrs. J. Hetherington & Sons, is made by Messrs. Platt Brothers & Co., and Messrs. Dobson & Barlow. The portrait of Heilmann, which was not received in time for publication when the article on Combing was written, is given below.

Fig. 248.—Portrait of Heilmann.

Referring to the Scutching of Cotton and *Lord's Self-Regulating Feed*, it has been already stated (page 66) that Mr. Lord had recently brought out a new motion, designed to dispense with the cones and strap, and it was then said that this plan would be illustrated, if successful. Mr. Lord now states that although the cones and strap can be avoided by his new plan, he does not think, on the whole, that it is any improvement.

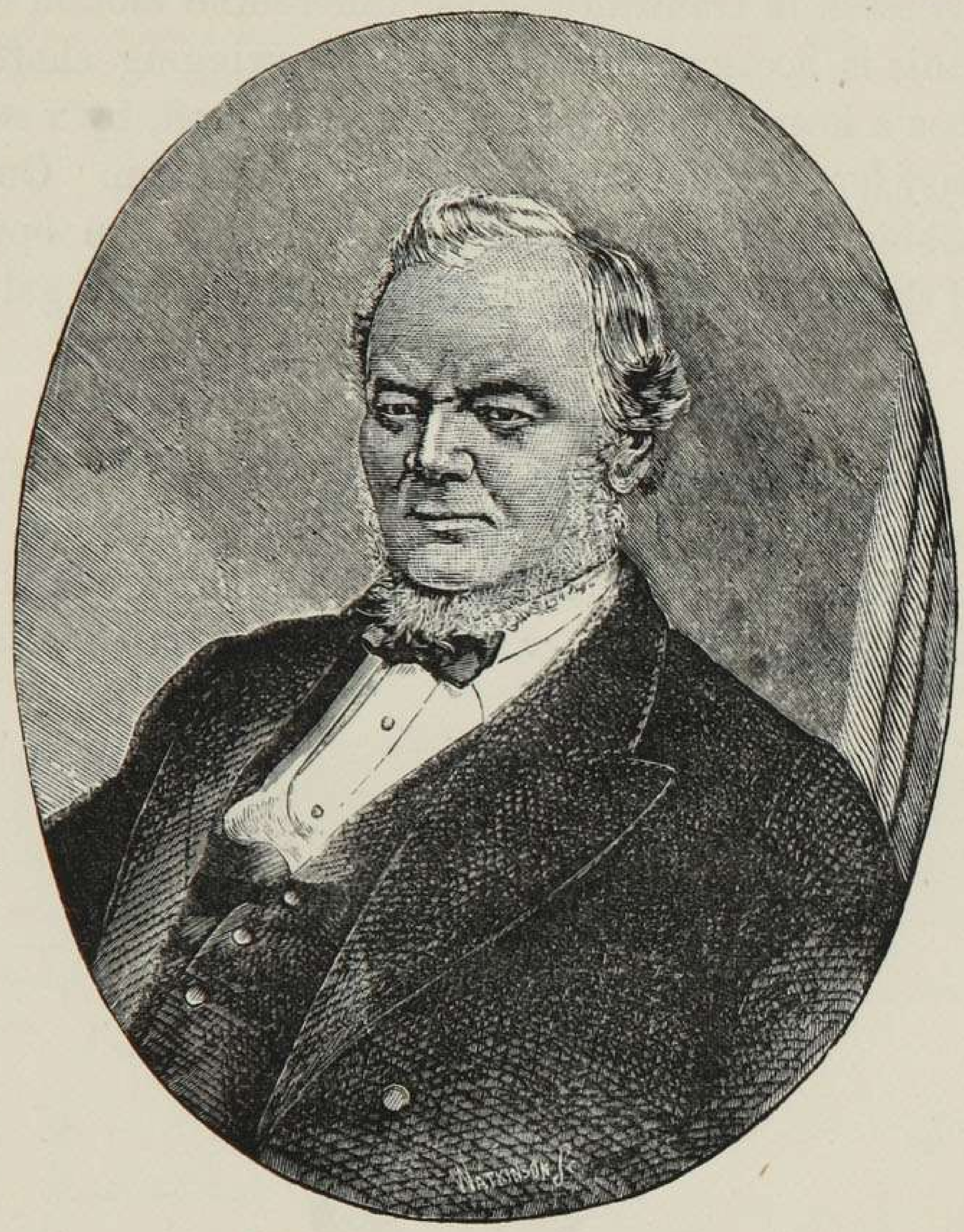


Fig. 249.—Portrait of Edward Lord.

An Interesting Improvement in Mule Spinning has just been patented by Messrs. Dobson and Barlow, of Bolton, which not only simplifies the headstock of self-acting mules, but has otherwise a beneficial effect upon the yarn, and improves the spinning. Instead of stopping the rollers when the carriage gets out, and during the after-draft in fine spinning, they are put upon a very slow speed, which continues during the putting-up of the carriage, as a letting-off motion, until the carriage gets nearly home. The idea embodied in this invention is very important, and might, with great advantage, be carried still further in all mules by never stopping the rollers at all, but merely putting them to a very slow speed during the twisting at the head and winding on This would not only simplify the mule, but prevent the evil effects arising from the spring in the long lines of rollers, the ingiving of which turns the rollers forward a little when stopped at the head, and prevents them starting again instantaneously along the whole line. This causes breakage and bad spinning, aggravated as the rollers get slack in the squares, and would be entirely avoided by a continuous motion forward.

Mule Rollers.—Considerable diversity of opinion exists amongst spinners respecting mule rollers. In Manchester, Stockport, and surrounding districts, two threads to a boss are preferred, and most of the mules intended for export to foreign countries are thus made; but in Ashton, Stalybridge, Hyde, Glossop, and neighbourhood, three threads to each boss is a general rule. In Oldham and its vicinity three threads to a boss are used for twist, and four threads to each boss for weft mules; whilst in Bolton, Preston, and their localities only one thread to a boss is common, with fixed cap bars; the middle and back top rollers being self-weighted, solid rollers, the same that are in use in throstle spinning.

The Manchester spinners contend that it is easier to piece the broken ends with two threads to each boss, and that they can adjust the front roller to any length of staple by the sliding cap bar. All the top rollers, on this system, are covered with cloth and leather, and they are weighted by levers, saddles, and bridles. The advocates of the three and four thread bosses assert that their system is simpler and neater, as they require fewer saddles, bridles, and weights, which more than compensate for the greater difficulty in piecing. The one-thread boss spinners say that their method is sounder in principle; that the middle and back rollers require neither covering nor weighting; that the front roller, being weighted by a dead weight, is more uniform than any system of levers, saddles, &c.; that no slides are required for adjusting the front roller, because the middle roller being of plain iron, with only its own weight bearing upon the roving, the longer fibres of cotton can be drawn from under it, however closely the rollers are set to each other, and the cap bars being cast all alike, the top rollers are sure to be parallel with the under rollers; also, that the rovings when coming through are each held by a gentle and equal pressure to the under rollers, as each roving has half the weight of the middle and back roller upon it; and if a lump or mote comes through the lifting of one side of the top roller, this cannot affect the hold it has upon the other roving or thread. All these advantages, they say, more than counterbalance the extra complication, difficulty in piecing, accumulation of dirt, and other inconveniences of the single-thread boss rollers.

There can be no doubt that the Bolton spinners have, on the whole, the best of the argument; and if the only drawback they experience be removed as shown in *Figs.* 250 and 251, the greatest perfection in mule top rollers will be attained. *Fig.* 250 represents a plan, and *Fig.* 251 a section of mule rollers as they ought to be. The front roller is a loose-boss roller, and has two threads to each boss. It may be weighted by lever or by dead weight, as shown; the middle and back are of plain iron, uncovered and self-weighted. Referring to the section, *Fig.* 251, it will be seen that the top rollers are set a little forward of the under rollers, the object of which is to prevent vibration or shaking when the carriage goes in. The clearers should be of dry deal, very light, but of sufficient diameter to rest on the front and back rollers, just missing the middle roller.

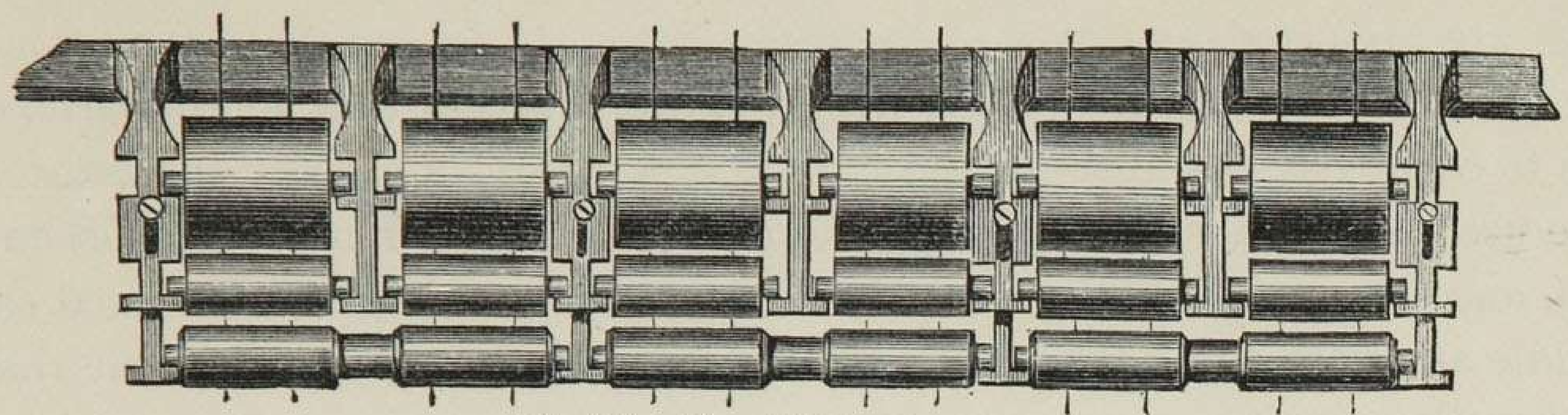


Fig. 250.—Plan of Mule Top Rollers.

If mule top rollers are made according to the above plan, the very best results will follow, both in good spinning, general cleanliness, saving of oil and power, and easiest piecing.

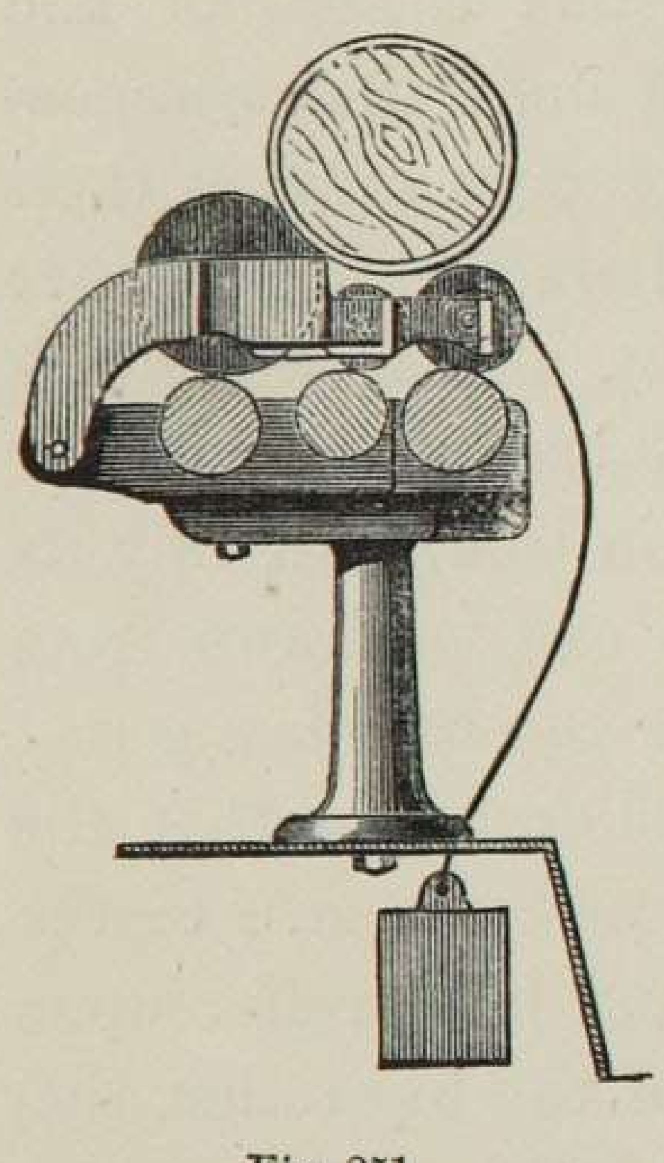


Fig. 251.
Section of Mule Rollers.

Cap Bars and Slides.—So far as cotton spinning is concerned, it may be said that the palmy days of great inventions are over. But as the ocean is composed of drops of water, and mountains of atoms, small improvements have, in the aggregate, important results, and should not be despised. As the room is now circumscribed, and the manufacture of vast extent, an ounce of metal saved, where it is not needed, but creates an inconvenience by the space it occupies, is of consequence. It seems never to have been hitherto thought of, that there is an unnecessary complication about *cap bars and slides*,—a complication, too, which causes extra fitting where it is not only useless but injurious: for instance, in placing a back support to the top rollers on the nibs of cap bars, and on the slides of drawing frames. It should be always remembered that in drawing cotton the rollers only move *in one direction*, and the pressure is consequently thrown entirely upon the front support; therefore, to retain the back support is worse than useless, because it is in the way when cleaning the pivots. How much easier, and how much more accurately, cap bars and drawing frame stands may be fitted without this mischievous appendage. Many a patent has been taken out for less useful things. A reference to *Fig.* 250 will show what is meant; and the same thing applies to all slides and cap bars thoughout a mill.

COTTON.

The following interesting analysis of the fibres of seven different species of cotton has been kindly presented to the author by Dr. Crace Calvert, F.R.S. The researches were undertaken in consequence of some cotton yarn being sent to his laboratory to ascertain if any impurity had been introduced with a view of weighting it. To test this, a portion of it was steeped for several hours in distilled water, and the solution thus obtained was carefully analysed, and a large quantity of magnesia was discovered in it. The first impression was that chloride of magnesium had been introduced with a view to imparting weight, but further researches detected a large quantity of phosphoric acid, which led to the belief that the yarn had not been artificially weighted with the magnesium salt, but that the magnesia and phosphoric acid extracted from the cotton yarn must exist naturally in the fibre. Accordingly seven samples of cotton were obtained from Liverpool; and after being carefully carded, to remove all seeds or impurities they might contain, 100 grammes of each sample were washed with pure distilled water until all traces of mineral matter were removed. These solutions were then evaporated to dryness, and the residue calcined with a little carbonate of soda and nitrate of potash, and in this calcined mass the amount of phosphoric acid was estimated as phosphate of uranium. The following are the results obtained:—

100	grammes of	Egyptian	Cotton	gave	·055	PO_5.
„	„	Orleans	„	„	·049	„
„	„	Bengal	„	„	·055	„
„	„	Surat	„	„	·027	„
„	„	Carthagena	„	„	·035	„
„	„	Maceio	„	„	·050	„
„	„	Cyprus	„	„	·050	„

These results show that phosphoric acid is a constant constituent of cotton fibre, from whatever part of the world it is obtained; and that out of seven samples examined five contained the same quantity of PO_5, viz. ·05 per cent.

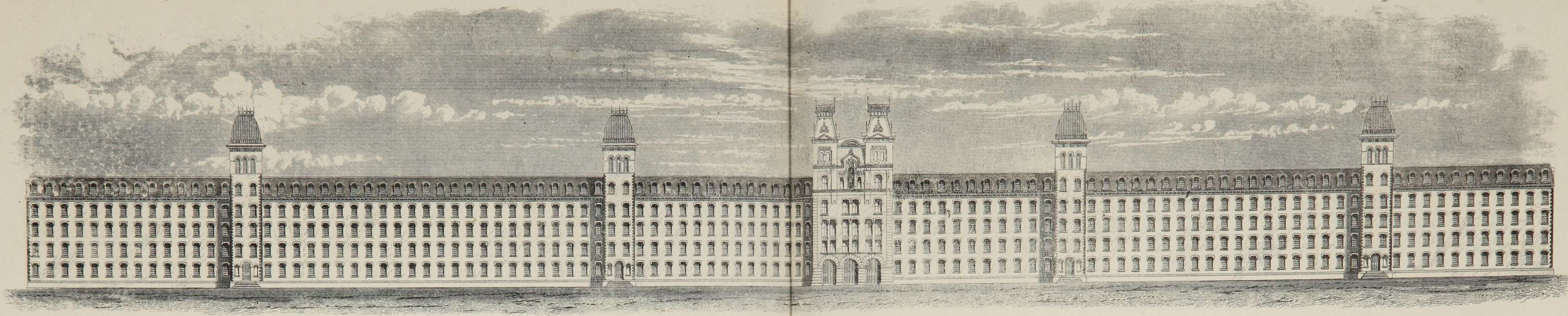
The disastrous effects of the late cotton famine may now be considered fairly at an end, and it is a matter of thankfulness that the United States of America have fully resumed their old position, under free labour, in this production. At page 5 a statement was given of the number of bales grown in the United States each year from 1821-22 to 1869-70, to which may now be added,

1870-71 .... 4,352,317 bales.	1871-72 .... 2,974,351 bales.

Although last year's crop shows a considerable falling-off, it has been made up by increased production in India and other countries, to such an extent that, notwithstanding the increased consumption, there is more cotton in sight now than at this time last year; and the present crop being gathered in the Southern States is expected to exceed 4,000,000 bales.

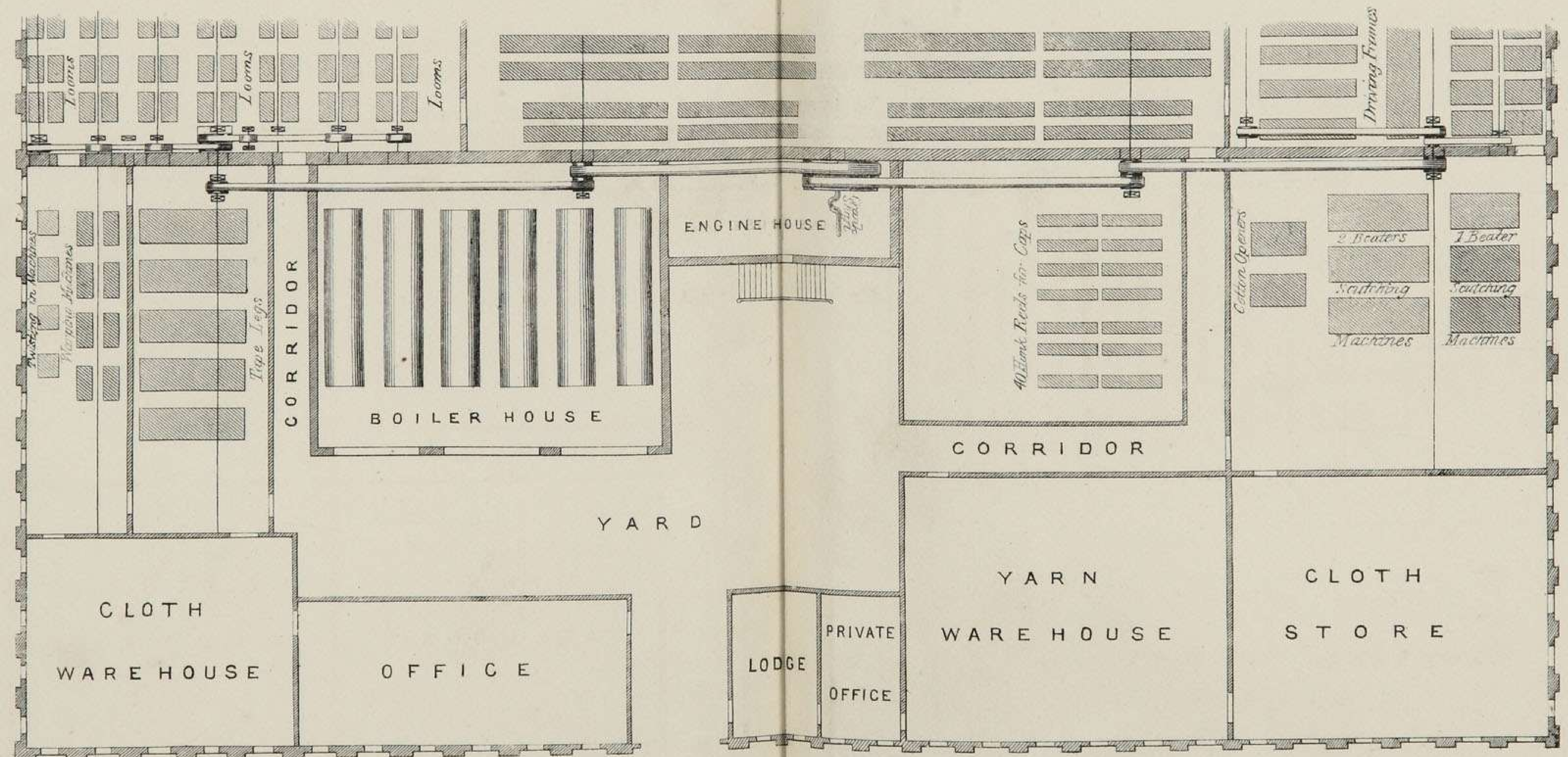
The happy result of an ample supply of the raw material, through the extension of its growth in various parts of the world, so conducive to the prosperity of spinners and manufacturers, and the teeming populations dependent upon the cotton trade, has been mainly brought about by the unwearied exertions of the members of "The Cotton Supply Association," amongst the most able and energetic of whom may be named Sir Thomas Bazley, Bart., M.P., Mr. Edmund Ashworth, Mr. Hugh Mason, and Mr. Malcolm Ross, gentlemen who deserve the lasting gratitude of the British cotton manufacturers, and especially of the people of Lancashire.

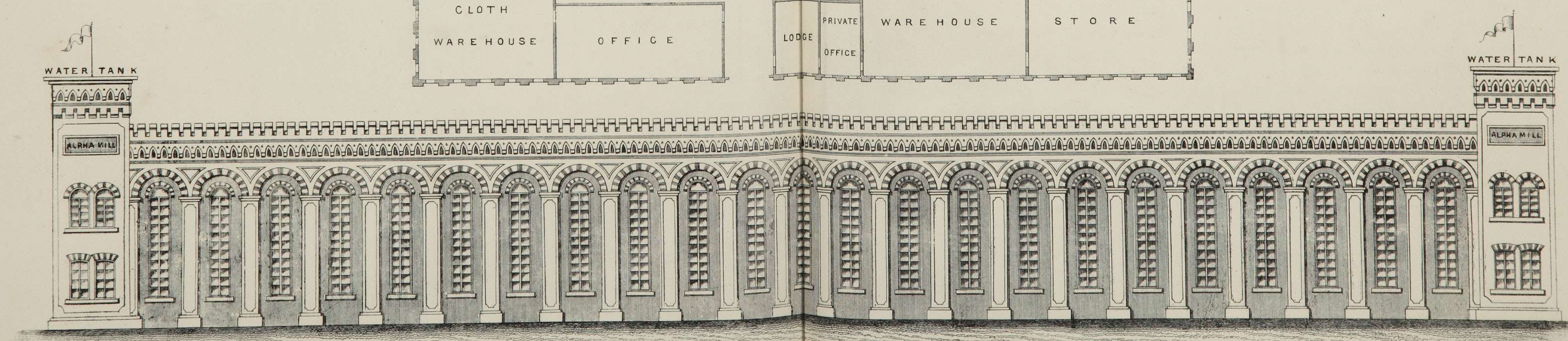
Fig. 252. Portrait of Sir Thomas Bazley, Bart., M.P.



HARMONY MILL AS RECENTLY EXTENDED.

PART PLAN OF ONE STOREY MILL SHEWING METHOD OF DRIVING BY BELTS.





ELEVATION OF ONE STOREY MILL.

SPECULATIVE REMARKS ON THE FUTURE ERECTION AND DRIVING OF COTTON MILLS.

IN the article on "Cotton Mill Architecture" in the early portion of this work examples of various mills were illustrated and described; and, in the article on "Moving Power," it was stated that the subject would be alluded to again, and (page 51) that *one storey mills* were capable of very considerable improvement.

Plate XXXIX. represents, first, the Harmony Mill at Cohoes since it has been enlarged. It is now said to be the longest, if not the largest mill in the world; 1,100 feet in length, 75 feet wide, and five storeys high, and contains a floor space of 412,500 square feet under one roof, not including the ante-rooms.

The next engravings show, in plan and elevation, a design for a *one-storey* mill with the method of driving all the shafting by belts, working horizontally. The floor may be of concrete or asphalte boarded over, or of wood pavement set in a mixture of bitumen and sand, used hot, and the walls may either be built of concrete or skeleton walls of bricks set with bitumen and sand run in the same manner, and afterwards lime pointed outside. This makes a cheap and exceedingly strong wall, quite impervious to wet, and perfectly dry as soon as erected. The room should be lofty, with long windows all round, sufficient to light it without dome lights, and the flat roof must be of concrete or asphalte. The roof may be utilized as garden ground, if laid out in walled beds and walks; the soil from below might be about two feet deep in the beds, and, being irrigated from the tanks and manured from the dry earth closets, would be highly fruitful. A portion might be covered in with glass, where the vine might be cultivated extensively and profitably, for the walks would always be clean, and weeds got rid of altogether—reducing labour to a minimum.

Cottages, built the same height as the mill, but of two storeys, flat roofed, applied to the same object, irrigated and manured in the same manner, would give each tenant his plot of garden ground for growing vegetables, fruits, or flowers, in the cultivation of which the occupiers might rival each other, and find innocent and healthy recreation. The houses should have no fire places, but be supplied by steam from the works for heating and cooking, baths, washhouses, &c. All the closets, both for the houses and mills, should be dry earth closets, as already used by Messrs. Strutt, of Belper, which are perfectly clean and without the slightest nuisance, the dry soil forming, after being used three times over, a sort of guano, which is eagerly bought by the farmers at seven shillings per ton.

The great convenience attending works where all the operations can be performed on one floor would compensate for considerable extra cost; but if judiciously erected in the country, where land is cheap, there would be no extra cost, and a superior class of operatives would be attracted by the moral and physical advantages offered. The principle affords scope for mills of any size, as they are not limited in length, and two may be erected together, with power, warehousing, &c., in the middle. The physical wants of the operatives may be provided by stores on the co-operative principle, and the mental wants by library and reading-room, which, together with in and out-door amusements, would give a higher tone to the factory system; and while assuring the success of the proprietor, would add much to his own and his employés' comfort and happiness.

It has often been said that "there is nothing new under the sun." Herodotus, the father of history, gives a glowing description of the beautiful hanging gardens of ancient Babylon; but connected with the factory system, such gardens could be far more profitably cultivated, and the land occupied by the works doubly redeemed, as the drainage would be perfect, irrigation and artificial heat convenient, and walks always clean without labour. High winds carry the seeds of noxious weeds over the walks and beds of gardens on *terra firmâ*, which can only be kept in tolerable order by the sweat of the brow, to say nothing of imperfect drainage and other inconveniences.

The productiveness of the soil under a state of high cultivation in such "hanging gardens" would be many-fold that of ordinary gardens, with a tithe of the labour. All this, however, is of secondary moment to the advantages of a more refined factory system, the main object sought.

WATER POWER.

In treating upon this subject it is not intended to enter into detail, or to repeat what has been so ably written by Sir William Fairbairn and others, who have made water power a special study, but simply to point out that, except in some peculiar situations where the fall is under six feet, all the experiments which have been tried to utilise ordinary waterfalls to the greatest advantage and economy have led to the conclusion that the Breast Wheel, with ventilated buckets, and the Turbine, give the best results. For moderate falls and slow speeds it is doubtful whether any known machine will excel the properly constructed breast wheel in simplicity and durability;

but for driving cotton machinery, which requires a rapid speed, the turbine is undoubtedly the best, because it takes its motion from the bottom of the fall, where the speed of the water is quickest, whilst the breast wheel takes its motion from the top of the fall, where the speed of the falling body is slowest. All bodies fall with a constantly accelerated speed, and, if unimpeded, pass through 16 feet of space in the first second of time, 48 feet more in the next second, and 80 feet in the third, and so on, continually increasing their speed by 32 feet every second, therefore the

Fig. 253.—Portrait of Sir William Fairbairn, Bart. *(Reduced from Portrait in "Engineering.")*

higher the fall the less costly is the turbine for any given power, inversely to that of the water wheel, which is more costly for high falls and cheaper for low falls than the turbine. But the turbine is better from the fact that it starts off at a higher velocity than the water wheel, therefore requires less gearing to get up the necessary speed of shafting for cotton mills. Suppose the fall to be 16 feet, and the water be conducted down a pipe that length, as in the case of the turbine, the water at the bottom of the pipe presses with a force equal to about 7lb. to the square inch, and would gush out of an orifice at a speed of 32 feet per second of time, because, although it only falls

16 feet during the first second, it has attained a speed of 32 feet per second by the time it has reached the first 16 feet. If it could continue its descent, it would attain a speed of 64 feet at the end of the next second, and would reach a speed of 96 feet at the end of the third second. Now, recurring to the fall of 16 feet and the pressure of the water at that depth, it is evident that the periphery of a turbine wheel can go three or four times faster than that of a water wheel, that acts altogether by gravitation, and the turbine both by gravitation and impact. The periphery of a breast water wheel can only go at a maximum speed of about five feet per second with advantage, whatever be the height of the fall. If it goes faster it overruns the natural gravitation of the water and wastes the power, therefore it is only properly adapted for slow speeds. Quick speeds can only be got from it by a multiplication of heavy gearing, occasioning a loss both of capital and power.

Formerly water wheels were constructed of wood, but they are now made entirely of iron. A fine specimen, by Smith of Deanston, is shown in *Fig.* 254, which is very imposing in appearance. This wheel is 70 feet in diameter, and 12 feet wide, being equal to about 200 horse power. Other fine specimens, similar in principle, but not quite so large in diameter, had been previously erected at the Catrine Works, in Ayrshire, by Messrs. Fairbairn & Lillie, and, later on, at the Deanston Works, in

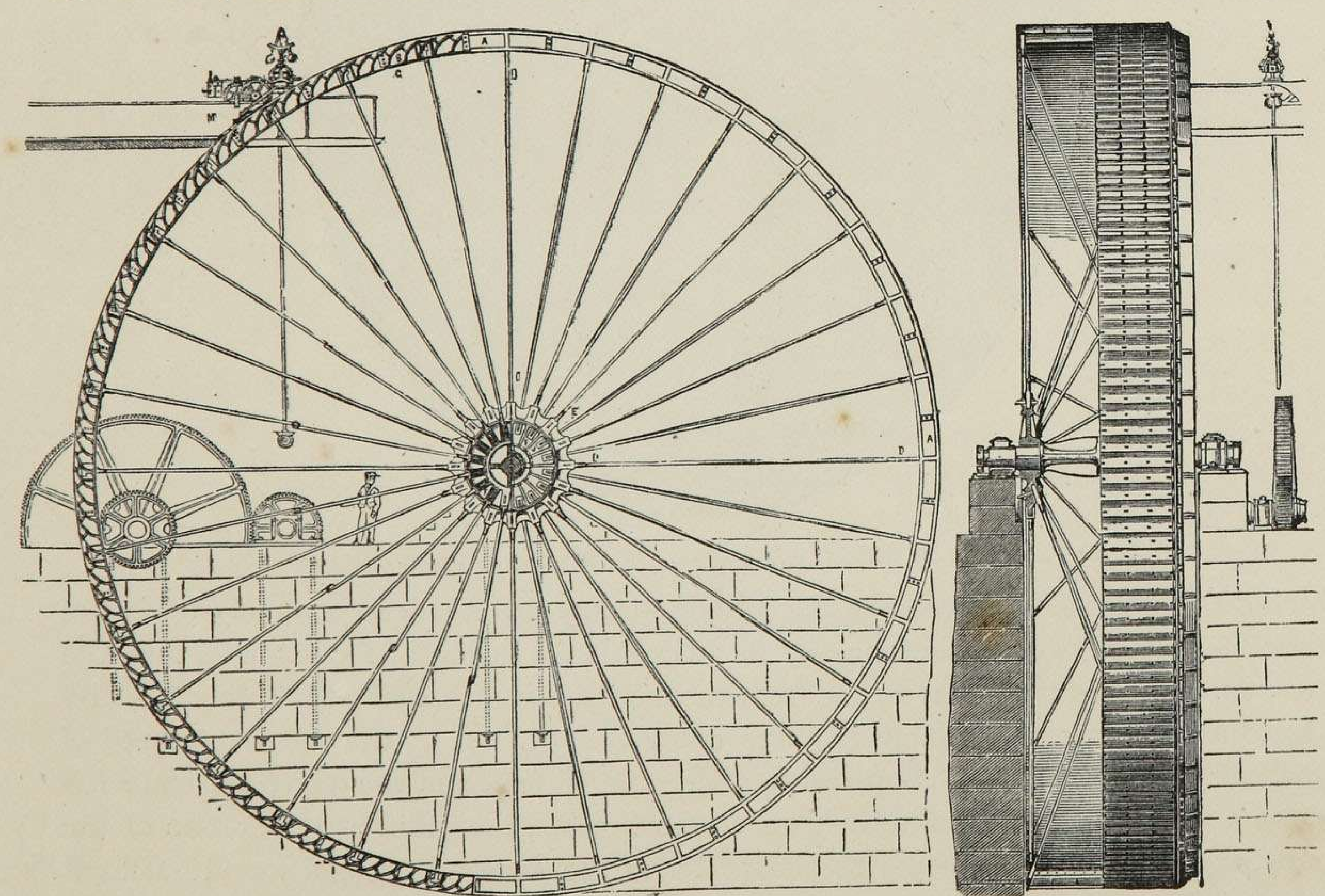
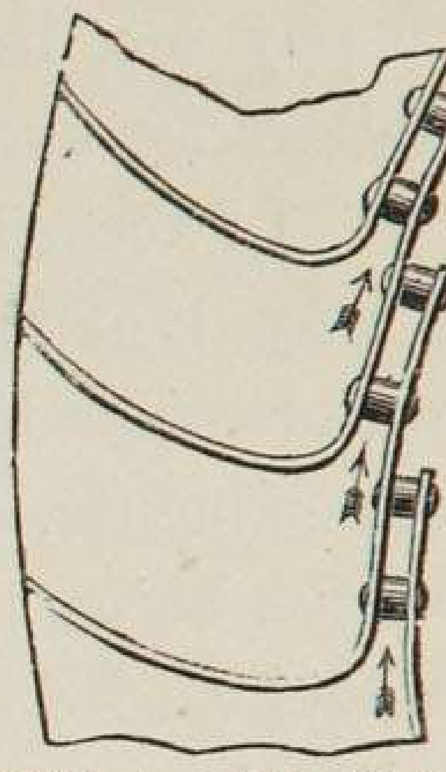


Fig. 254.—High Breast Water Wheel, erected at Greenock, by Mr. James Smith of Deanston.

Perthshire. These wheels were still more imposing in appearance, because there are two of 50 feet diameter and 10½ feet wide, connected together, at Catrine, and four of 36 feet diameter and 12 feet wide, connected, at Deanston.

Up to this time the maximum power derived from water wheels was only about 60 per cent of that due to the fall, but since they have been built of iron, and of greater mechanical accuracy, but especially since the invention, by Fairbairn, of the ventilated bucket, dispensing with the sole plate, *Fig.* 255, an effect equal to 75 per cent of the water due to the fall has been obtained.

Fig. 255.



Fairbairn's Ventilated Buckets.

For very low falls, of three or four feet, Poncelet's under-shot wheel, with curved buckets, is a very simple and useful contrivance. This wheel, when well made, will give off a duty of about 60 per cent of the water employed, with a circumferential velocity of about 12 feet per second.

TURBINES.

The Turbine is of French origin: the first invented is believed to have been by Burdin in 1826; next by Fourneyron in 1827; then Jonval brought out a turbine, known also as the Roachlin turbine; afterwards Fromont invented a turbine, which received the Council Medal at the London Great Exhibition of 1851. It differs from the last in the method of regulating the water, and is known as M. Fontaine Baron's turbine. The principle of these machines is the same; they differ only in detail.

Turbines are now almost exclusively used for driving cotton mills both on the continent of Europe and in America, where they have been brought to great perfection. A good example of their present state is shown in Plate XXI., which is one of a number employed in driving the Harmony Mills, United States. The Harmony Mills, before being enlarged, contained 204 carding engines, together with all necessary preparation of scutching, drawing, slubbing, and roving frames for about 70,000 spindles, mules, and ring throstles, likewise 1,540 looms, with winding, warping, dressing, &c. All this machinery is driven by three turbines, of 98 inches diameter and 10 inches deep each, under 25 feet water-fall, giving a power of 350 horses to each wheel, or 1,050 horse power in the aggregate.

Mr. Uriah A. Boyden, an eminent hydraulic engineer of Massachusetts, has been the most successful improver of turbines in the United States, having introduced several improvements of great value upon the Fourneyron turbine. In one of his contracts with the Appleton Company, wherein he superintended the construction of three turbines of 190 horse power each, his remuneration depended upon the performance of the turbines, and it was stipulated that two of them should be tested.

The contract contained the following clause: "And if the mean power derived from these turbines be 78 per cent of water expended, the Appleton Company to pay me twelve hundred dollars for my services, and patent rights for the apparatus for these mills; and if the power derived be greater than 78 per cent, the Appleton Company to pay me, in addition to the twelve hundred dollars, at the rate of four hundred dollars for every one per cent of power obtained above 78 per cent."

In accordance with the contract two of the turbines were tested by a very perfect Prony dynamometer, to measure the useful effects, and a weir to gauge the quantity of water expended, which was a great improvement in the mode of conducting hydraulic experiments, each set of observations being continuous, and the time of each observation being noted: thus the observer who noted the height of the water above the wheel recorded regularly, say every thirty seconds, the time and the height; and so with the other observers, the recorded times furnishing the means of afterwards identifying simultaneous observations. The observations were put into the hands of James B. Francis, Esq., C.E., for computation, who found that the mean maximum effective power of the two turbines tested was *eighty-eight per cent* of the power of the water expended. According to the terms of the contract this made the compensation for engineering services and patent rights for these three wheels amount to 5,200 dollars, which sum was paid by the Appleton Company without objection.

The following particulars about the Appleton turbine are borrowed from "Lowell Hydraulic Experiments:"—

"The workmanship in these wheels was of the finest description, without regard to cost, containing all Mr. Boyden's latest improvements. The principal points in which one of them differs from the constructions of Fourneyron are as follows, viz.:—

"*The wooden flume conducting the water immediately to the turbine is in the form of an inverted truncated cone the water being introduced into the upper part of the cone, on one side of the axis of the cone (which coincides with the axis of the turbine) in such a manner that the water, as it descends in the cone, has a gradually increasing velocity, and a spiral motion; the horizontal component of the spiral motion being in the direction of the motion of the wheel.* The horizontal motion is derived from the necessary velocity with which the water enters the truncated cone; and the arrangement is such that, if perfectly proportioned, there would be no loss of power between the nearly still water in the penstock and the guides, or leading curves, near the wheel, except from the friction of the water against the walls of the passages. It is not to be supposed that the construction is so perfect as to avoid all loss, except from friction, but there is, without doubt, a distinct advantage in this arrangement over that which had been usually adopted, and where no attempt had been made to avoid sudden changes of direction and velocity.

"*The guides, or leading curves, are not perpendicular, but a little inclined backwards from the direction of the motion of the wheel, so that the water, descending with a spiral motion, meets only the edges of the guides.*

"In Fourneyron's construction a garniture is attached to the regulating gate, and moves with it, for the purpose of diminishing the contraction; this, considered apart from the mechanical difficulties, is probably the best arrangement; to be perfect, however, theoretically this garniture should be of different forms for different heights of gate; but this is evidently impracticable.

"*In the Appleton turbine the garniture is attached to the guides, the gate (at least the lower part of it) being a simple thin cylinder.* By this arrangement the gate meets with much less obstruction to its motion than in the old arrangement, unless the parts are so loosely fitted as to be objectionable; and it is believed that the co-efficient of effect, for a partial gate, is proportionally as good as under the old arrangement.

"*On the outside oj the wheel is fitted an apparatus, named by Mr. Boyden, the Diffuser.* The object of this extremely interesting invention is to render useful a part of the power otherwise entirely lost, in consequence of the water leaving the wheel with a considerable velocity. It consists, essentially, of two stationary rings or discs placed concentrically with the wheel, having an interior diameter a very little larger than the exterior diameter of the wheel; and an exterior diameter equal to about twice that of the wheel; the height between the discs, at their interior circumference, is a very little greater than that of the orifices in the exterior circumference of the wheel; and at the exterior circumference of the discs the height between them is about twice as great as at the interior circumference. The form of the surfaces connecting the interior and exterior circumferences of the discs is gently rounded, the first elements of the curves, near the interior circumferences, being nearly horizontal. There is consequently included between the two surfaces an aperture gradually enlarging from the exterior circumference of the wheel to the exterior circumference of the diffuser. When the regulating gate is raised to its full height, the section through which the water passes will be increased by insensible degrees, in the proportion of one to four, and if the velocity is uniform in all parts of the diffuser at the same distance from the wheel, the velocity of the water will be diminished in the same proportion; or its velocity on leaving the diffuser will be one-fourth of that at its entrance. By the doctrine of living forces, the power of the water in passing through the diffuser must therefore be diminished to one-sixteenth of the power at its entrance.

"It is essential to the proper action of the diffuser that it should be entirely under water; and the power rendered useful by it is expended in diminishing the pressure against the water issuing from the exterior orifices of the wheel; and the effect produced is the same as is the available fall under which the turbine is acting, is increased to a certain amount. It appears probable that a diffuser of different proportions from those above indicated would operate with some advantage without being submerged.

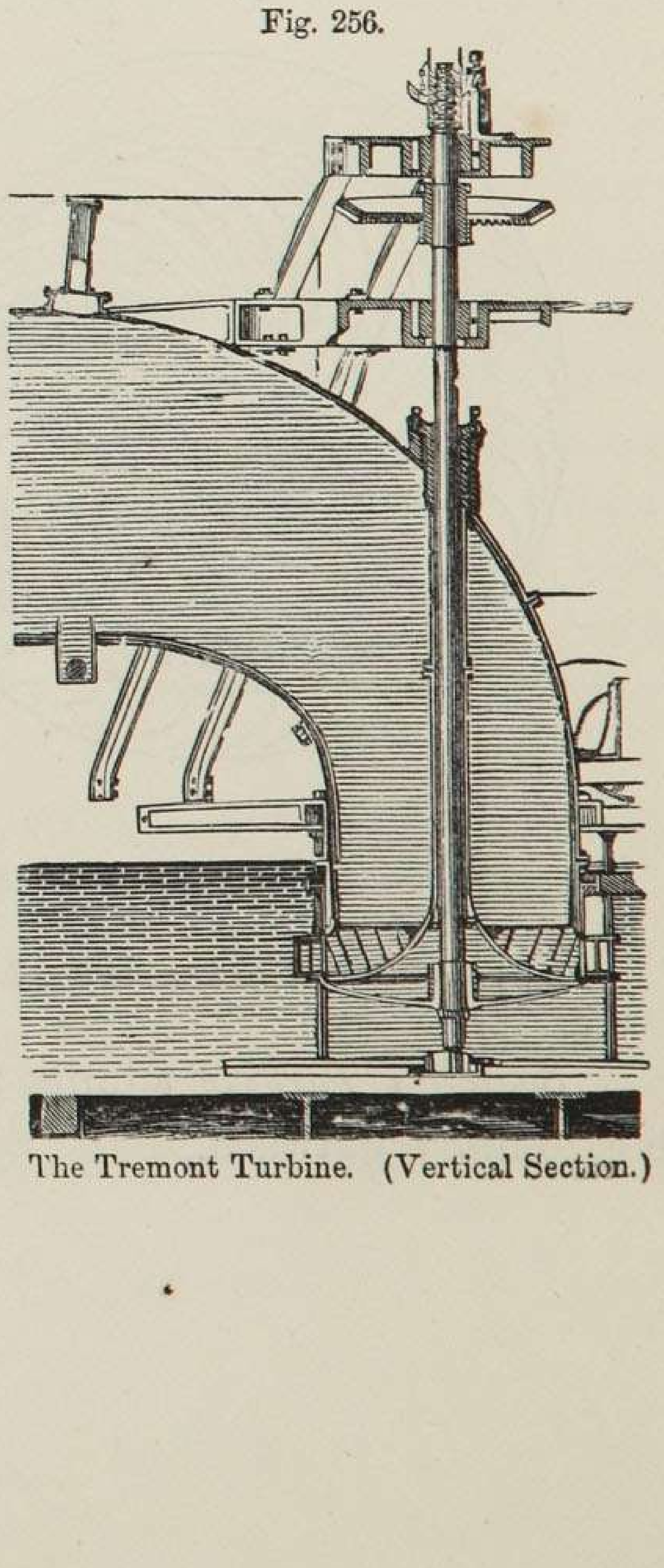
"It is nearly always inconvenient to place the wheel entirely below low-water mark; up to this time, however, all that have been fitted up with a diffuser have been so placed; and indeed, to obtain the full effect of a fall of water, it appears essential, even when a diffuser is not used, that the wheel should be placed below the lowest level to which the water falls in the wheel-pit, when the wheel is in operation.

"The action of the diffuser depends upon similar principles to that of diverging conical tubes, which, when of certain proportions it is well known increase the discharge; and there is good reason to believe that tubes of greater length and divergency would operate more effectively under water than when discharging freely in the air; and that results might be obtained that are now deemed impossible by most engineers.

"Experiments on the same turbine, with and without a diffuser, show a gain in *the co-efficient of effect*, due to the latter, of about three per cent. By the principles of living forces, and assuming that the motion of the water is free from irregularity, the gain should be about five per cent. The difference is due, in part at least, to the unstable equilibrium of water, flowing through expanding apertures. This must interfere with the uniformity of the velocities of the fluid streams, at equal distances from the wheel.

"*Suspending the wheel from the top of the vertical shaft, instead of running it on a step at the bottom.* This had been previously attempted, but not with such success as to warrant its general adoption. It has been accomplished with complete success by Mr. Boyden, whose mode is to cut the upper part of the shaft into a series of necks, and to rest the projecting parts upon corresponding parts of a box. A proper fit is secured by lining the box, which is of cast iron, with babbit metal, a soft metallic composition consisting principally of tin. The cast-iron box is made with suitable projections and recesses to support and retain the soft metal, which is melted and poured into it, the shaft being at the same time in its proper position in the box."

Fig. 256.



The Tremont Turbine. (Vertical Section.)

Figs. 256 and 257 show the turbine used at the Tremont Mills on Mr. Boyden's plan, but without a diffuser. Exhaustive experiments with this wheel on a fall of 13 feet show a maximum useful effect of over 79 per cent of the power expended when the ratio of the velocity of the inner circumference of the wheel was about $62\frac{1}{2}$ per cent of that due to the fall; and when the brake was taken off, and the wheel allowed to run as fast as it could go, this ratio was 1·335 that of the fall, when, of course, the co-efficient of effect was nothing. The co-efficient of effect was reduced to 70 per cent of the power expended at the velocities of 0·360 and 0·834 respectively.

Another kind of water wheel, called the *Centre-Vent Wheel*, is in extensive use in America. One of these of the best construction (shown in plan, *Fig.* 258), working at the Boot Cotton Mills, was tested during the celebrated "Lowell Hydraulic Experiments," and its maximum co-efficient of effect was found to be nearly 80 per cent of the power due to the fall of 14 feet, when the gate (which moves between the wheel and guides) was fully raised and the outside of the wheel was moving at a velocity of 67 per cent of that due to the fall. With this kind of wheel the co-efficient of effect diminishes rapidly as the regulating gate is lowered, becoming only 38 per cent of the power expended when the outside of the wheel is moving with a velocity about one-half of that due to the fall acting upon the wheel. The diameter of this wheel outside the buckets is 9 feet 4 inches, and inside the buckets about 8 feet, and its effective power is about 230 horse power for a considerable portion of the year, when the fall is about 19 feet. At these mills there is another wheel of the same construction, size, and power. These wheels are an improvement by Mr. Francis and Mr. Boyden upon a wheel patented by Samuel B. Howd, of Geneva, State of New York, in 1838. A similar wheel was proposed in France, in 1826, by Poncelet.

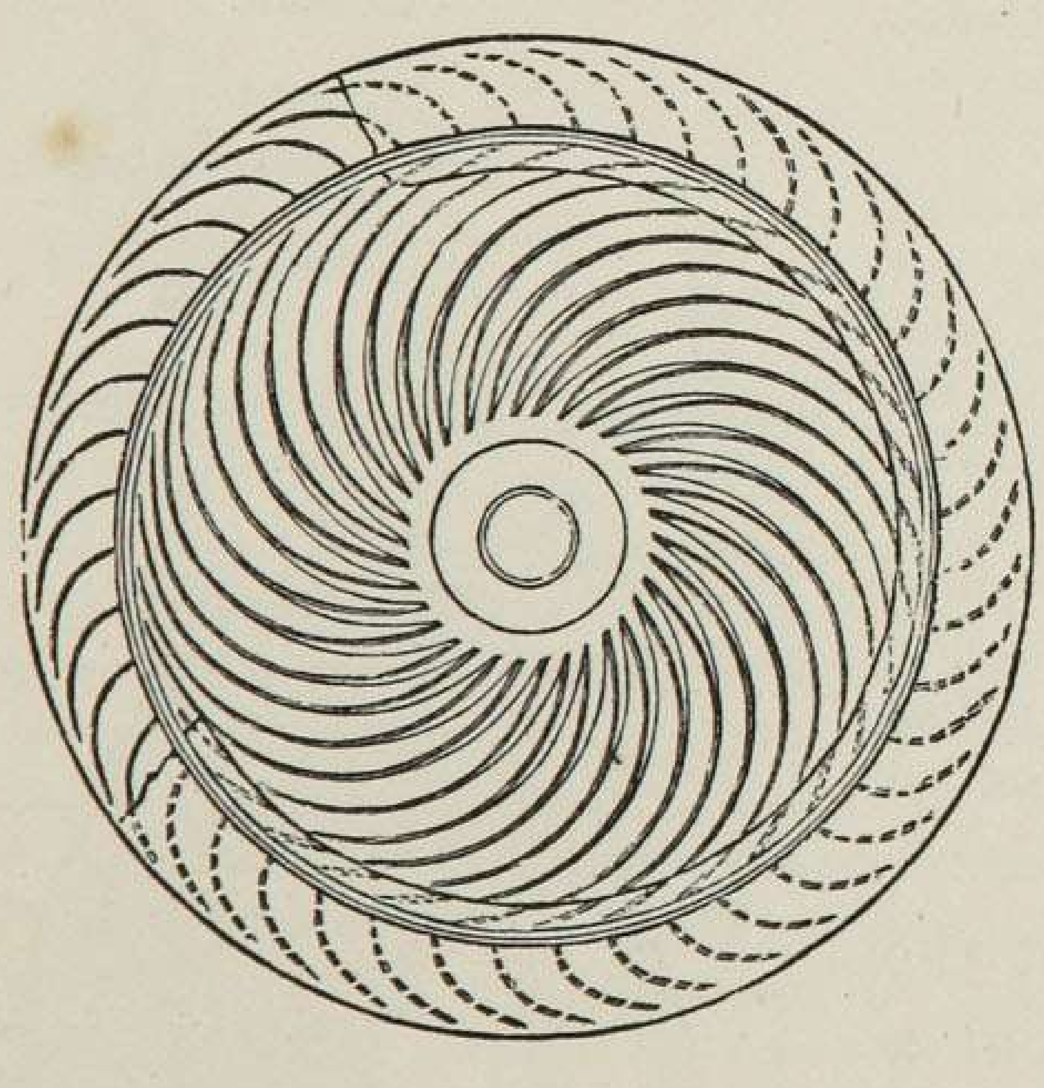


Fig. 257.
The Tremont Turbine. (Plan on larger scale.)

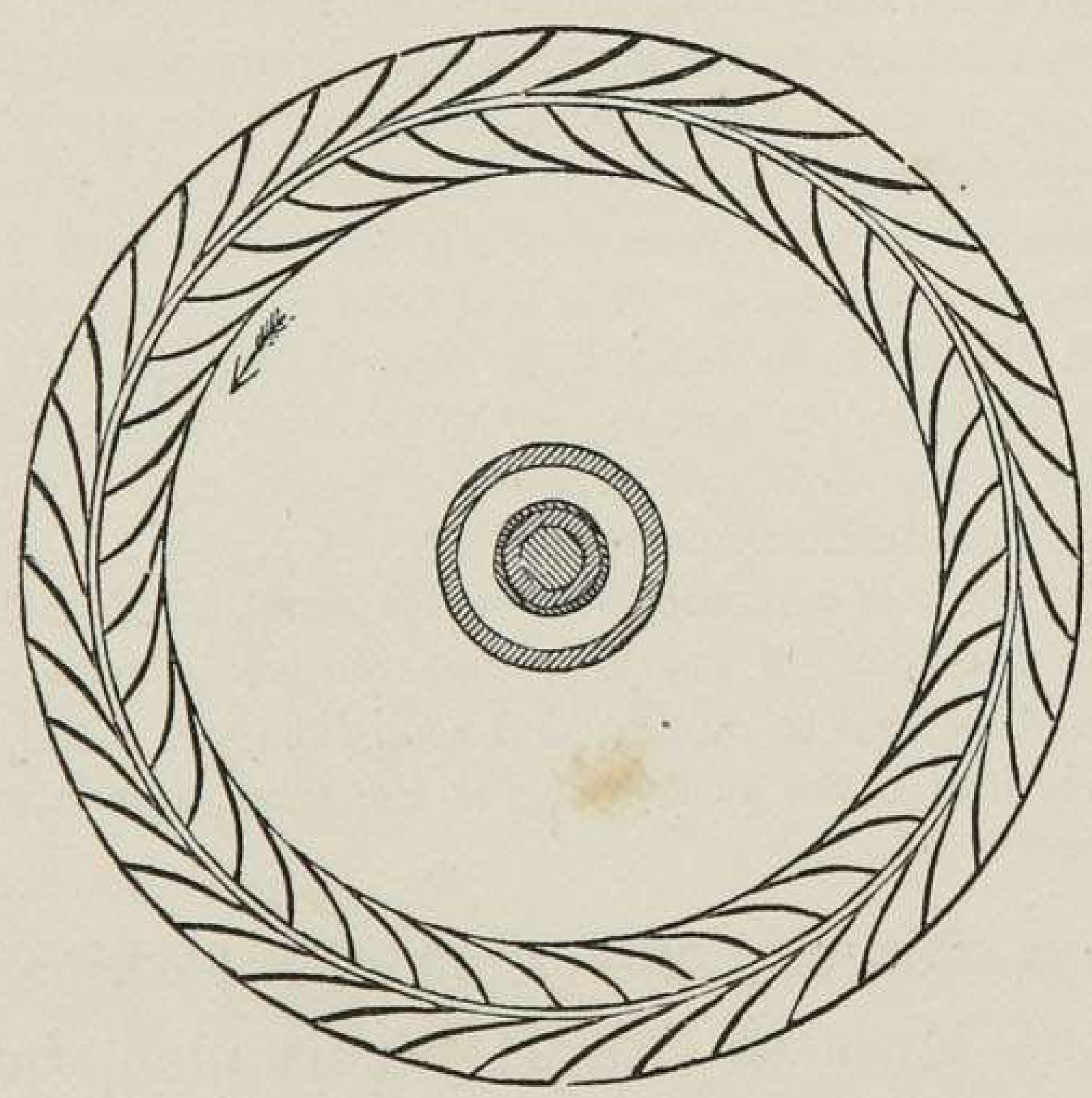


Fig. 258.
The Centre-Vent Wheel.

Thompson's Vortex Wheel is of this class, differing only in some of its details.

Schiele's Turbine admits the water on the underside of the wheel. and it flows horizontally outward.

Whitelaw and Stirratt's Wheel, generally called the Scotch Turbine, also admits the water at the bottom, the upward pressure balancing the weight of the wheel. It is similar in principle to Barker's Mill, and works by reaction. The main improvement effected by Mr. Whitelaw was in curving the arms to an Archimedean spiral. It is said to give out 74 to 78 per cent of the power due to the fall.

ROMANCE OF WATER POWER.

Before the steam engine was brought to its present state of perfection, and manufactories were smaller, water power was much esteemed, especially where a constant supply could be obtained; but this could be found only in country places, so many small mills were erected by Sir Richard Arkwright and others, in romantic spots, among hilly districts, generally at inconvenient distances from Manchester, the great mart and emporium of cotton yarns and goods. These mills were all wrought by wooden water wheels, the turbine being then unknown.

As the cotton trade grew larger in dimensions, and the steam engine became more perfect, so water power in England, some few places excepted, became despised, there being so few water falls of any practical value.

On the continent of Europe and in America water power is of great value, and almost exclusively used for manufacturing purposes. Being fed by lakes and large rivers, it is both constant and of unlimited extent. In such places, especially where easy of access, it is both a pleasant and highly valuable power. Pleasant because the works are situate in airy and beautiful localities, and the turning free from jerking. It is ready at all times, by day or by night, at a moment's notice, and without extra cost, to do the employer's bidding; the gardens and surrounding cottages are not polluted with smoke, but a halo of neatness and salubrity pervades the village. Rustic beauty, the song of the linnet and the thrush, the blushing rose and sweet smelling hawthorn, prevail at one period of the year, and field sports in the autumn and winter render a country mill pleasant to the proprietor, and to the operatives also, where they can have their patch of garden ground, reading room, baths, schools, and other means of moral, physical, and intellectual culture, combined with healthy amusements.

The contemplation of this subject reminds one of certain nooks and corners in Italy, and the happy and primitive condition of the Italian cotton spinner. Situate amongst scenery of the most lovely description, in many a spot of that charming and classic land, lies a little mill, containing its 8,000 or 10,000 spindles, bounded on one side by vine-clad hills, on the other by the mansion or "palazzo" of its proprietor, around which abound the mulberry, the orange, and fig tree, interspersed with other delicious fruits; in the back ground rise stately timbers, distant and lofty mountains, the whole forming an earthly paradise. An air of simplicity, contentment, and satisfaction pervades the whole premises. Owing to the balmy climate, the proprietor's wants are few; he requires no fuel to heat his mill even in winter, his olives produce the oil he needs, and, in the south, he can, if he please, grow his own cotton. Ambition, with its corroding cares, enters not there; for his mill being limited to the extent of his water power, and steam fuel unobtainable, he has no overweaning anxiety about extending his operations and acquiring wealth, so quietly he pursues the even tenor of his way. Of this land the poet sings:—

> "For ever and for ever shalt thou be,
> Unto the lover and the poet dear,
> Thou land of sunlit skies and fountains clear,
> Of temples and grey columns, of waving woods
> And rocks, and cataracts, that foam and roar,
> And rush into the Adrian sea."

Striking indeed is the contrast between the Italian cotton spinner, as he sits taking his evening's *whiff* of meditation under the shade of his vine, surrounded by the glories of an Italian sunset, in its gorgeous rainbow-coloured hues, the distant mountains tipped with gold, his wife and daughters displaying to him, in rich skeins, the produce of their silkworms, in which they take a pride, and by the cultivation thereof make their *pin money*. Striking is the difference between him and the care-worn Lancashire spinner, who, returning homeward after his daily toil, enveloped in a murky atmosphere, probably to brood over an extension of his already unwieldy premises. Striking the difference, but has not each his mission in the economy of creation? The Italian spinner enjoys the bounties of Providence and the beauties of nature; but will his position bear comparison with the Lancashire spinner? The mission of the latter is to clothe the million, to diffuse civilisation, with all its moral and social benefits, through the world, and, although a beautiful climate is not given him to enjoy, he has the inward satisfaction of knowing that his cheap and extensive manufactures carry blessings into distant lands, supplying comfort and warmth to poor widows and orphans. Sweet and consoling indeed is such a thought! Highly honourable such a position! Thus Nature compensates her apparent anomalies, and, with a just and equal balance, metes out her reward of happiness to those who obey her laws.

The situation of the Spanish spinner is somewhat similar to that of the Italian, except that the former is located chiefly on the coasts, where fuel can only be obtained at a high price, yet many mills there are driven exclusively by steam, others by steam in conjunction with inconstant water power, so inconstant that the beds of the rivers are often perfectly dry, and used as roads for conveying fuel and cotton up the country. Economy of fuel is, in Spain, the order of the day; and both their turbines and steam engines are, in many places, worthy of imitation.

In Switzerland and Austria, as well as in Germany and the countries comprised in the Zollverein, where water power is both abundant and constant, many excellent applications of it are to be found. In dry weather the melting of the snow on the mountains keeps up the supply, for the Swiss spinner has—

> "Above him the Alps!
> The palaces of Nature! whose vast walls
> Have pinnacled in clouds their snowy scalps,
> And throned Eternity in icy halls
> Of cold sublimity; where form and falls
> The avalanche—the thunderbolt of snow!
> All that expands the spirit, yet appals,
> Gather round these summits, as to show
> How Earth may pierce to Heaven, yet leave
> Vain man below."

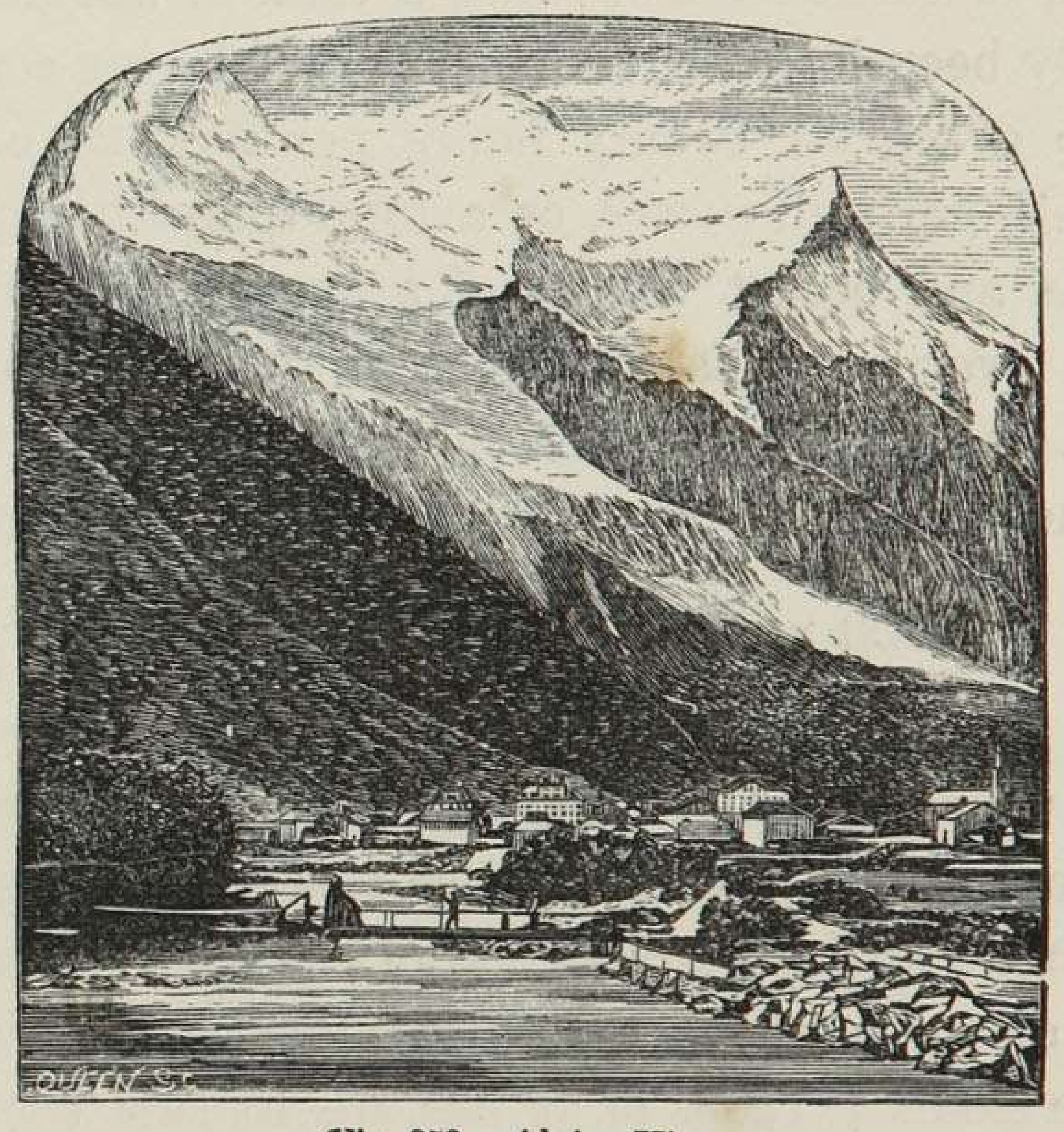


Fig. 259.—Alpine View.

France possesses an amount of water power lately estimated, in its useful effect, at about 20,000 horse-power. This is exclusive of Savoy, recently added to the French empire. Great improvements are now taking place in France and Belgium, both in their application of water power and in their machinery generally, probably stimulated by the recent Commercial Treaty with England in the direction of free trade. In the department of the Haut Rhin, bordering on Switzerland, the mills have long been far in advance of those in Rouen and the north in the quality of their machinery and general manufacturing intelligence of the proprietors, with some few exceptions; but great improvements have latterly taken place, both in the north of France and in Belgium.

Sweden possesses some good waterfalls, which are rendered almost useless in the winter by the rigour of the climate; those of Trolhatten are very fine. It is probably owing to the inconstant supply that the application of water power has in Sweden with few exceptions, been more neglected than in other countries.

North Russia, except at Narva, and Finland use very little water power for spinning cotton; but their steam-engines and machinery are generally of the very best description.

America presents a great contrast to Russia; its waterfalls are numerous, grand, and majestic. As an example, the company who own the Pantucket Falls on the Merrimac River have, by artificial means, obtained a steady power, equal to nearly 9,000 horse-power, which they let off in what are termed "mill powers," each of which is equivalent to a gross of nearly 100 horse power. The nett fall of this river at Lowell, Massachusetts, is about 33 feet; and a total of about one hundred and forty mill powers has already been let off to eleven manufacturing companies, each of which possesses the right to draw, for twenty hours per day, 25 cubic feet of water per second on the entire fall, per mill power, or a total quantity equal to 3,500 cubic feet per second. Turbines and breast wheels of a superior description use this water, which gives out on an average a useful effect of two-thirds of the water expended. The fall being 33 feet, and the weight of a cubic foot of water 62·33lbs., the effective power derived from the water privileges granted by this company is

$$\frac{3{,}500 \times 62\cdot33 \times 33 \times {}^2/_3}{550} = 8{,}560\cdot58 \text{ horse power.}$$

The river Merrimac, which takes its rise in New Hampshire, "the Switzerland of America," does excellent duty before it reaches Lowell, turning the mills of Concord and Manchester, a rising and prosperous rival of the English capital of manufactures.

The water power of the northern States of America is so vast, compared with the population, that only a small portion of it has, up to this time, been applied to the purposes of mankind. An amount is already derived from the Merrimac River and its branches in Massachusetts and New Hampshire exceeding the whole water power in France.

In Maine and other States it is also extensive; but for a lasting impression of the grandeur of the American waterfalls, let the reader contemplate those of Niagara. Sublime beyond description are these mighty falls, situate between the Lakes Ontario and Erie. The waters, of which Niagara is the outlet, comprised in the great inland seas of Erie, Huron, and Lake Superior, cover an area of 150,000 square miles,—lakes so grand and inexhaustible as to be utterly unconscious of the loss of ninety millions of tons, which it is computed they pour every hour from generation to generation, over these stupendous precipices. Empires may rise and fall, civilisation advance and recede, but the seething roar of Niagara's boiling cauldron remains the same—always the same to short-lived man. This stability, however, is only apparent, for human existence is too short to note any perceptible change in a generation. Yet there are undoubted geological indications that these mighty waters have, in the course of many thousands of years, carved out the fourteen miles of deep channel from Lake Ontario, a great part of the way through solid rock, and that they may eventually, by the same slow process, excavate the remaining twenty miles and drain Lake Erie! The angry torrent of the rapids, which has a fall of 51 feet in three-quarters of a mile, rushes madly on, lashing defiant rocks which hurl back its assault, and becomes comparatively quiescent before its great final plunge of 165 feet, assisting slowly but surely in the work of excavation. Could one visit this spot one thousand years hence, it would no doubt be found that a good day's work had been done; for in some of Nature's grand operations a thousand years are but as a day.

> "What is harder than a stone? What is softer than water?
> Yet hard stones are hollowed out by soft water."

Here is a water power which, if utilised, would be more than sufficient to turn all the mills in the world.

Alive to this, the enterprising Americans have, on their side of the river, a company already cutting canals to divert a portion of the stream, and convey it to Manchester, a third manufacturing city of that name, at present in embryo. Could one see these canals before viewing the falls, it would be thought a pity that one of Nature's grandest works should be spoiled by the cupidity of man, but, after a glance at Niagara, one may bid them go on and prosper, welcome to their bucket of water out of the ocean, for it is found on computation that Niagara is capable of giving out *fifteen million* horse power net, after allowing one-third for loss in application!

If it be asked, how can this enormous power be calculated? it may be answered that this volume of water gives out one hundred thousand horse-power in every foot of fall, therefore if the total fall be 216 feet from the commencement of the rapids, one has only to multiply 100,000 by 216 = 21,600,000, which, after allowing nearly one-third for loss in application, leaves 15,000,000 horse-power.

To bring to the mind's eye a vision of this stupendous power, imagine one thousand powerful dray horses placed abreast in a line extending a mile; then every ten feet forward place another row of one thousand. Repeat this until there be 15,000 rows of one thousand each, which would make 15,000,000 horses altogether, covering an area of about twenty-eight square miles.

Now suppose it were possible to yoke all these horses in such a way that their united strength would bear upon the power of these falls, the one being fairly pitted against the other, the whip might be applied in vain, for old Niagara would drag them all off their feet! Or, if the thirty millions of men, women, and children, comprising the population of Great Britain and Ireland, were all converted into strong men, it would require four times their united strength to equal Niagara's falls!

It is said that the roar of these cataracts, in very cold weather, when sound travels farthest, can be heard at a distance of forty miles. Imagine, then, the perpetual roar of these great waterfalls to be the voice of prolific Nature, calling upon feeble man to come and lean upon her powerful arm while she does his drudgery! and in thus wiping the sweat from his brow, and earning for him his bread, she gives him leisure to cultivate the nobler faculties of his mind, that raise him so much above the brutes that perish.

The advance of the white race in the West has quite changed the features of the country, as, where land is drained rushes and other noxious plants cease to grow, and give place to more profitable herbage. Where the *white* man, accompanied by science and civilisation, plants his foot, the *red* man falls back, the ground becoming untenable for him, and he is forcibly dispossessed by the white man, who sometimes is deaf to the remonstrances of Justice, or to the "shriek of Freedom." It is a law of nature, the same as when the land is drained and the wild and comparatively useless first products of creation, both animal and vegetable, perish, giving place to a new order of things, and opening another chapter in the history of the earth.

About many of the beautiful waterfalls in the Northern States of America the hum of the spindle and shuttle now resound on the former favourite fishing ground of the once "noble savage." To stand on the spot and gaze around, as the writer has done, produces strange reflections; and it is scarcely possible to contemplate these great changes without lapsing into a reverie; when suddenly, to the mind's eye, there appears, elevated on a rock above the gushing waters, a hoary and decrepit old Indian chief. His commanding figure, though bent with age, still reflects the symmetry of manhood. His garments worn, yet picturesque. A portion of his grey hair flutters in the breeze, the rest being held in check by faded plumes. In pensive mood, and with folded arms, he silently contemplates the ravages of civilisation! His appearance is startling, looking like Sublimity personified! . . . This once haughty but now subdued old chief, after many a desperate struggle with the white man, renewed often with hopeless valour, until the tomahawk and scalping knife succumbed to the deadly rifle and bayonet, his people exterminated, and himself driven from his forest home. This last remnant of his race has now made a long pilgrimage to bid a final adieu to the scenes where the palmy days of his youth were spent in hunting and fishing. With a sad countenance, mingled with astonishment and disgust, he sees the cotton mill and the workshop erected where stately timber stood, and the wild deer roamed; the noble river, in whose fresh and limpid waters the spotted trout and the silvery salmon leaped, now polluted with sawdust and other abominations. Suddenly as he

J. GALLOWAY, LITH. MANCHESTER

appeared, so suddenly, with a dignified contempt, he retires, murmuring "I like it not; I would the plain had on it its tall groves again." Hush! . . . 'tis the last of the Mohicans!—

"The last of the Mohicans sat on the ground,
At the close of a bright summer's day,
The night was fast closing in shadows around,
And the blue bird had finished its lay.
The deep roaring rapids dash'd on in their race,
As he sat with his cheek on his hand,
And he sighed, while the sunset played over his face,
'They are gone to the silent land.'

"He sought no companion to tell of his grief,
The monarch mates not with the slave,
But three moons had waned, since the Mohican chief,
Had borne his last son to the grave.
Alone in the forest, he wept for his race,
For he was the last of the band;
And he sighed, while the sunset played over his face,
'They are gone to the silent land.'"

GENERAL MANAGEMENT OF COTTON MILLS.

THE author has not considered it necessary to produce the figures and calculations so usual in works of this character, for it has been assumed that every one taking charge of machinery, or the management of a cotton mill, understands common arithmetic, and the manner of ascertaining the speed of any shaft, cylinder, or roller, by multiplying the *driving* wheels or pulleys together, and the *driven* wheels also, and then dividing the one product by the other. Beyond this, and a knowledge of the Rule of Three, there is really very little more required in the way of figures to enable one to manage a cotton mill; but a knowledge superior to that of the mere school boy is required to make an expert cotton spinner.

The manager should be thoroughly versed in mechanics, familiar with the fibres and qualities of the different cottons, see that everything about the premises is kept clean and orderly, the frames regularly scoured through, the drawing frames at least once a month, the slubbing and roving frames, also the mules and throstles, once in three months, when the rollers should be taken out, the flutes scoured and the squares oiled, all the studs and bearings at the same time thoroughly cleaned and oiled with good neatsfoot oil. There should be store-rooms, in which a constant supply of consumable articles are kept, always ready to hand, and duplicates of all parts of the machinery liable to break or wear out. The mechanics should work to stock the store-room, keeping up a supply of the various things given out to the overlookers for consumption, so that if anything breaks or requires repair no time is lost in the stoppage of the machines. Everything should be done with forethought and anticipation, so that the weekly production throughout the year may be kept steadily up to the maximum point. Weekly, if not daily, indications should be taken of the steam engines, and a proper register kept of the consumption of coals, oil, tallow, and other articles. When these things are done, and all trade charges, interest of capital, and depreciation tabulated, and the average taken of what they amount to weekly, the cost per pound of any particular number of yarn may be arrived at with tolerable accuracy. If the mill be spinning, say No. 30's, the production would be a certain number of pounds weekly, which must be a divisor for all incidental charges reduced to pence and cents, or hundredths of a penny. The wages in like manner. These added to the market price of the day for cotton, and the average loss in waste thereon, the cost of each pound of No. 30's yarn will be found. Having thus ascertained what the concern would produce if spinning 40's, 50's, or any other number, the wages being at a fixed average amount, the cost of any of these numbers, or intermediate numbers, may be tabulated, so that at a glance the spinner may know, when he goes to market, what numbers will pay best to sell, in reference to the price of the raw material.

It may be here only necessary to remark how important it is to observe a kindly but firm demeanour towards the workpeople, the manufacturer doing all in his power to make them happy and contented, avoiding as much as possible all changes of hands, and all unnecessary alterations in machinery.

As to alterations in counts, they cannot be avoided, and it is indispensable that the manager should be completely master of these things when they do occur. A few rules are appended, principally for the frames and mules, as they present the only difficulties.

RULES.

The following rules will be found useful in starting new machinery, or in making changes in slubbing and roving frames, self-acting mules, or other machines employed in cotton spinning.

To find the speed of spindle in roving frames for one of front roller:

RULE.—Multiply the driven wheels between first shaft in frame and front roller by the driving wheels between same shaft and spindle for a dividend. Then multiply the driving wheels between first shaft and front roller by the driven wheels between same shaft and spindle for a divisor. The quotient will be the revolutions of spindle for one of front roller.

Driving Wheels. Driven Wheels

EXAMPLE. $26 \times 40 \times 43 \times 25 = 30 \times 119 \times 54 \times 50$. *Ans.* 8·6

What the bobbin must gain at the spindle for each revolution of front roller will be found by dividing the diameter of front roller by the diameter of bobbin:

EXAMPLE.—Suppose the diameter of front roller is $1\frac{1}{4}$ inches and the diameter of bobbin $1\frac{1}{2}$ inches,

```
1·5 ) 1·25 ( ·833
      120
      ---
        50
        45
        --
        50
```

The bobbin must gain ·83 of one revolution at the spindle for each revolution of front roller, which being added to the speed of spindle 8·6

```
 8·6
  ·83
 ----
 9·43 Speed of bobbin for one of front roller.
```

N.B.—This calculation is made for frames when the bobbin leads the flyer. The relative speeds must be reversed when the flyer leads the bobbin. It is a disputed point which is best. (*Vide* page 183.)

To find the revolutions of first shaft for one of sun wheel at the beginning of set:

RULE.—Multiply the drivers between first shaft and sun wheel together for a divisor ; then multiply all the driven things together for a dividend. The quotient will be the speed of first shaft for one of sun wheel. In this calculation the respective diameters of the driving and driven cone must be taken where the strap is on.

When starting new roving frames, the following will be found useful, viz.:—

To find a pinion that will produce a required weight per 60 yards of roving:

RULE.—Multiply the carrier, the back roller wheel, the diameter of front roller, and the weight in grains per 60 yards of roving required, for a dividend, together. Then multiply the front roller wheel, the diameter of back roller, and the weight of 60 yards of rove or slubbing fed to the frame, for a divisor. The quotient will be the pinion required.

The above rule is equally applicable to the card-room, mule, or throstle-room.

EXAMPLE.—The frame to be started has a 70 carrier wheel, a 50 back roller wheel, the diameter of front roller is $1\frac{1}{4}$ inches, and 60 yards of roving is to weigh 167 grains.

Front roller wheel 26 teeth, diameter of back roller 1 inch, weight of rove going in 668 grains per 60 yards. Find the pinion required.

$$668 \times 26 = 70 \times 50 \times 1\tfrac{1}{4} \times 167$$

$$17368 =)\ 730625\ (\ 42 \text{ pinion required.}$$

For mule spinning the following will be found useful:

RULE.—Multiply the carrier, back roller wheel, and 500 together, for a dividend. The front roller pinion, the counts of yarn, and the weight of 60 yards of roving, in grains, multiplied together for a divisor.

From the above any draught wheel may be found, or the weight of 60 yards of roving to spin any counts required, with the wheels on hand, or a spinner may ascertain the counts of his yarn or roving without the aid of a wrap reel.

EXAMPLE.—Find a pinion to spin 50's; the front roller wheel is 13, carrier 78, back roller wheel 50, weight of 60 yards of roving 100 grains. Let x be the pinion required : $13 \times 50 \times 100 = 78 \times 50 \times 500$

$$65{,}000\,x = 1{,}950{,}000$$

$$x = 30 \text{ the pinion required.}$$

Suppose 60 yards of roving weighs 167 grains, and the largest draught wheel on hand is 56, and the smallest 27, carrier 78, front roller wheel 16. Under these conditions what are the lowest counts that can be spun ? Here x will equal the counts of yarn. $16 \times 56 \times 167 = 78 \times 27 \times 500$

$$149632\,x =)\ 1053000\ (\ 7\text{'s are the lowest counts.}$$

Suppose the front roller wheel be 16, carrier 78, pinion 41, back roller wheel 42, counts of yarns 16's. Find the weight of 60 yards of roving. Let x = the weight of 60 yards of roving.

$$16 \times 41 \times 16\text{'s} = 78 \times 42 \times 500$$

$$10496\,x =)\ 1638000\ (\ 156 \text{ grains 60 yards of roving.}$$

It must be noted that in all cases where the front and back roller differ in diameter, the diameter of front roller is multiplied with the carrier and back roller wheel, and the diameter of back roller is multiplied with the front roller wheel and pinion.

The reason for taking the weight of 60 yards of roving in grains, to work out a pinion, is because when the roving is considered by the hank per pound, it very often happens that it is a few grains over or under what it should be, and then the pinion so found is not so exact as when found by taking the weight in grains.

Where the hank roving can be depended upon as correct, the following rule will be found correct:

Rule.—Multiply the carrier, the back roller wheel, and the hank roving together for a dividend. Then multiply the front roller wheel, and counts required to be spun, for a divisor ; the quotient will be the required pinion.

For the better remembrance of the foregoing rules they are placed in the following form, viz. :—

$$C\,.\,B\,.\,500 = F\,.\,P\,.\,C^{ts.}\,.\,W.$$

where C means carrier wheel; B, back roller wheel; 500, the dividend for 60 yards of roving; F is the front roller wheel; P, the pinion; $C^{ts.}$, the counts of yarn; W, the weight in grains of 60 yards of roving. The dot between them means that they must be multiplied together; = is the sign of equality; and whichever term is being sought, multiply the other terms on the same side of the sign = for a divisor, and the terms on the other side for a dividend. The quotient will be the term sought.

Where the hank roving is used, and can be depended upon as correct, the following will assist the memory, viz. :—

$$C\,.\,B\,.\,H^{k}\,.\,R = F\,.\,P\,.\,C^{ts.}.$$

The above will also answer when using the roving as so many hanks per lb.

At mills where there is a great deal of changing, it is not uncommon to spin all counts from about 18's to 40's out of the same hank roving. The consequence is the spinner has many back and front roller wheel changes, which sometimes place him in a dilemma from want of a right pinion or other conditions.

Example.—Suppose 26's is being spun, with a 13 front roller wheel, 78 carrier, 45 back-roller wheel, and 37 pinion, and 36's are demanded : 37 × 26 and divided by 36 gives 26·7 as the pinion required, or, more nearly, a 27 pinion ; but this being less than any on hand (and even if on hand), they could not be geared on account of other conditions in headstock. This being the case, it is evident that the back-roller wheel must be changed, and the largest that can be got on is a 50. It then becomes a question how to change counts from 26's to 36's under the following conditions, viz. : The front-roller wheel is 13, back-roller wheel 45, the pinion is 37, and the back-roller wheel going on is 50 :

$$36 \times 45 = 26 \times 37 \times 50$$

1620) 48100 (29.6 Wheel required 29 or 30.

Rule.—Multiply the counts being spun by the pinion on, and again by the back-roller wheel intended to be put on, for a dividend ; then multiply the counts required by the back-roller wheel on, for a divisor ; the quotient will be the pinion required.

This rule is applicable to the card-room, mule-room, or throstle-room.

To assist the memory further in making these, or any other changes, first put down the counts being spun, next the pinion on, and if changing the front roller wheel put the wheel in gear down next, and the back roller wheel next going on, then the sign thus =. Then put down the counts to be spun, the front roller wheel to be put on, and back roller wheel on. Multiply all the terms on the left hand of the sign for a dividend, and multiply the terms on the right hand side for a divisor. The quotient will be the pinion required.

The material which the experienced spinner has to contend with has something to do with the regulation of the twist in both the roving and the yarn, but for general purposes in changing from one number to another, the following rule must be observed:

RULE.—Square the twist wheel on (that is multiply it by itself), then multiply by the counts being spun, and divide by the counts demanded. The square root of the quotient will be the twist wheel required.

In some headstocks the wheel to be changed is a driven wheel; in that case multiply by the counts it is desired to spin, and divide by the counts being spun, and extract the square root as before.

What is said here refers to what is generally called the speed wheel; the same rule will apply to the bell wheel or rim pulleys.

EXAMPLE.—Change counts from 42's to 28's, the speed wheel on being 23. What speed wheel will be required to give a proportionate number of turns per inch?

$23 \times 23 \times 42 = 28$) 22218 ($\sqrt{793} = 28$ speed wheel required.

Again :—Change from 26's to 32's, the diameter of the rim on being 18 inches; what diameter of rim will be required?

NOTE —*When regulating the twist by changing the rim, always multiply by the counts required to be spun.*

EXAMPLE.—$18 \times 18 \times 32 = 26$) 10368 (398·76, square root of which is 19·9; being extremely near 20 inch, the rim required.

To find a speed wheel that will allow a given number of turns per inch of yarn to be put in during the stretch:

RULE.—Multiply the revolutions of front roller per stretch, the number of teeth in crown bevel, the turns of spindle for one of rim, for a dividend, then multiply the length of stretch by the turns per inch wanted. The quotient will be the required speed wheel.

To find the diameter of rim that will produce a given number of turns per inch, other conditions being given:

RULE.—Multiply the circumference of front roller, the turns per inch wanted, the speed wheel on, the diameter of pulley in centre shaft, and the diameter of spindle wharve together. Then multiply the crown bevel on front roller by the diameter of centres for a divisor. The quotient will be the diameter of rim.

To find the drag wheel that will bring out the carriage with the same speed as front roller travels when starting new mules:

RULE.—Multiply the jack wheel on front roller, the small wheel connected with the drag wheel, and the diameter of the jack band scroll together for a dividend. Then multiply the wheel on back shaft and the diameter of front roller together for a divisor. The quotient will be the drag wheel required.

In mills where coarse numbers are spun, say from No. 10's to 26's, it is best to run the mule at some minimum speed, which will be determined by the experience of the spinner, and when the speed most suitable for the mule and material is found, then all changes, for the regulation of twist to be put in, must be effected by changing the rim, and it will be necessary for the spinner to make himself acquainted with the number of turns of spindle for one of rim, for each size of rim he may occasionally use.

The most exact way of finding the turns of spindle for one of rim, is to multiply the diameter of rim, and the diameter of tin roller together, for a dividend; and the diameter of centre pulley and the diameter of spindle warve, for a divisor. The quotient will be the turns of spindle for one of rim.

Most of the foregoing rules and examples are condensed from the practice of Mr. James Ardern, of Marple.

The Slide Rule is very convenient for working out the calculations, extracting square roots, &c., and a perfect knowledge of it is very essential to a manager. It is likewise convenient to have a pocket table of the square roots of all the numbers likely to be spun.

HOW TO MAKE YARN OF SUPERLATIVE QUALITY.

In establishing a mill, capitalists, not thoroughly conversant with the business, are sometimes at a loss how many frames or carding engines they shall put in for a certain number of mule or throstle spindles, and what hank roving they shall make for the different frames. Examples have already been given of some of the best existing mills, for general purposes, both for fine and coarse spinning, which they cannot do better than imitate. But if a spinner wants to make a very superior quality of yarn, it can only be done by an extra quantity of cards or frames. If rovings are put through an extra frame before being spun and doubled two, three, or four-fold together, a wonderful improvement in the quality of the yarn will be effected. In doubling three or four-fold together, the finishing frames should only have a single row of spindles, or have the bobbins doubled three or four-fold upon a machine with stopping motions, and then the frame might have two rows in the usual way.

CONCLUDING REMARKS.

IN concluding the subject of "THE SCIENCE OF MODERN COTTON SPINNING," and tracing the successive inventions that have led to the important results—political, social, and intellectual—brought about during the last hundred years, it cannot fail to strike the reader that the manufacture of Cotton has been the main-spring in effecting the wonderful changes which have taken place. To this manufacture may be traced the general and rapid improvement of the mechanical arts which have developed other important inventions, through the expansion of our commerce, creating a demand for improved transit by land and sea. To this manufacture may be mainly attributed the largely increased revenues of the State, the development of our mines and minerals, and the construction of railways.

In this manufacture, Lancashire has played the most important part. It has, so to speak, clothed the world, covered all known seas with merchant vessels, carried civilisation and Christianity amongst the heathen, developed the products of heretofore unknown lands, been foremost in free-trade principles and in knocking off the fetters from the slave, has scattered blessings amongst the destitute, and raised mankind generally to a higher level of social life and happiness. Lancashire has also produced not a few eminent statesmen, philanthropists, and orators; raised the value of our lands, and developed trade and exchanges of commodities everywhere. Lancashire fabrics are now worn by the Arabs of the Desert, the Negroes of Central Africa, the Hindoos and Chinese of the far East, the Red Indians of the West, and the numerous tribes of Polynesians in the Pacific Ocean. No manufacture of any kind, of any age or country, has ever developed so much original talent and true genius, so much power of invention, mechanical skill, and enormous wealth, as the cotton manufacture of Lancashire. It has drawn out of poverty and obscurity men who have become the controllers of their own destiny, some by life-long struggles, and others by a short but brilliant career;—men who were their own ancestors, as regards family, wealth, and fame;—self-made men, the founders of an original aristocracy, "cotton lords" and merchant princes, who owed their elevation, not to the favour of the Crown, but to their own brain and sinew and indomitable spirit. No wonder, then that Lancashire has taken a proud position in the nation, and that her voice is listened to with great respect in the Senate. If the nation has been backward in raising sculptured monuments to her eminent mechanicians and sons of toil, the stranger who visits Lancashire has only to look around at the colossal manufactories and palatial warehouses for monuments of their worth.

In concluding this last number of "THE SCIENCE OF MODERN COTTON SPINNING," the author desires to record his thankfulness for the very gratifying reception his work has met, not only in Great Britain, but also on the Continent of Europe and in America. He regards this favourable reception more as a testimony to its practical character than to any literary merit. Enlarged editions of its parts have been demanded while passing through the press, which have caused some delay from the intended period of publication of the different numbers. The work is for the most part the result of the thinkings and jottings down of a long and varied experience, during which cotton mills have been visited in all parts of the globe, except the few in the far East. He lays down his pen not without hope, that the comprehensiveness of the numerous details of Cotton Spinning, in its various branches and operations, as well as the elaborate illustrations of machinery, embracing the most recent improvements and inventions, will render the work full and complete, if not altogether exhaustive upon the subject of "THE SCIENCE OF MODERN COTTON SPINNING."

THE END.

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