A.D. 1784 . . . . . N° 1432.

Fire and Steam Engines, &c.

WATT'S SPECIFICATION.

TO ALL TO WHOM THESE PRESENTS SHALL COME, I, JAMES WATT, of Birmingham, in the County of Warwick, Engineer, send greeting.

WHEREAS His most Excellent Majesty King George the Third, by His Letters Patent bearing date at Westminster the Twenty-eighth day of April, in the twenty-fourth year of His reign, did give and grant unto me, the said James Watt, His special licence, full power, sole privilege and authority, that I, the said James Watt, my exors, admors, and assigns, should and lawfully might, during the term of years therein expressed, make, use, exercise, and vend, throughout that part of His said Majesty's Kingdom of Great Britain called England, his Dominion of Wales, and Town of Berwick-upon-Tweed, my Invention of "CERTAIN NEW IMPROVEMENTS UPON FIRE AND STEAM ENGINES, AND UPON MACHINES WORKED OR MOVED BY THE SAME;" in which said recited Letters Patent is contained a proviso obliging me, the said James Watt, by writing under my hand and seal, to cause a particular description of the nature of the said Invention, and in what manner the same is to be performed, to be inrolled in His Majesty's High Court of Chancery within four calendar months after the date of the said recited Letters Patent, as in and by the said recited Letters Patent, and the Statute in that behalf made, relation being thereunto had, may more at large appear.

NOW KNOW YE, that in compliance with the said proviso, and in pursuance of the said Statute, I, the said James Watt, do hereby declare that the nature of my said Invention, and in what manner the same is to be performed, is particularly described and ascertained as follows, that is to say:—

My first new improvement on steam and fire engines consists in making the steam vessel so as to be capable of turning round on pivots, or on an axis, either in a vertical or horizontal direction, and in employing the elastic power of the steam to press upon it the surface of any dense fluid or liquid contained in the steam vessel, and to force it to pass out at an hole or holes made in the circumference or external part of the steam vessel, in such manner that the fluid or liquid shall issue out in a line forming a tangent to the circle described by the rotation of that part of the steam vessel where the hole is situated, or at least in a line approaching to such tangent; which fluid or liquid, by its action on the fluid or liquid in which the steam vessel is immersed, causes the engine to turn round; and I replace the fluid so issuing by immersing the steam vessel into another vessel filled with the same fluid, and by dividing it into two or more divisions or chambers in the direction of its axis of rotation, which chambers are furnished with valves in their bottom or sides which admit the fluid to enter into one of them, while by the force of the steam it issues from another; and the steam is admitted into these chambers and its action is suspended alternately by proper valves and regulators, which are opened and shut by the rotation of the machine. The machine may be made in various forms. I have delineated one of the most commodious in Fig. 1st of the annexed Drawing, where A, B, C, D, E, represents a section of the steam vessel mounted on a vertical axis, with one perpendicular partition; F, G, two valves in its bottom to admit the surrounding liquid; H, the place of one of the holes at which it issues; J, the pivot on which it turns; K, a collar which is fitted exactly to the neck of the steam vessel, so as to be steam tight, and yet to give liberty to the vessel to turn round in it freely; L, a pipe conveying steam from a boiler to the steam vessel, and which is joined to the collar. There are two holes in the neck of the steam vessel which communicate with its two chambers, and as the vessel turns round present themselves alternately to the opening of the steam pipe within the collar, and to an opening on the opposite side of the collar which communicates with the empty part of the vessel M, N, which contains the liquid in which the steam vessel is immersed. The vessel M, N, is made of a cylindric or other form, and contains a quantity of quicksilver, water, oil, or other fluid or liquid, of a depth sufficient to give a resistance to the issuing fluid proportioned to the effect wanted to be produced, and to cause the fluid to fill the empty chamber of the steam vessel in proper time. If the machine is required to act only by such steam as has a greater expansive force than the pressure of the atmosphere, this vessel M, N, is opened at top, and the steam which has done its office is then discharged into the open air; but when the steam is required to act with the pressure of the atmosphere, in addition to

its own elastic force, then the vessel M, N, must be shut at top, and made everywhere air tight, and the steam be made to pass from it by the pipe O into another vessel called a condenser, where it is condensed by the application of cold water or other cold bodies, by which means a vacuum is obtained, and the power of the steam is augmented. Fig. 2d is a ground plan of the steam vessel and of the external vessel; H, H, are two apertures at which the fluid alternately issues; and F, G, are the valves by which it enters. Fig. 3d is a horizontal section of the collar and of the neck of the steam vessel, in which R, R, are the two apertures which admit and discharge the steam, and L the steam pipe coming from the boiler. The action of the machine is as follows:— Steam being admitted into one of the chambers causes the fluid contained in it to issue with violence at the lower aperture belonging to that chamber; and the fluid so issuing, by its action against the quiescent fluid contained in the outer vessel, causes the steam vessel to turn round, by which means the upper aperture of the other chamber is presented to the steam pipe, and the action on the fluid in that chamber commences; at the same time the steam issues at the upper aperture of the first chamber, and it is replenished by the fluid entering by the valve at the bottom. The machinery to be worked by the engine is put in motion by being attached, fixed to, or connected with the end of the axis P, which passes through a hole or collar in the cover of the outer vessel M, N. This engine is delineated by a scale of one inch for each foot of the real size, but may be larger or lesser, and its proportions varied at pleasure.

My second new improvement on the steam engines consists in methods of directing the piston rods, the pump rods, and other parts of these engines so as to move in perpendicular or other straight or right lines, without using the great chains and arches commonly fixed to the working beams of the engines for that purpose, and so as to enable the engine to act on the working beams or great levers, both by pushing and by drawing, or both, in the ascent and descent of their pistons. I execute this on three principles. The first principle is delineated in Fig. 4th, and is performed by connecting with the top of the piston rod A, by means of joints, two secondary levers or beams B, C, the other ends of which are furnished with arches D, E, which roll upon the walls of the house F, G, or on pieces of timber or other proper resisting bodies fixt at convenient distances, parallel to the line of motion of the rod which is required to receive the right-lined or perpendicular motion, and these arches are suspended in their places by means of leather belts, chains, or jointed bars of iron attached to them. The top of the piston or pump rod and the working beam are also connected together by means of a piece of iron or wood, H, having a joint at each end, on

which it can move freely, and accommodate itself both to the angular motion of the working beam J, J, and to the perpendicular motion of the piston or pump rod. The second principle, by which I produce a right-lined motion from an angular or circular motion, is delineated in Figs. 5th and 6th, and consists in guiding the top of the piston rod or pump rod perpendicularly by means of a piece of wood or iron or other material, A, sliding in a groove made in an upright, B, firmly fixed to some part of the machine, so as to be higher than the working beam C, and in the direction of the required motion, and by connecting of the working beam with the top of the piston rod or pump rod D, or with the said sliding piece A, by means of a bar or bars of wood or iron, E, having joints at each end. Fig. 6 shews an end view of the working beam, piston rod, sliding piece, and connecting bars; and the prickt circular and angular lines, Fig. 5th, shew the quantity of angular motion of the working beam.

In Fig. 19 is delineated another method of using this principle. A, A, is the piston of the engine, which has a hollow piston rod, B, B, and the connecting rod C, C, is attached to the bottom of that hollow rod by means of a joint, and to the working beam by means of another joint, and the hollow piston rod, by sliding in the collar D, D, serves to direct the motion, and the hollow rod is made wide enough to permit an angular motion of the connecting bar proportioned to the versed sine of the angle described by the working beam. The third principle, upon which I derive a perpendicular or right-lined motion from a circular or angular motion, consists in forming certain combinations of levers moving upon centres, wherein the deviation from straight lines of the moving end of some of these levers is compensated by similar deviations, but in the opposite directions, of one end of other levers.

In Fig. 7th and 8th is delineated one method of putting this principle into practice. A, A, represents the working beam of the engine; B, the wall or support on which it rests; C, C, the spring beam; D, E, a lever or bar of iron, moveable about the axis or centre D (which is fixt to the spring beam), and also about the axis or centre E, which is connected with or is a part of the bar or rod E, F. The bar E, F, is capable of sliding towards or from the axis or centre of the working beam by a sliding motion between a pair of cheeks at E, and by a portion of a circular motion of the end F round the centre H, from which it is suspended by the coupling bars or links H, F. The piston rod or pump rod G is fastened to the bar F, E, and to the link H, F, by the joint pin at F. The right line F, L, is that in which the piston rod or its end F moves upwards or downwards. K, M, is a portion of a circle described from the centre of

the working beam, to which L, E, is a tangent, and K, L, and M, F, shew its greatest deviations from the straight line or tangent. E, N, J, is a portion of a circle described on the centre D by the joint pin E; and the length of D, E, and the situation of the centre D, are such that the lines J, L, N, O, E, F, are equal, and are represented by the rod E, F. Therefore, whenever the working beam is moved on its centre, the cheeks at E and the joint at F oblige the bar E, F, to move upwards or downwards along with it; but, the centre D being fixed, the end E of the rod E, D, can only move in the circle E, N, J, and the joint pin E obliges the rod E, F, to slide under the working beam between the cheeks, and to come nearer to the centre, or to recede from it, according to the position of the working beam. And as the distances between every point of the arc J, N, E, and the corresponding points of the line L, O, F, are always equal, the point or joint F, together with the top of the piston rod, must move in the straight line L, O, F.

In Fig. 8th is delineated a view of the underside of the working beam, seen from below, in which it is shewn that the bar E, D, is made double in order that one part may go on each side of the working beam, and that the joint pins E, D, and F reach from side to side of the beam. Though the apparatus is in these Drawings placed below the working beam, and that beam is fixed above its own axis or gudgeon, yet the contrivance will answer equally well if the whole were reversed, or if the rod E, F, and the axis of the working beam were placed in the middle of its depth by making the beam double. The proportions of the lengths and thicknesses of the parts to one another are such as answer in practice, but may be considerably varied, provided the principle be attended to.

In Fig. 9, 10, and 11 I have delineated another method whereby I carry this third principle into practice. A, A, represents the working beam of an engine; B, D, the piston rod or pump rod; C, D, E, one of two bars of iron or wood connected by joints at E and D with the working beam and with the top of the piston rod respectively, and at C by a joint to an angling bar or bars, C, F, the other end or ends of which is or are connected with the wall of the house or some firm support by a joint or joints at F, on which, as a centre, the bar C, F, is moveable. When the working beam is put in motion on its axis, the point E describes the arc (H, E, I), and the point C describes the arc K, C, L, on the centre F; and the convexities of these arcs, lying in opposite directions, compensate for each others variations from a straight line, so that the joint D, at the top of the piston rod or pump rod which lies between these convexities, ascends and descends in a perpendicular or straight line. The respective lengths of the radii G, E, and C, F, and their proportions to

one another, may be varied; but if the radius C, F, be lengthened more in proportion than G, E, the point D must be placed proportionably further from E, and nearer to C, and vice versa, as is pointed out by geometry. The regulating radius or rod C, F, may also be placed above the working beam, and the latter may be reversed in regard to its own axis where such construction is found more convenient.

In Fig. 10th I have delineated a horizontal view of the radii C, F, and in Fig. 11th an end view of the working beam A, and the connecting bars E, D, C, with the piston rod B, B.

In Fig. 12th I have delineated another method whereby I put this third principle into practice. The regulating radius F, H, being centered at H on a firm support, and the connecting bar F, B, G, being connected with the working beam by a joint at B, is prolonged to G, where it is connected with the piston rod or pump rod G, C, by another joint. As the radius F, H, is shorter than the radius J, B, the parts of the connecting rod F, B, B, G, are so proportioned to one another that, on account of the difference of the convexities of the arches F, E, and B, C, the point G and the piston rod G, C, will always ascend and descend in a perpendicular or straight line. This machinery also admits of being reversed; that is, the regulating radius H, F, may be placed under the working beam, and the working beam above its own centre of motion, in cases where that is found more convenient. This third principle may also be put in practice by other methods, but those delineated are in general the most eligible. All of them are laid down by a scale of one fourth of an inch for each foot of the real size, in their proper proportions for engines whose cylinders are twenty inches in diameter, and the length of whose stroke is four feet, except Fig. 5th and 6th, which are delineated for a six-feet stroke, and Fig. 19, which is laid down for a cylinder fifteen inches in diameter and twelve inches length of stroke; but all the dimensions admit of considerable variation, according to the exigency of the case, and, preserving the proportions, are applied to cylinders of different diameters and lengths of stroke.

My third new improvement is upon the application of steam or fire engines to work pumps or other alternating machinery. It consists in causing by proper machinery one half or one part of the pump rods to ascend while the other descends, whereby the weight of the pump rods and other moving parts always nearly ballance one another, and the necessity of employing other matters to ballance their weights, which are frequently enormous, is avoided. It is particularly applicable to engines which act forcibly both by the ascent and descent of the piston in the cylinder, but may also be advantageously employed to

engines which act forcibly by the motion of the piston in one direction, as in such cases the weight of one sett of pump rods may be employed during their descent to pull up the rods of other pumps, and thereby to work them. I perform this in various methods, of which I have delineated two of the best. The first of these consists in suspending one half or part of the pump rods to one end of a lever or working beam, and the other part or half to the other end of the same lever, which lever or working beam is supported on a centre or axis in some part of its length between the two rods, and the said rods are connected with or suspended to or from the said double lever by means of simple joints, or by means of chains and arches, or, in place of a lever, a wheel and chain may be used. The said lever may either be the working beam of the engine or a seperate lever placed over or within the mouth of the pitt or shaft, and receiving its motion either directly from the piston rod of the engine or from the working beam by means of a stiff rod, or, in case of the engine's being of that kind which acts only in one direction, by means of a chain or rope.

In Fig. 13th, A, A, represents the double lever; B, its centre or axis; C, L, and D, M, two rods of wood or iron, or two chains, connecting this beam with the pump rods, which pump rods are suspended to the joints M, L; K, K, represent two wheels which serve to guide the rods, and to bring them nearer together than they would naturally hang, in cases where the connecting rods C, L, D, M, cannot be admitted to hang perpendicularly under the ends of the double lever; and J represents the lower end of a stiff rod reaching from the working beam or other moving part of the engine, and connected with the double lever A, A, by means of the joint H. And be it remarked, that in cases where the connecting rods C, L, D, M, are kept from their perpendicular position by means of wheels, (such as K, K,) the lower ends, M, L, of these rods would describe curved or angular lines, which would disturb the perpendicularity of the pump rods suspended from these points. In order, therefore, to avoid such defect, I form the lower part of these connecting rods into curves, as shewn in the Drawing, which curves, acting against the wheels K, K, compensate for the irregularities which would otherwise take place, and cause the points L and M, and the pump rods which are attached to them, to ascend and descend in perpendicular lines. (The figure of such curve is readily found by geometry.) The second method consists in connecting together levers which turn or move on seperate or different axes or centres in such a manner that the moveable end of one lever shall descend when the moveable end of the other lever ascends, and vice versa, and in connecting the moveable end of one of these levers with the working beam or piston of the engine in some proper manner, and in suspending the pump rods

to the moveable ends of these levers by means of joints or chains. No. 14 represents a combination of levers which comes under that description. The two similar frames B, F, E, H, and C, G, D, J, are moveable on their respective centres E and D, and are connected together by a brace or braces H, K, J, so that the pieces H, E, and J, D, must when put in motion continue parallel to one another, and, consequently, from the positions of the pieces or levers F and G, when the joint pin B describes the arc B, N, the joint pin C of the other frame must describe the arc C, O, in the opposite direction, by which means the pump rod L ascends when the pump rod M descends, and vice versa; and these frames are connected with the engine or its working beam by means of the rod or chain A, B, or, in place thereof, one of the levers F or G is prolonged on the other side of their respective centres, E or D, to a sufficient length to become itself the working beam of the engine. And the whole of this machinery may be reversed or placed upside down; that is, the levers E, H, and D, J, with the brace or braces H, K, J, may be placed above their centres E and D, instead of being placed below them, and may also upon the same principle be varied in other manners.

The machinery delineated in Figures 13 and 14 is laid down by a scale of one fourth of an inch for every foot of the real dimensions, and is adapted for cylinders of twenty inches diameter and four feet stroke; but machinery on the same principles is made for larger or lesser engines, as required.

My fourth new improvement consists in new methods of applying the power of steam engines to move mills for rolling and slitting iron and other metals, or to move other mills which have many wheels which are required to turn round in concert, so that the same steam or fire engine shall directly, by means of a double working beam or by means of a strong piece of wood or other materials fixed across one end of the working beam and by means of two seperate rods connecting the said working beam or cross beam with proper machinery for producing rotative motions, give motion to two primary wheels, fixt either on the same or seperate axes, whether acting in concert or applied to different uses, and in connecting together by means of a secondary axis carrying two or more wheels different primary motions produced by the same engine, or by two or more different engines; which methods are particularly applicable to the connecting together the motions of the rollers and slitters, or of different pairs of rollers, in mills for rolling and slitting metals, which are worked by fire or steam engines.

In Figs. 15, 16, and 17 is delineated the application of this improvement to a slitting mill, which Drawings exhibit that machine in three different views, in all of which the same parts are markt with the same letters.

Fig. 16th is a section of the mill through the line *x*, *x*, of Figure 17, except in what relates to the working beam A, B, the cross beam C, and the upper ends D, E, of the two connecting rods of the rotative motions. In order to avoid confussion, the rod E is represented as broken off, and the remaining part of it, and the position of the rotative motion which it works, are represented by the red ink lines and circles Q and R; F is the revolving wheel of a rotative motion, which is fixt to the rod D; and G, G, is the centre wheel of the same motion, which is fixt upon the axis of the fly wheel J, J, and of the toothed wheel K, K, to both which it gives motion, and also to the lower set of the slitters which are turned by that axis. The toothed wheel K, K, acts upon and gives motion to another toothed wheel N, N, which is fixt on the same axis with the fly wheel O, O, which turns the upper roller in the roll frame P, and the direction of the motion of these and the other wheels is shewn by the darts; and the rod E, with the rotative motion Q, R, (Fig. 15 and 17,) turns the fly wheel M, M, and the toothed wheel L, L, which is upon the same axis with that fly, and which axis also turns the upper sett of the slitters. The toothed wheel L, L, acts upon and turns the toothed wheel S, S, and its fly wheel T, T, and their axis turns the lower roller. The motion is thus communicated to all the wheels and flys, and also to both the rollers and slitters; but, as the flys J, J, and T, T, must turn in the opposite direction to the flys M, M, and O, O, and as there is nothing in the rotative motions themselves that can determine these wheels to take contrary motions at first setting out, and as at the top and bottom of the motion of the connecting rods D and E, and the revolving wheels which are fixt to them, the necessary shake in the teeth of the wheels of the rotative motions will permit the fly wheels on one side of the mill to run faster than those on the other, which produces a very prejudicial effect on the whole machine, I have contrived to connect the toothed wheels K, K, and S, S, together, by means of the toothed wheels V and W, fixed on the secondary axis Y, under the other machinery, the teeth of the wheel V are engaged into the teeth of the wheel K, and the teeth of the wheel W are engaged into those of the wheel S, so that W and V being on the same axis, cause K and S to turn in the same direction, and consequently L and N to turn in the contrary direction, and the whole wheels to move in an uniform manner. In place of the cross beam C, two working beams may be used, united together at the ends which are next the cylinder, and opening to the proper distance at the other ends like the letter V, and one of the connecting rods may be suspended to one of these beams, and the other rod to the other beam. In other cases where the power required is not very

great, I construct slitting mills with engines which have only one working beam and one set of machinery for producing a rotative motion, which is connected with the axis of one of the fly wheels, from whence the motion is transmitted to the other parts of the machine by the toothed wheels K, K, L, L, N, N, and S, S, and by the secondary axis Y, and its toothed wheels V and W. The whole of this machinery is drawn in its due proportions to a scale of one fourth of an inch to each foot of the real size, to be moved by an engine with a cylinder of forty-eight inches diameter, and six feet length of stroke, but it is made larger or lesser as required. Be it remembered, that, although in order to explain my said fourth new improvement I have been obliged to delineate the whole of a slitting mill, yet that the new improvements which are the subjects of this article of the Specification are only the communicating the motion from the same steam or fire engines to two seperate primary axes or shafts and setts of wheels moving in the same or in contrary directions, and in connecting together four or more setts of wheels by means of secondary axes or shafts carrying two or more wheels each, such as the shaft or axis Y, and its wheels V and W, both which improvements are to the best of my knowledge entirely new. In Fig. 20th I have delineated the machinery by which the rotative motion is in this case proposed to be communicated from the working beam of the engine to the mill work (which is one of the methods described in the Specification of certain Letters Patent which His present Majesty was most graciously pleased to grant to me, bearing date October 25th, in the twenty-second year of His reign); but this Drawing is only intended for elucidation, for I apply to this purpose, not only the rotative machinery now delineated, but also any other kind which is proper or suits the particular case.

My fifth new improvement consists in applying the power of steam or fire engines to the moving of heavy hammers or stampers, for forging or stamping iron, copper, and other metals or matters, without the intervention of rotative motions or wheels, by fixing the hammer or stamper to be so worked either directly to the piston or piston rod of the engine, or upon or to the working beam of the engine, or by fixing the hammer or stamper upon a secondary lever or helve, and connecting the said lever or helve by means of a strap or of a strong rod to or with the working beam of the engine, or to or with its piston or piston rod. In Fig. 18th is delineated, on a scale of one third of an inch for each foot of the real size, a view of an engine of my invention, with a cylinder of fifteen inches diameter, working a hammer of five hundred pounds weight, in which A is the cylinder; B, the piston rod; C, C, the working beam of the engine; D, D, the drom beam of the forge,

which in this case is made double; E, a strong post which carries the end of the drom beam; F, the rabbit or spring piece, which regulates the ascent of the hammer, and beats it back; G, G, one of the two legs which carry the axis of the hammer; H, the hurst or axis of the hammer helve; J, the helve; K, the puppet or piece which supports the rabbit; L, the hammer; N, the anvil, and M, the rod which connects the helve with the working beam; O, P, the nozles or regulator boxes; R, the condensing vessel; S, the condenser pump; T, T, a cistern of cold water; V, the plug frame which opens and shuts the regulators; and W, a steam pipe coming from a boiler. In Figure 19th is delineated on a larger scale a section of the cylinder and a view of the apparatus, by which, in cases where the engines are required to be workt very quick, the regulators are opened and shut, which shall be described in the next section.

My sixth new improvement consists in making the regulating valves which admit the steam into the cylinders of fire or steam engines, or which suffer it to go out of them in such manner that they are pushed open by the action of the steam upon them, and are kept shut by certain catches or detents, which are unlocked at proper times either by hand or by the engine itself. I perform this by making the circumference of these valves in a conical or tapering form, as shewn at P and Q, Fig. 19th, and by grinding or otherwise fitting exactly the said circumferences to a ring of metal which is called the valve seat, so that when shut it may be steam or air tight; the valves Q and P are suspended or supported by links, or by racks and sectors, which connect them with certain levers, E and F, in the insides of the nozles, which, by means of the spindles or axes on which they are fixt, communicate with the levers G, G, which are upon the outside of the nozles, and are connected by the rods H, H, with the short levers S, T, and V, W, turning upon their respective axis's S and V. When the valve is shut, the centre of the pins T and W lie a little beyond the straight lines passing through the centres of S and G, and of V and G, and no force applied at G, G, can unlock or discharge the valves P and Q, until the points T and W are moved to the other sides of the straight lines S, G, and V, G, respectively. When the piston of the engine descends, the valve P is shut, and Q is open; the pin *x* strikes the handle K, which shuts Q, and the pin M immediately strikes the handle J, which, moving the point T from the right line, disengages the valve P, and suffers it to open. The piston A, A, then ascends with the plug tree L, and the pin Z returns the handle J to its proper position, which shuts P, and the pin N strikes the handle K, which

permits Q to open, and the piston A, A, descends into its first position, and commences a new stroke upward, and so continuedly. And the power and velocity of the engine is regulated by opening or shutting a regulating valve placed at O, which admits more or less steam as required.

My seventh new improvement is upon steam engines which are applied to give motion to wheel carriages for removing persons or goods or other matters from place to place, and in which cases the engines themselves must be portable. Therefore, for the sake of lightness, I make the outside of the boiler of wood or of thin metal, strongly secured by hoops or otherwise, to prevent it from the bursting by the strength of the steam; and the fire is contained in a vessel of metal within the boiler, and surrounded entirely by the water to be heated, except at the apertures destined to admit air to the fire, to put in the fuel, and to let out the smoke, which latter two apertures may either be situated opposite to one another in the sides of the boiler, or otherwise as is found convenient, and the aperture to admit air to the fire may be under the boiler. The form of the boiler is not very essential, but a cylindric or globular form is best calculated to give strength. I use cylindrical steam vessels with pistons as usual in other steam engines, and I employ the elastic force of steam to give motion to these pistons; and after it has performed its office, I discharge it into the atmosphere by a proper regulating valve, or I discharge it into a condensing vessel made air tight, and formed of thin plates or pipes of metal, having their outsides exposed to the wind, or to an artifical current of air produced by a pair of bellows or by some similar machine wrought by the engine or by the motion of the carriage, which vessel, by cooling and condensing part of the steam, does partly exhaust the steam vessel, and thereby adds to the power of the engine, and also serves to save part of the water of which the steam was composed, and which would otherwise be lost. In some cases I apply to this use engines with two cylinders which act alternately, and in other cases I apply those engines of my invention which act forcibly both in the ascent and descent of their pistons; and by means of the rotative motion in Fig. 20th, or of any other proper rotative motion, I communicate the power of these engines to the axis or axletree of one or more of the wheels of the carriage, or to another axis connected with the axletree of the carriage by means of toothed wheels; and in order to give more power to the engine, when bad roads or steep ascents require it, I fix upon the axletree of the carriage two or more toothed wheels of different diameters, which, when at liberty, can turn round freely on the said axletree when it is at rest, or remain without turning when it is in motion. But by means

of catches, one of these wheels at a time can be so fixt to the axletree, that the axletree must obey the motion of the toothed wheel which is so lockt to it; and upon the primary axis which is immediately moved by the engine, or which communicates the motion of the engine to the axletree of the carriage, I fix two or more toothed wheels of greater or lesser diameters than those on the axletree, which are moved by them respectively, so that the wheels on those two axles, having their teeth always engaged in one another, the wheels on the axle of the carriage always move with the wheels on the axle of the rotative motion, but have no action to turn the wheels of the carriage except one of them be lockt fast to its axletree; then the latter receives a motion, faster or slower than that of the axle of the rotative machinery, according to the respective diameter of the wheels which act upon one another. In other cases, instead of the circulating rotative machinery, I employ toothed racks or sectors of circles, worked with reciprocating motions by the engines, and acting upon ratchet wheels fixed on the axles of the carriage; and I steer the carriage or direct it's motion by altering the angle of inclination of its fore and hind wheels to one another by means of a lever or other machine. As carriages are of many sizes and variously loaded, the engines must be made powerful in proportion; but to drive a carriage containing two persons will require an engine with a cylinder seven inches in diameter, making sixty strokes per minute of one foot long each, and so constructed as to act both in the ascent and descent of the piston, and the elastic force of the steam in the boiler must occasionally be equal to the supporting a pillar of mercury thirty inches high.

Lastly, as throughout this Specification I have particularly described my several new improvements as applied to the improved steam engines of my Invention (the sole use and property of which His present Majesty was most graciously pleased to grant to me, my executors, administrators, and assigns, by His Royal Letters Patent bearing date the Fifth day of January, in the ninth year of His reign, and which were confirmed by an Act of Parliament made and passed in the fifteenth year of His reign, and for sundry improvements on which His Majesty was also most graciously pleased to grant to me His Royal Letters Patent, bearing dates on the Twenty-fifth of October and the Twelfth day of March, both in the twenty-second year of His reign), be it therefore remarked, the said new improvements herein particularly described are all or most of them not only applicable to the improved engines of my Invention, but also to engines of other constructions which would be improved thereby; and that as I suppose the Specifications of the several above-mentioned Letters Patent to be generally known, I refer to

them for an explanation of any particulars relative to my former Inventions which may not be clearly understood from these presents.

In witness whereof, I, the said James Watt, have hereunto set my hand and seal, this Twenty-fourth day of August, in the year of our Lord One thousand seven hundred and eighty-four.

JAMES (L.S.) WATT.

Signed and sealed (being first duly stampt) in the presence of

JOHN SOUTHERN,
ZACCHEUS WALKER, Junior.

AND BE IT REMEMBERED, that on the Twenty-fourth day of August, in the year of our Lord 1784, the aforesaid James Watt came before our said Lord the King in His Chancery, and acknowledged the Specification aforesaid, and all and every thing therein contained and specified, in form above written. And also the Specification aforesaid was stampt according to the tenor of the Statutes made for that purpose.

Inrolled the Twenty-fifth day of August, in the year of our Lord One thousand seven hundred and eighty-four.

LONDON:
Printed by GEORGE EDWARD EYRE and WILLIAM SPOTTISWOODE,
Printers to the Queen's most Excellent Majesty. 1855.

FIG. 1.ST.

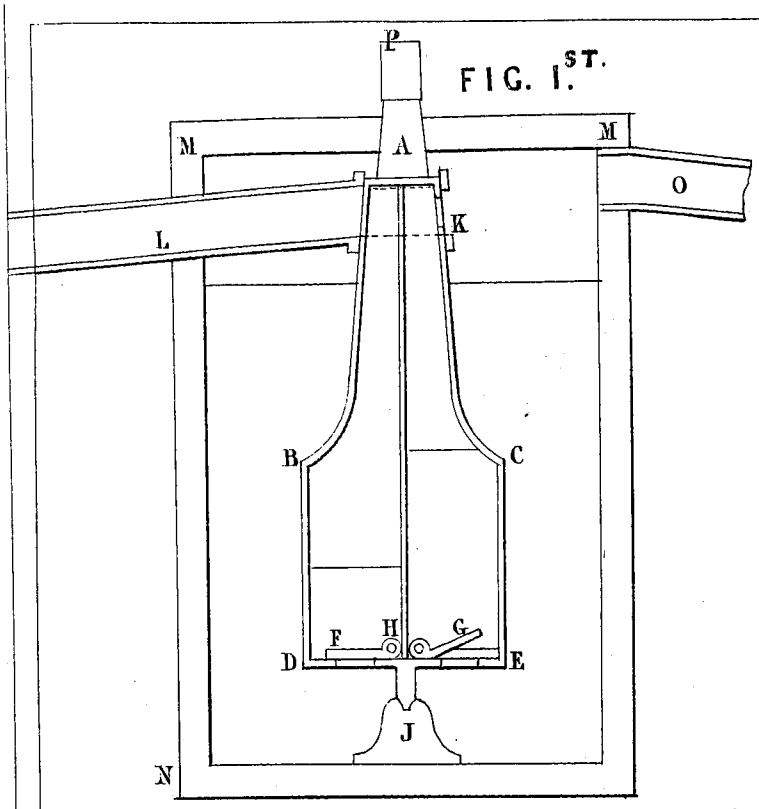


FIG. 2.D

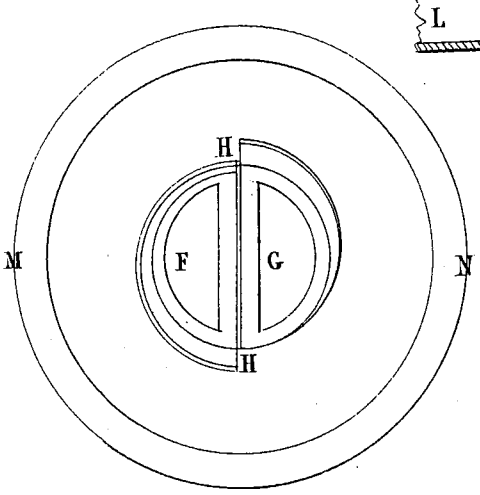
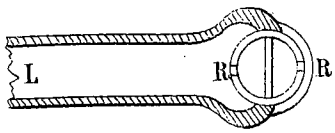


FIG. 3.d



st nd rd th
Scale for the Drawings at Figures 1. 2. 3 and 19.

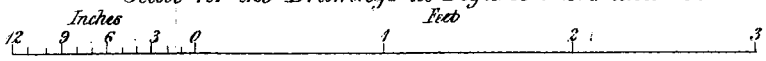


FIG. 6.

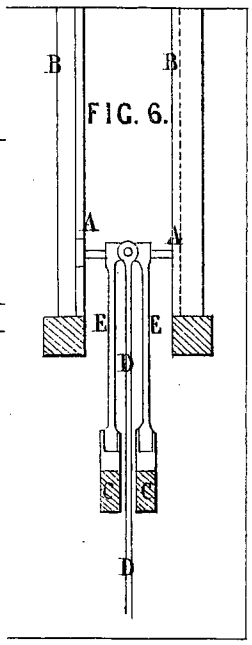


FIG. 4.

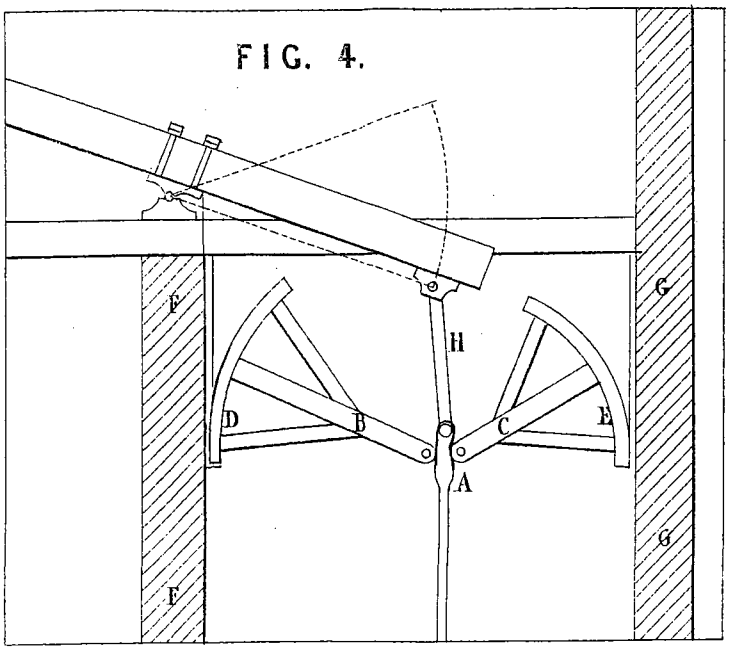


FIG. 5.TH.

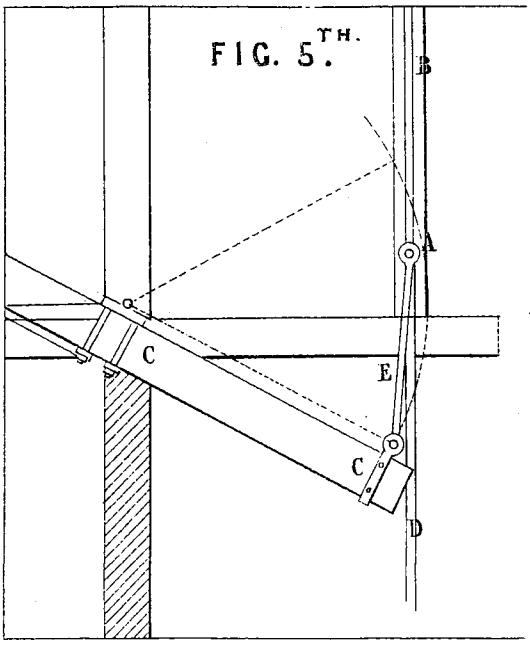


FIG. 7.

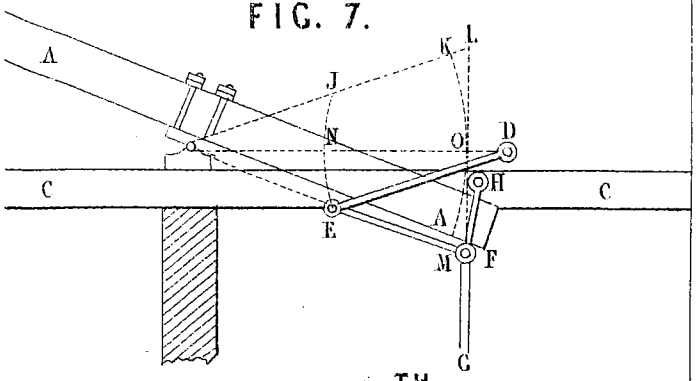
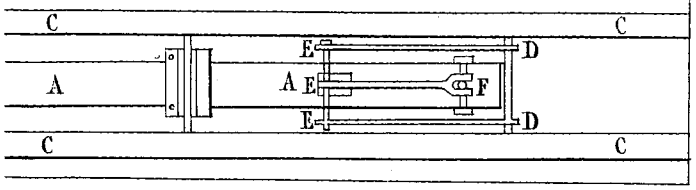


FIG. 8TH



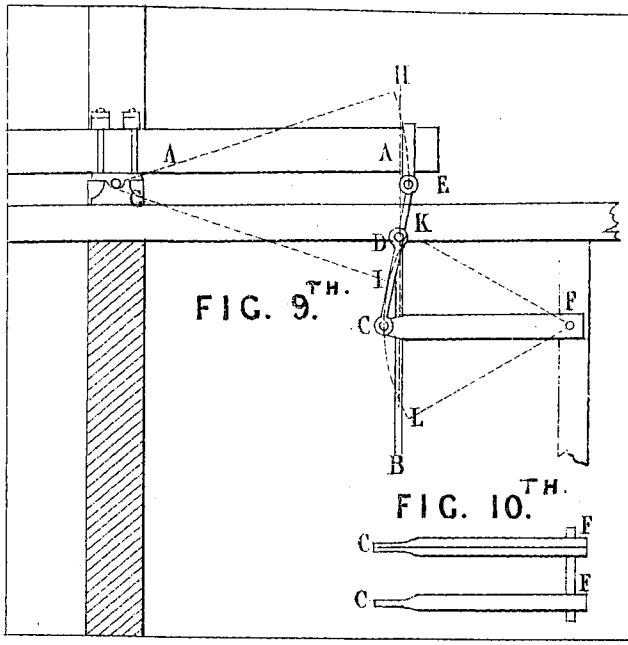


FIG. 9TH.

FIG. 10TH.

FIG. 11

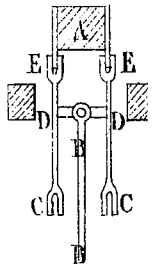


FIG. 12.

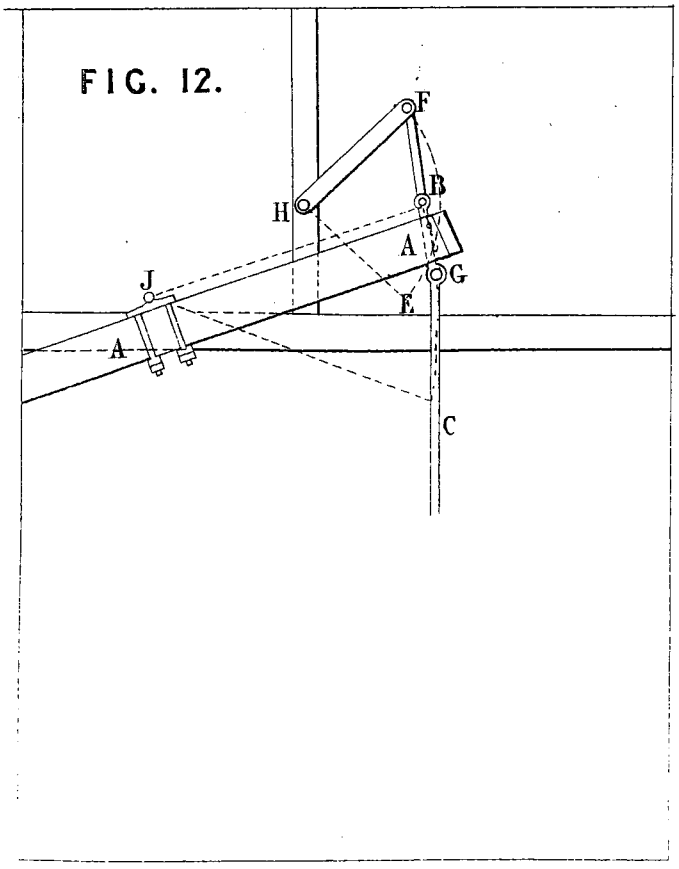


FIG. 13.TH.

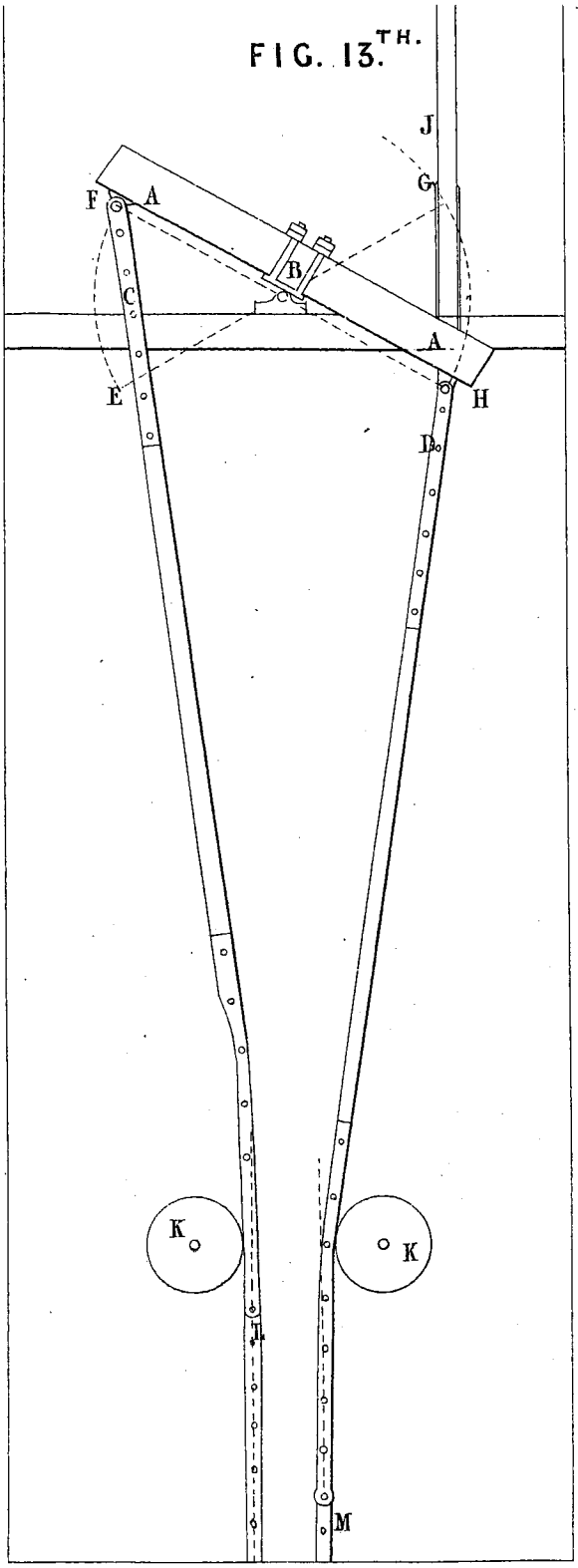
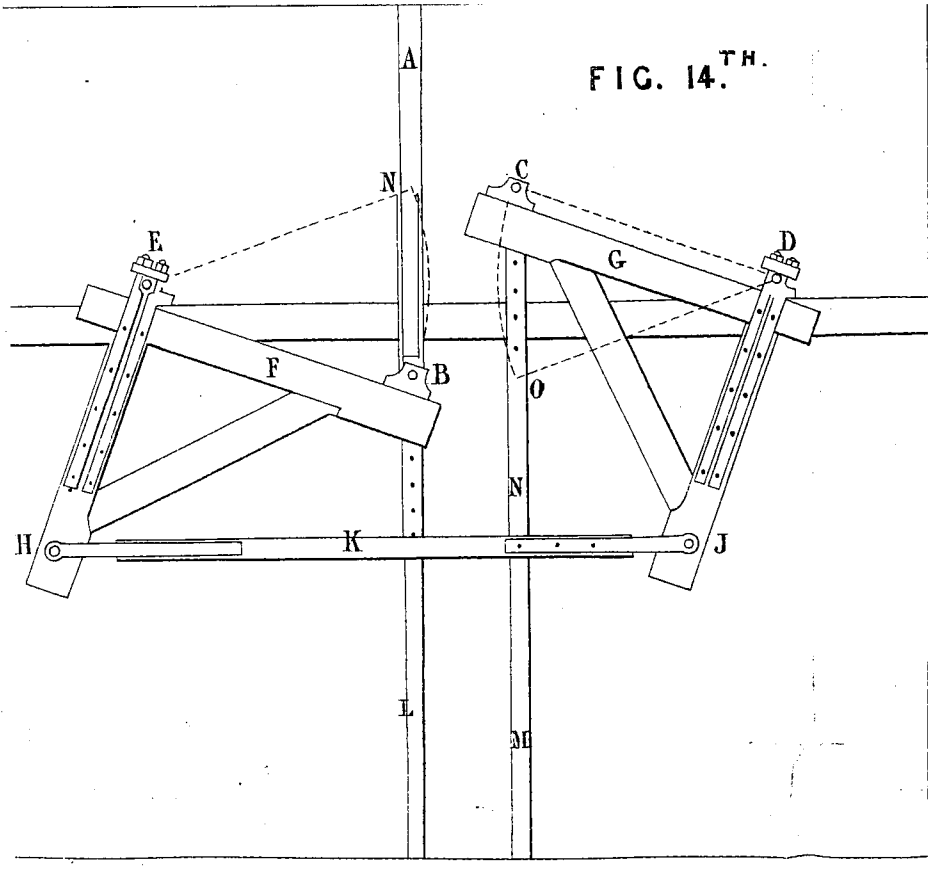


FIG. 14.TH.



rolled drawing is partly colored.

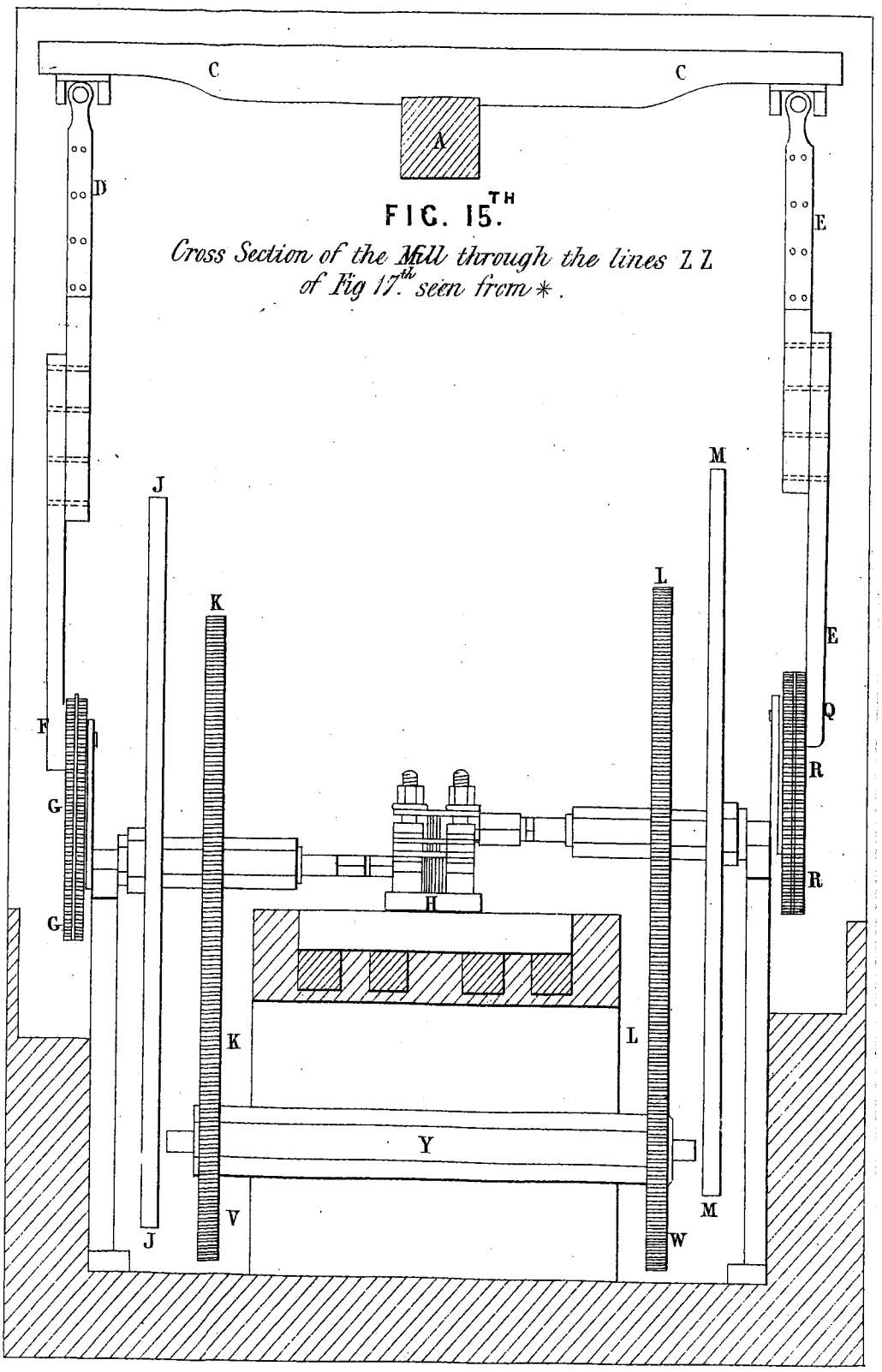


FIG. 15.TH

Cross Section of the Mill through the lines Z Z of Fig 17.th seen from ∗.

Section of the Mill through the line X X of Fig 17.th

FIG. 16.TH.

Scale for Drawings at Figures 4.5.6.7. 8.9.10.11.12.13.14.15.16.17 and 20.

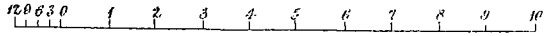
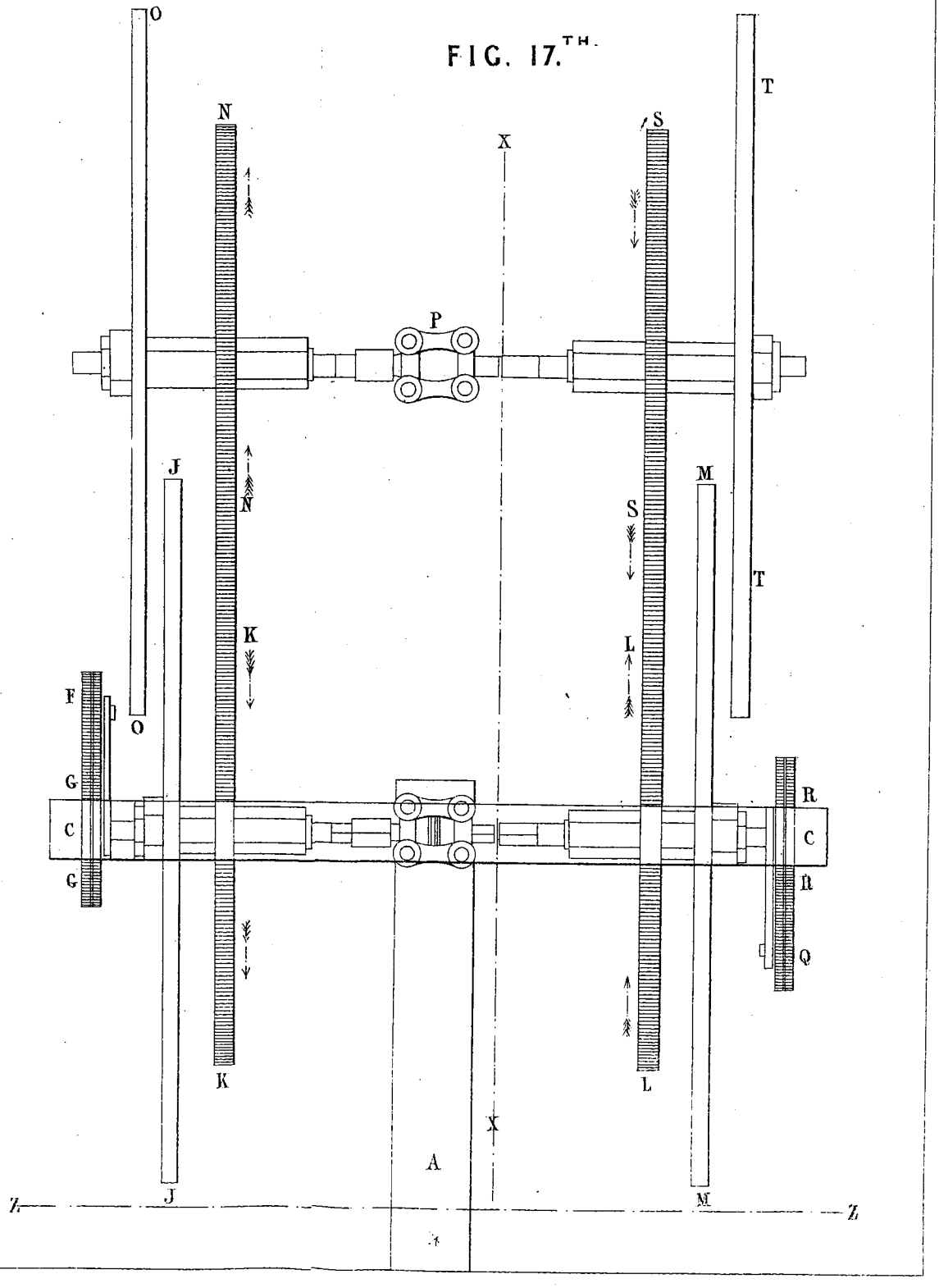
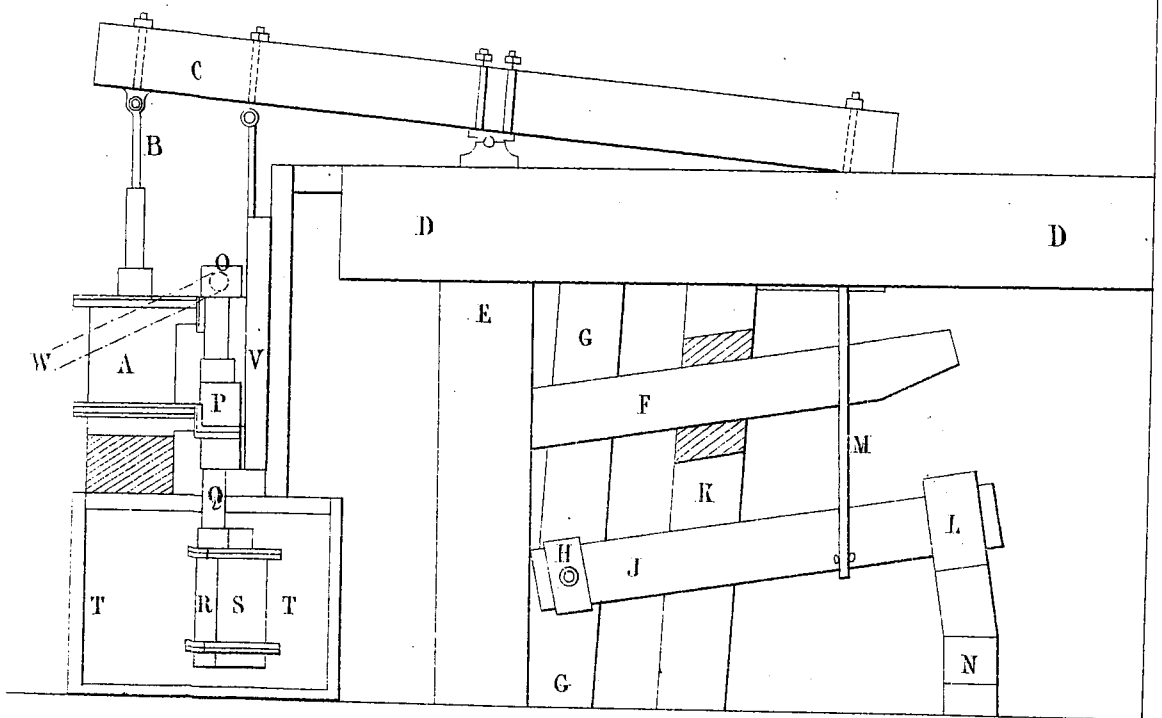


FIG. 17.TH.



Drawn on Stone by Malby & Sons

FIG. 18.TH



Scale for Fig. 18th

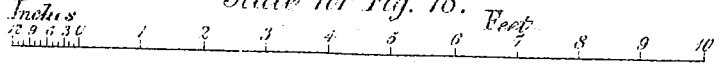
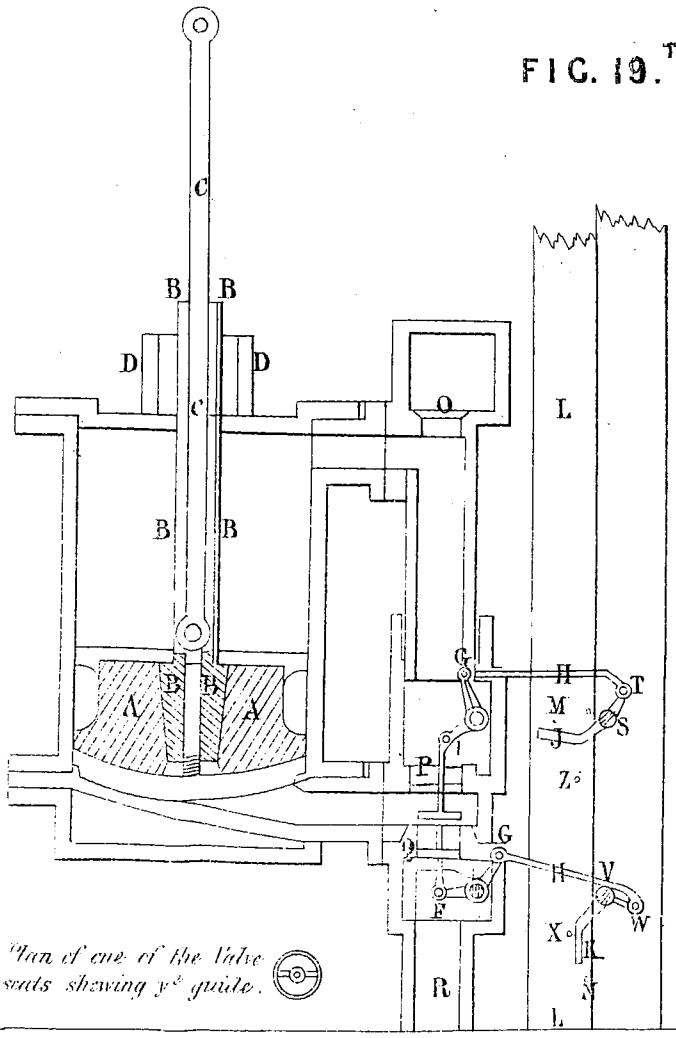


FIG. 19.TH



Plan of one of the Valve seats shewing y^e guide.

FIG. 20.TH.