A.D. 1850 . . . . . N° 13,035.

Machinery and Apparatus for the Manufacture of Metal Tubes, &c.

PROSSER'S SPECIFICATION.

TO ALL TO WHOM THESE PRESENTS SHALL COME, I, RICHARD PROSSER, of Birmingham, Civil Engineer, send greeting.

WHEREAS I did, by petition, humbly represent unto Her present most Excellent Majesty Queen Victoria, that I had invented certain "IMPROVEMENTS IN MACHINERY AND APPARATUS FOR MANUFACTURING METAL TUBES, WHICH IMPROVEMENTS IN MACHINERY ARE IN PART APPLICABLE FOR OTHER PURPOSES WHERE PRESSURE IS REQUIRED; ALSO IMPROVEMENTS IN THE MODE OF APPLYING METAL TUBES IN STEAM BOILERS, OR OTHER VESSELS REQUIRING METAL TUBES TO BE APPLIED WITHIN THEM;" and Her said Majesty, being willing to give encouragement to all arts and inventions that may be for the public good, was graciously pleased, by Her Royal Letters Patent under the Great Seal of the United Kingdom of Great Britain and Ireland, bearing date at Westminster, the Eleventh day of April (One thousand eight hundred and fifty) in the thirteenth year of Her reign, for Herself, Her heirs and successors, to give and grant unto me, the said Richard Prosser, my exors, admors, and assigns, Her especial license, full power, sole privilege and authority, that I or they, by myself or themselves, or by my or their deputies, servants, or agents, or such others as I should agree with (and no others), during the term of fourteen years from the date of the said Letters Patent, should and lawfully might make, use, exercise, and vend my said Invention, within that part of Her said Majesty's Dominions called England, Her Dominion of Wales, and Town of Berwick-upon-Tweed, in such manner as to me, my exors, admors, and assigns, shall

seem meet, and that I or they shall enjoy the whole profit and advantage arising by reason of the said Invention during the said term of fourteen years. And whereas the said Letters Patent contain a proviso obliging me, the said Richard Prosser, particularly to describe and ascertain the nature of my said Invention, and in what manner the same is to be performed, by an instrument in writing under my hand and seal, and to cause the same to be enrolled in Her Majesty's High Court of Chancery within six calendar months next and immediately after the date of the said Letters Patent, as in and by the same (reference being thereunto had) will more fully and at large appear.

NOW KNOW YE, that in compliance with the said proviso I, the said Richard Prosser, do hereby declare that my said Invention, and the manner in which the same is to be performed, are described and ascertained in manner following, and by the aid of the twelve Sheets of Drawings hereunto annexed, with the writing thereon, that is to say:—

My said improvements relate for the most part to certain improvements in the manufacture of metal tubes, and in the machinery and apparatus therefor, and for which improvements former Letters Patent were granted to me, the said Richard Prosser, by Her present most Excellent Majesty, on the First day of May, in the year One thousand eight hundred and forty-five, and the most part of my said former improvements were performed by bending or turning up flat plates or skelps of metal to the form of tubes by pressing the said flat plates into the hollows of suitable moulds, so as by successive pressings to bend the plates by degrees and turn them up to the required form of tubes. And in my Specification, which I caused to be enrolled in Chancery on or about the First day of November, One thousand eight hundred and forty-five, in conformity with the aforesaid former Letters Patent, I described different means of cutting the edges of such flat plates of metal truly straight, and with grooves, or rabbits, or bevels, or other forms along such edges suitably for preparing the two edges of each such plate for fitting closely one of those edges to the other edge of the same plate after it became bended and turned up to the form of a tube, with the said two edges meeting in contact; and amongst those said means I explained how such cutting might be performed in a planing machine, the moving table of which was to be provided with a long narrow flat bed for receiving the flat plate (which was to be previously set truly flat), with suitable means of fastening the flat plate down on the said bed, which was to be somewhat narrower than the breadth of the plate, and raised above the moving table of the planing machine, so as that the two edges of the plate would overhang the narrow bed at each side thereof, suitably for those two edges being acted upon by the cutting edges of two tools, which were to be held in

suitable tool holders sustained by the fixed part of the planing machines, and in proper positions for cutting the two edges of the plate at the same time, one edge with a vee groove, and the other with a double-bevelled edge, the said vee groove and double bevels being formed in the usual manner of planing by as many successive cuts with the said tools, from end to end of the plate or skelp, as might be requisite. The means of fastening the flat plate down on the long narrow bed was to be such as would be comprised within the space over the flat plate, leaving the two edges thereof exposed in order that the fastening might not interfere with the tools or their tool holders. For that purpose the flat plate could be fastened down upon the bed by a number of upright pinching screws in a strong bar, extending over the flat plate all the length thereof, and fastened at each end of the bar to each end of the bed, leaving space between the upper surface of the bed and the under side of the said bar for the reception of the flat plate, wherefore the said upright pinching screws would press upon the upper surface of the flat plate, at suitable places along the length thereof, for fastening the flat plate down upon the bed, in a proper manner for being acted upon by the tools at each edge as aforesaid, without any part of the fastenings for the flat plate being in the way of those tools.

The first part of my present improvements consists in additional new parts, and in compound cutting tools to be applied to a planing machine for the purpose of facilitating the planing of the edges of two flat plates of metal at once, in order to prepare each of those edges for fitting with close contact to the opposite edge of the same plate, when each such plate is afterwards turned up to the form of a tube. The moving table of such planing machine is provided with new parts for firmly holding the said two flat plates edgeways upwards in parallel vertical planes, the lengthway of the edges of those two plates being horizontal and conformable with the endway motion of the moving table of the planing machine. And each of the compound cutting tools contains several distinct cutting edges, held fast in a row by suitable means of fastening them, which row constitutes a compound cutting tool, and the same is held fast over the uppermost edge of one of the two flat plates, with the lengthway of the row conforming to the lengthway of the plate. And when that plate is moved with the usual endway motion of the moving table of the planing machine, the uppermost edge of the plate is carried along beneath the row of cutting edges, so as to be cut and planed by one of those edges after another in succession, for each such succeeding cutting edge in such row is adapted for penetrating into the metal so much deeper (or so much further laterally) than the preceding edge, as the thickness of the shaving of metal that is intended to be planed off and removed by the cutting action of the preceding edge. All the

cutting edges in the row are operating at the same time, although each one is cutting at a different place along the length of the plate, and is removing its own thin shaving of metal from its own place, so that they all concur in expediting the performance of the intended planing. And one such compound cutting tool is to be firmly held with its row of cutting edges over the uppermost edge of one of the two flat plates, and another like compound tool with its row of cutting edges over the uppermost edge of the other of the two flat plates, so that by the usual endway motion of the moving table the two uppermost edges will be carried beneath the two rows of cutting edges in the two compound tools, and be subjected to the planing actions thereof, so as to perform the intended planing of the uppermost edges of the two flat plates at once; and, with a sufficient number of cutting edges in each of the compound tools, the intended planing of the uppermost edges of both the flat plates may be finished at one endway motion (or at two endway motions) of the moving table, though at a distance somewhat greater than the whole length of the flat plates. The several cutting edges which constitute each compound tool may be adapted for cutting either downwards from above into the metal of the uppermost edge of the flat plates, or else for cutting laterally into that metal in a direction from one side or surface of the plate towards the other side or surface thereof. And the said several cutting edges may be arranged for cutting in regular succession one after another, and in like manner, so that each succeeding edge will remove a thin shaving of metal in the same direction (either downwards or laterally) as the preceding edge is at the same time removing. Or some of the cutting edges (for instance, every alternate cutting edge in the row) may be adapted for cutting downwards and removing a thin shaving from off the uppermost portion of the metal of the edge of the flat plate, but others of the cutting edges (for instance, every intermediate cutting edge in the same row) may be adapted for cutting laterally, and removing a shaving from off some portion of one side of the thickness of the same metal. And such cutting downwards by some of the cutting edges, and cutting laterally by others of them, will be carried on at the same time, so that in such case the conjoined operation of all the cutting edges in the same compound tool will be to cut downwards and laterally at the same time, in order to perform the intended planing thereof, at one endway motion (or at two endway motions) of the moving table. It is not necessary that the two sorts of cutting edges should be arranged in any particular order (such as the alternate and the intermediate in the row), but those which cut downwards may form one portion of the row, and those which cut laterally another different portion of the same row. The two sorts of cutting edges may be combined in the same row in any order that

may be convenient. The cutting edges for planing the edges of metal plates to some particular forms (such, for instance, as rabetted forms) may be adapted for cutting laterally at one portion of each cutting edge, and for cutting downwards at other portions of the same cutting edge. Or each compound tool may be furnished with two parallel rows of reversed cutting edges, that is to say, the cutting edges in one of those rows being adapted for planing during the endway motion of the moving-table in the usual direction of that motion called its forward motion, but the cutting edges in the other row of the same compound tool being adapted for replaning, and further cutting the same metal during the next succeeding endway motion or return of the said moving table in a contrary direction, called its backward motion. The planing machine is furnished with two such compound tools, each having two parallel rows of reversed cutting edges for planing the metal of the uppermost edges of two flat plates at once during the forward motion, by the cutting edges of one of the rows in each compound tool. And then, previous to the commencement of the return or backward motion, both the compound tools are moved laterally a sufficient space to bring the cutting edges of the other row of each such tool into a proper position for replaning the same metal during the backward motion, and the same moving laterally of both compound tools will have removed the first mentioned row of cutting edges of each tool out of the way for the present. The cutting edges in one of the said two rows in each compound tool may be adapted for cutting downwards into the metal, and the cutting edges in the other row for cutting laterally, or for cutting both laterally and downwards, or each row may contain both sorts of cutting edges combined, in any order that may be convenient.

For more completely describing this first part of my present improvement, see Sheet A of the Drawings hereunto annexed, wherein Figure 1 is a lateral elevation, and Figure 2 a horizontal plan, of a planing machine having this first part of my improvements added thereto. Also Figure E, *x*, Figure E, W, E, Figure *x*, and Figure *p*, are detached parts. In Sheet B some portions are represented on a larger scale, the lower part of Figure 3 being a transverse section; Figure 4, a corresponding end elevation; Figure 5, part of a corresponding lateral elevation; and Figure 6, part of a horizontal plan corresponding to Figure 5. The same letters and numeral characters for reference denote the same parts in all the said Figures. Note, in the Drawings hereunto annexed, the figures of detached parts are titled with the letters wherewith the same parts are marked for letters of reference in some other Figure or Figures where such parts are shewn in their places. For instance, Figure E, W, E, Sheet A, represents two long clamps with a long

wedge between them, which parts are marked E and E and W, in Figures 2, 3, 4, and 6. The writing upon the Drawings will assist the following description.

DESCRIPTION OF THE NEW PARTS which are to be applied upon the Moving Table of a Planing Machine for holding two flat Plates at a time edgeway upwards in Parallel Vertical Planes, in a suitable manner for Planing the uppermost Edges of both Plates at once.

The horizontal line 1, 1, Figures 1 and 3, 4, 5, represent the level of the upper flat surface of the moving table of the planing machine, which machine may be on any of the different constructions which are in common use for planing long lengths of metal works. It should be capable of planing at least sixteen feet in length and about three feet in width. On the said upper flat surface 1, 1, of the moving table, a long narrow trough of cast iron, marked *b*, *a*, A, B, *c*, A, *a*, *b*, in the section, Figure 3, is securely fastened by suitable holding-down screws and steadyments. The trough is open at each end, and also at its upper part. And in order to give the trough great strength for retaining its two vertical sides *a*, A, A, *a*, firmly in their intended vertical positions (and with the upper edges *a* and *a* of those sides at their intended distance asunder), the trough is cast with a number of external ribs *b*, *c*, *b*, which stand up in transverse vertical planes at six inches apart from one such rib to the next along the lengthway of the trough, each rib extending across beneath the bottom B at *c*, and rising up at the outside of each vertical side A and A. All those ribs, *b*, *c*, *b*, are in the same piece of casting with the bottom B and sides A, A, of the trough. The undermost edges of the bottom parts *c* of the several ribs are all planed to conformity with a flat surface. The ribs *b*, *c*, *b*, render the trough A, B, A, very firm to preserve its figure, and they serve as its base for standing upon the surface 1, 1, of the moving table. The two sides A and A of the trough are planed straight on their uppermost edges *a* and *a*, and also at their insides, conformably to parallel vertical planes, for a little way down below the level of those edges *a* and *a*. Within the hollow *a*, A, B, A, *a*, of the trough, another long casting D, *d*, D, F, *f*, F, *f*, Figure 3, is placed, and is firmly fastened by screw bolts at its base *f*, *f*, so as to become like one piece with the trough A, B, A, and it occupies the whole length and nearly (but not quite) the whole width of the hollow thereof. And after the long casting is so fastened within the trough, then the uppermost parts D, D, are planed straight and conformably to a horizontal surface, which is below the level of the horizontal plane of the two uppermost edges *a* and *a*, so as to support two strong

bars E and E (which I call clamps, see Figure E, W, E, Sheet A), which clamps, being laid flatways on D and D, their uppermost surfaces will be in a horizontal plane, which is conformable (or nearly conformable) with the uppermost edges *a* and *a*. By this combination of parts, two long narrow crevices (open from end to end) are left unoccupied between the internal edges *a*, *a*, of the two sides A and A of the trough, and the edges *e*, *e*, of the two clamps E and E. And those two crevices *a*, *e*, and *a*, *e*, can be opened wide enough for receiving the two flat plates of metal whereof the uppermost edges are to be planed both at once. Those plates are shewn in section at P and P, in Figure 3, as they stand edgeways upwards. After they have been let down from above into the two crevices *a*, *e*, and *a*, *e*, and the vacant spaces beneath them, which are of sufficient depth for receiving nearly the whole breadth of the plates P, P, the lowermost edges of those plates come to rest on bearing stops *p* and *p* (see Figure *p*, Sheet A), which are of suitable height to prevent the plates P, P, descending lower than they are intended to do. When so resting on the stops *p* and *p*, the uppermost edge of each of the two plates P and P will stand up above the level of the uppermost parts of the edges *a* and *a*, and above the level of the edges *e* and *e* of the clamps E and E, and standing so much above such levels as is suitable for the operation of planing the uppermost edges of the plates P and P both at once. But before commencing such operation, the plates P and P are both held fast in their respective positions, edgeways upwards, by means of a long tapering wedge W, which occupies all the space between the two clamps E and E, and the wedge W, being made to enter further in between those clamps, will force them further apart one from the other, and thereby press their edges *e* and *e* towards the two plates P and P, in order to hold those plates fast against the edges *a* and *a* of the trough A, B, A, which edges *a*, *a*, are unyielding in consequence of the strength given to the trough by its numerous external ribs *b*, *c*, *b*. The wedge W is considerably longer than the two clamps E and E, and its breadth (measuring across it horizontally) has a regular tapering from end to end, see Figure E, W, E, Sheet A. When the wedge W is so far withdrawn from between the two clamps E and E, that the narrow end of the wedge is nearly even with the ends of those two clamps, then their edges *e* and *e* will become removed to their greatest extent from the edges *a* and *a* respectively, so as to open the crevices *a*, *e*, and *a*, *e*, to a sufficient width for admitting the two plates P and P to be lowered down into the two crevices. And then, in order to close up those crevices and fasten the two plates P and P therein, the wedge W is forced endways with its narrow end foremost, so that the broader part of the wedge will enter further in between the two clamps E and E; and

as the clamps do not partake of the endway motion of the wedge, they are by that motion forced further apart one from the other, and consequently their edges *e* and *e* press the two plates P and P forcibly against the two edges *a* and *a*. The under side of the long wedge W slides upon the flat bottom of a recess formed between D and D, but in the same piece of metal, and that bottom is planed down to a level as much lower than that of D and D as the wedge W is thicker than the two clamps E and E; therefore the upper surfaces of the wedge W, and of the two clamps E and E, conform to the same horizontal plane. The part of the wedge *w*, W, *w*, which is below the level of the undermost surfaces of the two clamps E and E (and below the level of the two uppermost surfaces of D and D) is of uniform breadth from end to end, and occupies nearly, but not quite, the whole breadth of the aforesaid recess, with liberty to slide endways freely therein, without close confinement laterally. It is the part W that is between the two clamps E and E that is really the operative wedge for fastening the plates P and P, which wedge W is broad at one of its ends, as it appears in Figure 2 and Figure E, W, E, but at the opposite end it is very narrow. The two clamps E and E are each of them tapering, as well as the wedge W, see Figure E, W, E, because the two edges of those two clamps, which apply against the two edges of the wedge W, correspond to the tapering thereof, but the two outer edges *e*, *e*, are always parallel one to the other, and are also parallel to the two edges *a*, *a*, of the trough. The wedge W, when it is in the act of being withdrawn or moved endways between the two clamps E and E, with its broadest end foremost, is caused to react upon those clamps in order to withdraw their edges *e* and *e* away from contract with the plates P and P, and release those plates by opening each of the crevices *a*, *e*, and *a*, *e*, to a sufficient width for allowing the plates to be removed and other plates inserted. For this purpose the wedge W is provided with two prominent straight edges *w* and *w*, see Figure E, W, E, which are in the same piece of metal as the wedge, and are parallel to those tapering edges of the wedge W against which the edges of the clamps E and E apply. The two prominent edges *w*, *w*, are received into corresponding grooves, which are planed out in the undermost surfaces of the two clamps E and E all the length thereof from end to end, the said grooves being parallel to those adjacent edges of the clamps E and E which apply against the tapering edges of the wedge W. The outermost edges of the prominent parts *w* and *w* are not in close contact with the adjacent edges of the grooves into which they are received, and the said parts *w* and *w* do not operate for forcing the two clamps E and E outwards away from the solid part W. The two tapering edges of that part W alone

perform all such forcing outwards; and the parts *w* and *w* are only operative for bringing the two clamps E and E back again, or inwards towards the part W of the wedge whenever the latter is withdrawn or moved endways between the two clamps with its broadest end foremost. The expression endway motion of the wedge W is to be understood as mere relative motion of that wedge in respect of the two clamps E and E, between which the wedge W is interposed and moved, as well as in respect to the trough A, B, A, and the recess between the parts D and D wherein the wedge W is lodged. Such endway motion of the wedge *w*, W, *w*, is communicated to it when required (and with the requisite force and in the intended direction) by means of a rack and pinion, and wheel and pinion, worked with winch handle or handles, as follows:—A toothed rack R (see Figures 3, 4, 5, and 6) is fastened into a cavity provided for it at the under side of the wedge W at the broadest end thereof (see the dotted lines in Figure E, W, E), and the teeth of the rack R project downwards below the level of the under surface of the wedge W, a recess being left above the part *d* to admit those teeth without touching. The rack R is actuated by a pinion G of six teeth fastened upon a horizontal axis I, which extends across somewhat beyond that end of the trough A, B, A, where the broadest end of the wedge W is situated, and the axis I is sustained in its said position by four bearings *i*, *i*, and S, S. The two bearings *i* and *i* descend from near one end of each of the two clamps E and E, one bearing at each side of the pinion G; each bearing *i* being bolted to the under surface of one of the clamps E, sustains the axis I as much below that surface as will cause the teeth of the pinion G to act properly with the teeth of the rack R. The other two bearings S and S are bolted to the endmost of the ribs *b*, *c*, *b*, at the end of the trough A, B, A, and it is by those two bearings S and S that the axis I is sustained in its intended position in respect to the trough. The two bearings *i* and *i* are merely for the purpose of preventing the two clamps E and E from moving endways when the axis I and pinion G are turned round, and (when the consequent action of the teeth of that pinion in the teeth of the rack R) causes the wedge W to be moved endways between the said two clamps E and E. The two bearings S and S, for the ends of the axis I, extend onward from the end of the trough A, B, A, in order to serve as bearings for two other horizontal axes J and N of the wheel and pinion work, by which the requisite power is obtained for moving the wedge W. The axes J and N are parallel to the axis I, which latter has a spur wheel H of thirty-three teeth fastened upon the outer end of it, and those teeth are actuated by the teeth of a pinion T, of twenty-two teeth, that is fastened upon the outer end of the axis J. The teeth of the pinion T are

engaged (when required) by the teeth of another pinion M (also of twenty-two teeth), which is fastened upon the outer end of the third axis N. That axis N is turned round when required by means of a double-ended winch handle or handles, applied on a square or on squares at the extreme end or ends of that axis N, and thereby motion is transmitted to the wheel H, axis I, and pinion G, for moving the rack R and wedge W endways between the two clamps E and E, so as to commence holding the two plates P and P between the edges *a*, *e*, and *a*, *e*; and then, in order to obtain greater power for holding the same two plates P and P very fast, the axis N is slided so far endways and outwards in its bearings S and S, as to remove the pinion M laterally out of gear with the pinion T, and by the same sliding endways a smaller pinion Q of eleven teeth (which is fastened on the said axis N) is brought laterally into gear with a large wheel O, which is fastened upon the axis J. After such change of gear, then, by continuing to turn round the axis N (by the same double-ended winch handle or handles on the end or ends of it as before), the same endway motion of the wedge as before is continued, but with three times greater power, in order to pinch and hold the two plates P and P very fast between the edges *a* and *e*, and *a* and *e*. The two clamps E and E, and the wedge W between them, rest by their own weight on their common supporter D, D; and to prevent any rising of those parts, thin flat bars *z* are applied across the upper surfaces of E, W, E, at five places in the whole length thereof, see Figures 2, 3, and 6. The two ends of each cross bar *z* are kept firmly down upon the two clamps E and E by upright bolts, see Figure 3, which pass down through those clamps, and fasten by nuts screwed on their lower ends to the supporting parts D and D. The wedge W is kept down by being beneath the middle parts of the said cross bars *z*. The holes through the two clamps E and E, for the said bolts, are sufficiently oblong to permit the small lateral motions of the two clamps E and E, when they are forced outwards by action of the wedge W, or returned by reaction of the parts *w* and *w*. The edges *e* and *e*, of the two clamps E and E (which edges are pressed against the plates P and P for the purpose of holding them), are provided with a number of small but stiff steel springs *x* (see Figure E, *x*, and Figure *x*, Sheet A), which springs *x* will come into contact with the plates P and P at an early period of the lateral motion that is given by the wedge W to the two clamps E and E, and before the edges E and E come into actual contact with those plates. By aid of the springs *x* the pinching of the two plates P and P is commenced easily from the first condition of the plates P and P, when they are standing loosely edgeways upwards after their insertion into the crevices *a*, *e*, and *a*, *e*, without beginning abruptly to

be pinched between the edges *a*, *e*, and *a*, *e*, as would be the case without such springs *x*. The springs *x* are inlaid into grooves planed out for their reception in the edges *e* and *e*, of the clamps E and E, see Figure E, *x*, each groove extending all the length of the clamp, and containing a row of the springs *x*, each of which is a short piece of steel fitted in its breadth to occupy the breadth of the groove, and held therein by one screw passing horizontally through a hole at the mid-length of the spring (and through a washer behind the spring), and screwing into the metal of the clamp E. The ends of each spring *x* are thicker than the springing part, which is one eighth of an inch thick by one inch and a quarter broad. Those thicker ends alone apply against the plates P and P; and when the springs *x* are at liberty, their said ends outwards beyond the border edges *e* of the groove about one sixteenth part of an inch. The springs *x* being thick and broad compared with their length, which is only three inches, they are very stiff, and there is one spring *x* at every six inches in length, as appears in Figure E, *x*, wherefore a considerable force of elastic pressure is exerted by all the springs *x* against the two plates P and P so as to hold the same with tolerable firmness before any actual contact commences between the edges *e* and *e* of the clamps E and E, above and below the grooves and the plates P and P for holding them very fast by such contact. That elastic pressure continues to be exerted in its full force by all the springs *x* after such contact has taken place, whereby the springs *x* insure an equal distribution throughout the length of each plate P of as much force as is exerted by all the springs *x* which are in contact with that plate. The plates are previously set as flat and out of twist (or out of winding) as can be done); but nevertheless some inaccuracy in those particulars must be expected to remain, and the springs *x* tend to neutralize the effect of such inaccuracy. The bearing stops *p* and *p*, for sustaining the lowermost edges of the two plates P and P, Figure 3, are fitted upon blocking pieces *u*, which are firmly fastened upon the flat bottom B of the trough A, B, A, and there is one screw passing upwards through that blocking piece *u*, for fastening each stop *p* in its place on that blocking piece *u*. There is an opening through the upright side A or A of the trough for introducing or removing the stop *p* (or the blocking piece *u*) as may be required. Those places at the bottom B of the trough, whereon the several blocking pieces *u* are fastened at each side of the trough A, B, A, are all planed conformably to one horizontal plane, and the blocking pieces *u* are all of one thickness, so that all the places on those blocking pieces *u*, whereon the stops *p* are to be applied, will be conformable to one horizontal plane. The stops *p*, which are to be used at one time for the same plate P, are all of the same height. Figure *p*,

Sheet A, represents one of the bearing stops detached. Those stops *p*, which are used for one of the plates P at one side of the trough A, B, A, should be somewhat lower than the like stops *p* for the other of the plates P at the opposite side of the trough, because the plate P, at the first mentioned side, will be undergoing the first operation of planing one of its edges, while the other plate P, at the opposite side of the trough, will be undergoing the final operation of planing the second of its edges, wherefore the heights of the stops *p* and *p*, at the opposite sides of the trough, should differ as much as the breadth of the plate P will be diminished by the first operation of planing one of its edges. Previous to planing the edges of the plates P and P, those plates are to be prepared, as will be herein-after explained, by setting the plates as flat, and out of twist or out of winding, as can be done, and then shearing the edges of the flattened plates as straight as can be done, but leaving the plates after the shearing as much broader than they are ultimately required to be as will allow metal enough for planing both edges of each plate, so as to render those edges straight, but without reducing the breadth to less than is ultimately required. The height of the stops *p*, at one side of the trough A, B, A, must be adapted for sustaining a plate P in its state of greater breadth, so that the uppermost edge of that plate will stand up sufficiently prominent above the level of the edges *a*, *e*, for the planing of that edge to be performed. And after one edge of the plate P has been thus planed (so that the plate may be considered as half finished), then that half finished plate is to be transferred to the opposite side of the trough A, B, A, and in so transferring the plate it is turned over and then placed in the crevice *a*, *e*, at that opposite side, with its recently planed edge downwards, and resting upon the stops *p*, at that opposite side, which stops are so much higher than the like stops *p* at the first-mentioned side of the trough, that the unplaned (and now uppermost) edge of the plate P will stand up sufficiently prominent above the level of the edges *a*, *e*, for the planing of the unplaned edge to be performed in final completion of the planing of the plate P. Every time, when a half finished plate P (with one of its edges planed) is about to be transferred from one side of the trough A, B, A; to the opposite side, a finished plate P (whereof both edges have been planed) will have been recently removed from that opposite side, and carried away as finished. Also, immediately after such transferring, a fresh plate P (with neither of its edges planed) will be put into that side of the trough from which the half-finished plate has been removed; therefore, at every time when the wedge W is forced in between the two clamps E and E, there will be two plates P and P in the trough at the same time to be held fast by that action of the wedge W.

Every time that the operation of planing is performed, two edges (but belonging to two different plates P and P) will be planed at the same time, one of those edges belonging to a fresh plate P, and the other belonging to a different and half-finished plate P, whereof the opposite edge has been previously planed and then turned downwards, whilst the said half-finished plate was in the act of being transferred from one side of the trough A, B, A, to the opposite side. Those stops *p* which are at the same side of the trough should be disposed at such distances apart as will afford the best support to the lowermost edge of that plate P, which is to rest on such stops. Five places are provided in the whole length of the trough at each side A, A, thereof, where stops *p* may be fixed (see Figure 1), so as to suit the length of the plates P and P that are to be planed. One stop *p*, towards each end of the plate P, will be suitable for supporting the lowermost unplaned edge of a fresh plate. For the second or final planing of half-finished plates, whereof one edge has been previously planed, three stops *p* may be thought preferable, one such stop being near the midlength of the plate, and one other stop towards each end thereof. Each stop *p* gives two places of bearing for the lowermost edge of the plate P or P (see Figure *p*), the space between those two places being hollowed to avoid bearing. To guide each plate P when it is let down edgeways into the crevice *a*, *e*, and retain the plate in its intended vertical position therein, each of the blocking pieces *u* has a vertical part standing up from it within the hollow of the trough A, B, A (see Figure 3), so as to stand in a suitable position for forming one vertical side to the crevice, and the two plates P and P apply with one flat surface of each plate in easy contract with the vertical parts of the blocking pieces *u* and *u* at each side, until the two plates are held fast in the crevices by action of the clamps E and E, and wedge W. Whenever narrower plates P and P are to be planed (for turning up into tubes of smaller diameter), the stops *p* and *p* must be changed for other similar stops, but as much higher than those used for broader plates as the plates are to be narrower; so that the uppermost edges which are to be planed will in all cases stand up nearly to the same height of prominence above the level of the edges *a*, *e*, and *a*, *e*.

Description of the Compound Cutting Tools to be used in the Planing Machine.

They appear in their places in Figures 1 and 2 in Sheet A, and again, but drawn on a larger scale, in Figures 7 and 8, Sheet B; also, Figure 3, in that Sheet, includes an end elevation of the two compound tools, held in their respective places over the uppermost edges of the two plates P and P, on

which edges those tools are to operate. Also, Sheet C contains Figures of different parts of the compound tools detached. The horizontal line 1, 1, represents the level of the upper flat surface of the moving table 2, 2. Figures 3, 7, and 8, are the inside edges of the vertical fixed standards, at each side of the moving table, and 3 represents the cross bar, which is fastened by binding screw bolts 4 and 4 with nuts to the standards 2 and 2, so as to reach across over the moving table; and the fastenings 4 and 4 of the bar 3 being slackened, it can be adjusted by means of two suspending screws 7 and 7, Figures 1 and 2, to any height required, and there it can be fastened by its fastenings 4 and 4, all which is as usual in ordinary planing machines. In place of the slider, which is usually fitted to slide endways along the bar 3 and 3 by screw motion work for carrying one cutting tool in a direction across the moving table, I make a new slide 5 to fit upon the same bar 3 for sustaining the two new compounding tools, which are to operate both at the same time on the uppermost edges of two flat plates P and P, Figure 3, which are held edgeways upwards at the opposite sides of the trough A, B, A. The slider 5 may be fitted upon the cross bar 3 in the usual manner, as shewn in Figure 7, the upper and lower edges of 3 being formed with dovetails, to which the slider 5 is fitted by aid of a triangular fitting piece 6, which can be tightened by pinching screws, to make the slider 5 fit or fasten on the bar 3. The slider 5 is formed with a frame K, K, projecting out from it horizontally, in the direction of the endway motion of the moving table, the slider 5 and frame K, K, being in one piece, and the interior of the frame K, K, leaves two distinct openings through its whole height for the reception of the two compound cutting tools L and L, and of two moveable edges C and C, Figure 8, one in each opening, for pinching one of the compound tools L very fast within the opening, when the wedge *l* is moved endways with its smallest end foremost; or vice versa, by a contrary motion of the same wedge *l*, it will release the compound tool L, to allow the same to be removed from its place in the frame K. Such motions are communicated to the wedge *l* by turning the nut *m* of a screw bolt *t*, which is connected with the wedge *b*. The several cutting edges which constitute each compound tool may either be formed at the lower ends of as many square steel bars *r*, see Figure *r*, Sheet C, which I name tool shanks, or, otherwise, such cutting edges may be formed out of as many small pieces of steel *n*, which I name teeth, see Figure *r*, *n*, which teeth *n* are fastened into notches at the lower ends of square bars *r*, which I name tool handles. In either case, whether tool shanks or tool handles, the whole number of such square bars *r*, belonging to the several cutting edges which are to constitute each compound tool, are fitted into as

many cells in a piece of cast iron L, which I name a tool rack, see Figure L, Sheet C, and each of the bars *r* is fastened into the cell wherein it is lodged by means of two small screws for each bar *r*. The bars being so fastened into the cells of the tool rack L, all the cutting edges belonging to the same compound tool become connected in a row, as if they were united one to another, in order that the whole row may constitute a compound tool, which can be removed like one piece from its place within one of the openings of the frame K whenever the cutting edges of that tool require sharpening; and it can be immediately replaced by another similar compound tool, that is to say, another tool rack, which is ready furnished with cutting edges, newly sharpened and adjusted, in those cells (by means herein-after described) and then fastened therein; the said tool rack being fitted to go into the same opening in the frame K, as the former tool rack has been removed from, and it can be fastened therein by the same wedge *l* and nut *m*, and when so fastened, all the cutting edges of such fresh compound tool will be held in precisely the same positions in respect to the planing machine as were occupied by the cutting edges of the former tool which has been removed. The cells in each tool rack L (see Figure L, Sheet C) are planed out parallel one to another, and all alike to an equal depth, so that the bottoms of all the cells conform to an imaginary plane, and the cells are thereby adapted for the reception of the square bars *r*, which (as already stated) may be either tool shanks or tool handles. The back surface of each tool rack L is planed flat to fit against the corresponding inside surface of one of the openings in the frame K, that inside surface, as well as the upper edge of the opening bounding the said surface, being also planed. When the slider part 5 of the frame K, K, is mounted in its place upon the cross bar 3, 3, then the said inside surfaces of the two openings in the frame K, K, will stand in two parallel vertical planes, the directions (horizontally) of which are conformable to the endway motion of the moving table, also the aforesaid upper edges of the two openings will then be in one horizontal plane. Each of those edges serve as a lodgement for a prominent border *j* at the back surface of the tool rack L along its uppermost edge. That border *j* is in the same piece with the tool rack L, and is planed true, in order to lodge upon the said horizontal upper edge of one of the openings in the frame K. The lengthway of the border *j* is at right angles across the lengthway of the cells of the tool rack. The back surface of the tool rack L is not quite parallel to the aforesaid imaginary plane at the bottom of all the cells. To insure that the border *j* is put down in close contact with the horizontal upper edge of the opening in the frame K, two steady pins *s* and *s*, Figures 7 and 8 are fitted horizontally through holes

in the metal of the frame K, and those steady pins are connected together by one handle, by which both can be moved together in order to insert the tapering ends of the two steady pins *s* and *s* into corresponding holes into the back surface of L, and after such insertion the tool rack L is held fast in its opening in the frame K by turning the nut *m* and tightening the wedge *l*. After both tool racks L and L are thus steady pinned and held fast in their proper places in the two openings of the frame K, K, then the back surface of those tool racks will be held in two parallel vertical planes, the directions of which horizontally conform to the endway motion of the moving table; also the several bars *r*, which are fastened into the cells of each tool rack L, will be held in vertical positions endway upwards; but as to the row of those bars *r* which belong to each tool rack L, although those bars stand included between two imaginary parallel vertical planes to constitute a row, yet such planes make a very small angle of inclination laterally to the direction of the endway motion of the moving table, as will be further explained. The whole interior width of the frame K (across both the openings in it) measuring horizontally across the lengthway of the planing machine, from the inside flat vertical surface of one of those openings to the like surface of the other opening, is adapted to suit the width across between the two edges *a* and *a* of the trough A, B, A, so that the uppermost edges of two plates P and P can be planed at once by the two rows of cutting edges of the two compound tools, which tools are held fast in the two openings of the frame K, K, by their wedges *l* and *l*. Each of the tool handles *r* (see Figure *r*, *n*, Sheet C) may be composed of two flat bars of iron or steel, put together by two screws, so that the two bars together form a square bar *r*. The uppermost of those screws is countersunk into the square bar *r*, and the lowermost of those screws passes across a notch cut out at the lowermost end of the tool handle *r*, and through the small steel tooth *n*, which tooth *n* is fitted into the said notch so as to be held fast therein by a binding action of the lowermost screw. There is a close contact between the uppermost part of the tooth *n* and the corresponding part of the notch wherein it is held. To secure the tooth *n* from any motion in its notch, a small steel wire O, Figure *r*, *n*, is inserted into a hole formed by two half round grooves, one cut out in the inside of the notch, and the other on the flat side of the tooth *n*, those two grooves corresponding so as to leave a small round hole for the wire O, which, being pinched therein by the binding action of the lowermost screw, the wire O will assist in fastening the tooth *n* in the notch. With such a wire O, it will not in all cases be necessary for each tooth *n* to have a hole through it for the lowermost binding

screw to pass through, but that screw may pass across the bar *r*, just above the upper part of the notch for the tooth *n*, as shewn in Figure *n*, *r*. The tooth *n* is to be fitted with close contact between its upper part and the upper part of the notch. The wire O is parallel to the upper of the notch and of the tooth *n*. In any case the steel tooth *n* protrudes downward out of the notch, below the lowermost end of the tool handle *r*, and also protrudes forwards beyond that front side of the tool handle towards which the motion of the moving table advances when the cutting by the tooth *n* is performed. The cutting edge of the tooth *n* is the angle formed at the intersection of the two protruding parts, namely, the lowermost and the foremost parts; that is the case for one sort of cutting edge for cutting downwards into the metal, but for cutting laterally into the metal, the cutting edge is the angle formed at the intersection of one of the flat sides of the tooth *n*, and the foremost protruding part of that tooth. In some cases, such as for planing out rabbets along the edges of the flat plates, the several cutting edges may be formed for cutting laterally at one portion of each such edge, and for cutting downward at other portions of the same edge. This is shewn in Figures *r*, and *r*, *n*, and *n*, *r*. The square bars *r* are all of one size, whether they are tool shanks, as in Figure *r*, or tool handles, as in Figures *r*, *n*, and *n*, *r*; the bars in either case fit into the cells of the tool rack L, and are held fast therein by two screws for each square bar. Those screws may be applied according to two indifferent modes. In one of those modes they may be two small screw bolts, which pass horizontally through two oblong holes in each square bar *r*, see the left-hand of Figure L, also Figures L, *r*, and *r*, *n*. The heads of those bolts are countersunk into the back surface of the tool rack L, and by means of nuts screwed on the ends of the bolts the bars *r* are held fast in their respective cells to form a compound tool. In the other mode (shewn at the right-hand end of Figure L, also in Figure L, *r*, Z) two pinching screws are held in horizontal dovetailed bars *y* and *y*, which are fastened into dovetail notches cut out across the protruding divisions between the adjacent cells of the tool rack L, so that the two bars *y* and *y* will pass across all the cells in order to hold the two pinching screws for each bar opposite thereto. Those pinching screws have nicks across their ends for applying a turnscrew, in order to cause the screws to pinch the bars *r* so as to hold them fast in the cells. When the pinching screws are slackened the bars *r* can be withdrawn endways from their cells without removing the dovetailed bars *y* and *y*. The divisions between the adjacent cells of the tool rack L protrude beyond the ends of the screw bolts and nuts, or the

dovetailed bars *y* and *y*, and the protruding edges of all the divisions are planed to conform to a flat surface, and one side of the wedge *l* applies crossways against all those planed edges, when it produces the pinching action for fastening the compound tool in one of the openings in the frame K. The screw bolts and nuts or pinching screws and dovetail bars *y* and *y* are all out of the way of the wedge *l*, which has no effect for fastening the bars *r* into their cells, but that depends solely on the two screws for each bar. One of the interior sides of each of the openings in the frame K (see Figure 8) is formed to suit the inclined side of that wedge *l* which belongs to such opening, and the screw bolt *t*, which gives motion to the wedge *l*, although horizontal, is parallel to the inclining side. The screw bolt *t* for each wedge *l* and a vertical pin *v* is put down into a hole across that hollow, and through the eye of the bolt *t*, so as to connect the wedge *l* with that bolt. The nut *m* for each of the bolts *t* is fitted into a socket in the metal of the frame K, the nut having a shoulder upon it to go inside the frame, and also having a collar fastened securely upon it, outside the frame; and the nut *m* being turned one way round will force the wedge *l* further into the frame for pinching the tool rack L therein, or the nut *m*, being turned the contrary way, will withdraw the wedge *l* sufficiently for releasing the tool rack. The weight of each wedge *l* is supported on a small fixed straight bar, which is fastened horizontally along the lower part of the opening of the frame K, the lengthway of that bar being in the oblique direction of the motion of the wedge *l* which slides along the fixed bar. A groove formed along the under side of the wedge *l* receives that bar, and the two ends of the same bar are let into the under edges of the frame K, and fastened thereto by a countersunk screw at each end. Each of the two compound tools L is fitted into its own opening in the frame K, and is secured therein by two steady pins *s* and *s*, connected by one handle, and is held fast by a wedge *l*, moved by a screw bolt *t* and nut *m* in the same manner one as the other. The planing machine will require to be provided with several compound tools for change when the cutting edges require sharpening, and the tool racks L for all such compound tools must be alike, and adapted to fit into and fasten into one or other of the two openings of the frame K, K, according as each tool rack L is intended for one or other of the two. Owing to the manner whereby the several bars *r* are fastened into their respective cells of the tool rack L by two screws for each bar, the several cutting edges, which are to cut downwards into the metal of the uppermost edges of the plates P and P, can be adjusted by lowering or raising any one of the bars *r* a little endway into its cell,

so that the cutting edge at the lower end of that bar *r* will penetrate more or less into the metal beneath. And whether those cutting edges, which are for cutting downwards into the metal beneath them, constitute the whole row of cutting edges in the compound tool, or only part of such row, the foremost cutting edge of that sort in the row is to be adjusted to stand at the highest level in respect to the metal that is to be planed by the compound tool; and the next succeeding edge of the same sort in the same row is to be adjusted to stand as much lower than the level of the preceding edge as the thickness of the shaving of metal that is to be planed off and removed by the downward cutting action of such succeeding edge, and so on of all the other succeeding cutting edges of the same sort in the same row; each succeeding edge is to stand lower by the thickness of a shaving than the preceding edge, and the hindmost cutting edge is adjusted to stand at the lowest level to which it is intended to reduce the metal by the downward planing with the compound tool. The several cutting edges being adjusted in such manner in their tool racks L, those cutting edges will all conform to an imaginary straight line. And when the tool rack, with the cutting edges so adjusted therein, is held fast in its place in one of the openings of the frame K, that line will be conformable to the direction of the endway motion of the moving table, except that the line will have a small inclination from the horizontal, being highest at that end where the foremost of the cutting edges is situated, and lowest at the other end where the hindmost of those edges is situated. Respecting those cutting edges which are adapted for cutting laterally into the metal of the uppermost edges of the plates P and P, whether those lateral cutting edges constitute the whole row in the compound tool or only part thereof, the foremost of such lateral cutting edges is to be adjusted to stand close to one side of the metal that is to be planed, and the next succeeding lateral cutting edge is to be adjusted to stand so much further sideways towards the metal as the thickness of the shaving that is to be planed off, and removed laterally by that succeeding edge, and so on of all the other succeeding lateral cutting edges in the same row; each succeeding edge is to stand further sideways, the thickness of a shaving, towards the metal than the preceding edge, and the hindmost lateral cutting edge is adjusted to stand as far in towards the metal as it is intended to penetrate into the thickness thereof by the lateral planing with the compound tool. To obtain some lateral adjustment of those cutting edges which are to cut laterally into the metal, a thin wedge Z (see Figure L, *r*, Z, Sheet C) is applied behind the square bar *r* belonging to each lateral cutting edge, so as to be interposed between the back of that bar *r* and the bottom of the cell in the tool rack L, wherein the bar *r* is fastened, that cell

being made as much deeper than represented in Figure L, *r*, as the whole of the tapering thickness of the said thin wedge Z; and by moving the wedge Z endway, downward, or upward in the cell, a thicker or thinner part of the wedge Z will become interposed, so as to produce a small lateral adjustment of the lateral cutting edge that is at the lower end of the bar *r*. In case of two screw bolts and nuts being used for fastening each bar *r* into its cell, the wedge Z must have two oblong holes through it (the same as those through the bar *r*) for those two bolts to pass through; but, in case of two pinching screws in the dovetailed bars *y* and *y*, as in Figure L, *r*, Z, no holes will be required through the wedge Z. In either case the nuts and screws will bind, or the pinching screws will pinch, the bar *r* against the wedge Z, which occupies the bottom of the cell for that bar *r*. The thickest end of the wedge Z is prolonged upwards above the uppermost part of the tool rack L, with a lateral prominence from the upper end of the wedge Z, reaching over the uppermost part of L, see Figure L, *r*, Z, and a perpendicular setting screw *q* is tapped through the prominence of Z with the lower end of the screw *q* bearing upon the uppermost part of L, so as to suspend the wedge Z, and prevent it descending when the two screws for fastening the bar *r* are slackened, and leave the bar *r* and the wedge Z at liberty in the cell. And then, by turning the screw *q*, the wedge Z can be set either higher or lower in the cell as may be required for producing a small lateral adjustment of the lateral cutting edge at the lower end of the bar *r*. The adjustment of the several lateral cutting edges in the same compound tool is to be such as will bring them all to conformity with an imaginary straight line, which will be nearly conformable with the endway motion of the moving table, except that such line will have a very small inclination laterally thereto, being close to the side of the metal that is to be planed, at that end of the line where the foremost of the lateral cutting edges is situated, and further in towards the same side of the metal, at the other end of the said line where the hindmost of the lateral cutting edges is situated; and that hindmost lateral cutting edge is adapted for penetrating as far into the thickness of the metal as is required to be done by lateral cutting with the compound tool. It has been mentioned that the back surface of the tool rack L makes a very small angle of inclination laterally with the imaginary plane of the bottoms of all the cells in the tool rack L. The reason for making the tool rack in that manner is to give the above-mentioned very small angle to inclination laterally to the imaginary line of the row of lateral cutting edges. And in case of lateral cutting edges being combined in the same compound tool with cutting edges for cutting downwards, the two sorts of cutting edges must be so formed and arranged in.

the combination as not to interfere one with another in their respective cutting actions. Also in the case already mentioned for rabbeting when the same cutting edges are formed for cutting laterally at some portion of each edge, and for cutting downwards at other portions of the same edge. Those compound cutting edges must be formed so that the cutting action of one such portion will not interfere with that of the other portions. In all cases the whole quantity of cutting work that is required to be performed by the planing should be equally divided amongst all the cutting edges that are contained in the compound tool, so that each cutting edge shall remove a thin shaving of metal, and that no cutting edge shall fail to do so. The mode of forming the cutting edges by means of apparatus, which I call two adjusting frames (see Figures 13 and 14, Sheet D), before finally fastening the square bars *r* of those cutting edges into the cells of their tool racks L, so as to constitute the two compound tools, and the mode of adjusting the cutting edges, will be hereafter described. The cross bar 3 of the planing machine, after having been once set at its proper height for performing the planing of the edges of the plates P and P by the two compound tools, is to be secured by steady pins and by its fastenings 4 and 4 to its upright fixed standards 2, 2, so that it cannot afterwards be moved. Also the slider 5 is made very fast on the cross bar 3 by the pinching screws of its filling piece 6, and secured with steady pins so as to render the frame K, K, immoveable, and prevent any alteration in the position of the two compound tools in respect to the planing machine. The frame K, K, overhangs considerably from the cross bar 3 and bearing pieces *h*. Figures 1, 3, 7, and 8 are fastened by screws to each side of K, K, at those parts thereof which are farthest from the cross bar 3, so as to bear lightly on the upper edges *a* and *a* of the trough A, B, A, in order to prevent any springing or bending down of the frame K, K.

Operation of the Planing Machine.

It has been explained that one of the two flat plates P, which are held at the same time in the trough A, B, A, is undergoing the first operation of planing one of its edges at the same time, whilst the other plate P (at the opposite side of the trough, is undergoing the final operation of planing the second of its edges. Also, that the last-mentioned plate is removed as finished after the completion of the planing of the second of its edges. The other first-mentioned half-finished plate, which has only had one of its edges planed, is to be transferred to the opposite side of the trough, being turned over in so transferring it, in order to place it in the trough with its recently-planed edge downwards and its unplaned edge upwards. Suppose the two compound tools

to be in their places in the two openings of the frame K, K, and, for a commencement of the description, suppose that they just concluded their planing action on the uppermost edges of the two plates P and P. The planing machine is to be adapted to stop the endway motion of its moving table by its own self action (in the usual manner of ordinary planing machines) as soon as that table has moved forwards in the proper direction for planing as far as it is appointed to move. Nevertheless, such self action is not to cause the immediate return of the moving table, but is to leave it motionless; and it is whilst the table continues motionless that the clamps E and E are to be slackened by turning back the double-ended winch handle, so as to draw back the wedge W between those clamps E, E, and then the finished plate P is to be removed altogether from the planing machine; also, the half-finished plate P is to be lifted out from the crevice *a*, *e*, which it occupied in the trough A, B, A; and it may then be laid down flatwise upon the cross bars *z*, *z*, in part of the aforesaid transferring of that plate. Then the usual reversing motion of the planing machine is to be brought into operation by the hand of one of the attendants, in order to commence the return of the moving table, and that return may be performed (in the usual manner of some planing machines) with a more rapid motion backwards than the previous motion forwards for planing was performed. And when the moving table has moved back as far as it is appointed to do, then it will stop by its own self action; but that self action does not cause the reversal of the motion of the table, which will remain motionless, and whilst it continues so the aforesaid half-finished plate P is lifted up from off the cross bars *z*, *z*, and let down edgeways with its planed edge downwards into one of the crevices *a*, *e* (namely, that one from which the finished plate P has been recently removed), and the said planed edge of that half-finished plate will rest upon the stops *p*, beneath the said crevice; thus completing the intended transferring of that half-finished plate. Also, a fresh plate, whereof neither of the edges has yet been planed, is at the same time let down edgeways into the other of the crevices *a*, *e* (namely, that one from which the aforesaid half-finished plate P has been recently removed), and the lowermost unplaned edge of that fresh plate will rest upon the stops *p* beneath the said crevice. Then the two plates P and P are both fastened in the said two crevices at once by turning the double ended winch handle round forwards, so as to force the wedge W in between the two clamps E and E, and thereby cause them to hold the two plates P and P fast between the edges *a*, *e*, and *a*, *e*. After such preparation the usual reversing motion of the planing machine is brought into operation by the hand of one of the attendants, in order to commence the endway motion of the moving table

in the proper forward direction, and with the proper rapidity for planing the uppermost edges of the two plates P and P; both these edges being planed at once by the cutting edges of the two compound tools which are held in the two openings of the frame K, K. In case the cutting edges are adapted for cutting downwards, then the foremost of them in each row (namely, that one which comes first into operation on the metal) stands at a higher level than the next succeeding cutting edge in the same row, and that is higher than the next one in succession; and so on, in order that each succeeding cutting edge may cut away and remove a thin shaving of metal from that edge of the plate P or P, upon which it is operating; and the hindmost of the cutting edges in each row will complete the planing downwards to the intended level. Or, in case the cutting edges are adapted for cutting laterally, then the foremost of such lateral cutting edges will be close to one side or surface of the uppermost edge of each of the plates P and P, and each succeeding lateral cutting edge in the same row will penetrate further into the thickness of the metal at that side or surface thereof than the lateral cutting edge which precedes it in the row. In such manner the planing will be performed by removing thin shavings of metal, one such shaving by each cutting edge; but as all the cutting edges are doing so at the same time, the planing operation is completed upon two edges of the plates P and P during one endway motion forward of the moving table through a distance somewhat greater than the whole length of those plates; and when that endway motion is stopped by self action as already explained, then one finished plate will be removed as so much work completed, for the complete planing of that one plate will be the equivalent for the whole amount of work performed by the planing machine, with its two compound tools during the endway motion of the moving tables and the return thereof. The operation of the planing machine is carried on in that manner until it is found that the cutting edges require sharpening, and then all those which belong to the same compound tool can be removed like one piece by merely turning back the nut *m*, and withdrawing the two steady pins *s* and *s*, and then lifting out the tool rack L, or both compounded tools can be removed if requisite; and either or both can be replaced without delay by fresh compound tools which are kept ready prepared, their cutting edges having been newly sharpened and then adjusted by aid of the same two adjusting frames, Figures 13 and 14, so as to be precisely in the same positions in respect to the tool racks L as the cutting edges occupied in the tool racks which have been removed; and, consequently, when such fresh compound tools are fastened into their respective places in the two openings of the frame K, K, their cutting edges will be certain to occupy precisely the same positions in respect

to the planing machine as were occupied by the cutting edges of the two compound tools which have been removed. The form which must be given to the operative parts of the cutting edges of each of the two compound tools will necessarily vary according to the form which is intended to be given to the edges of the plates P and P, in order to adapt the two edges of the same plate for fitting one such edge to the other, with exact correspondence after that plate has been turned up to the form of a tube with the two edges brought into mutual contact.

In my former Specification of the First of November, One thousand eight hundred and forty-five, different forms, which may be given to the edges of such plates, are described amongst other forms. It is there stated that the said edges may be cut with what are called feather edges, suitably for overlapping with one feather edge over the other after being turned up. In such case all the cutting edges in each compound tool must cut laterally, each succeeding cutting edge in the row thereof cutting further in laterally than the cutting edge immediately preceding it in that row.

In another of the forms described and claimed in that Specification one of the edges of each plate is cut out with a vee groove, and the other edge of the same plate with a double levelled edge adapted to fit into and fill up the vee groove after the plate has been turned up into the form of a tube. In such case the several cutting edges in one of the compound tools for plaining the double bevel must all cut laterally, some at one side or surface of the plate, and others at the opposite side or surface; and they may cut one after another in alternate succession, that is to say, every alternate lateral cutting edge in the row may cut laterally for the intended bevel at one side of the flat plate, suppose the right-hand side, and every intermediate lateral cutting edge in the same row may cut laterally for the other intended bevel, at the contrary or left-hand side of the same plate, each of the lateral cutting edges on either side cutting deeper into the thickness of the metal than the preceding lateral cutting edge on the same side. Some of the hindmost cutting edges in the row should be adapted for cutting the bevel on both sides of the plate at once, being for that purpose in the form of a vee notch. Such cutting edges should not come into operation until after the preceding lateral cutting edges right and left have reduced the edge to straightness, and so far formed the double bevel that its ridge is become quite sharp, leaving no more cutting to be performed than is necessary for ensuring that the intended double bevel form should be given with precision and without any wiry edge along the ridge.

And as to the cutting edges of the other compound tool for planing the vee groove, they must be of two kinds, some of the foremost of those edges being

adapted for cutting downwards into the metal and across the whole breadth of the uppermost edge of the plate that is to be vee grooved along that edge, one such cutting edge operating after another in succession, and each cutting deeper than the preceding cutting edge, in order to render that uppermost edge quite straight and flat across before the actual cutting of the vee groove is begun by the remainder of the cutting edges in the same compound tool, such remainder having angular points, which are adapted for cutting out the required vee groove, and each one in succession penetrating deeper down into the metal than the preceding one until the hindmost cutting edge completes the vee groove to the intended depth, and to the full breadth of the said uppermost edge of the plate.

In another of the forms described and claimed in that Specification, the two edges of each plate are rabetted, that is to say, a rabbet is formed along one edge by cutting away at one side or surface of the plate, and another corresponding rabbet is formed along the opposite edge of the same plate by cutting away at the contrary side or surface. In such case the cutting edges of the compound tool for planing out each such rabbet may be adapted for cutting out all the three sides of the rabbet by different portions of the same cutting edges, one portion being formed for cutting laterally, and two other portions for cutting downward into the metal for the formation of the same rabbet. See Figures *n*, *r*, and L, *r*, Z, Sheet C. The foremost of such cutting edges, in each compound tool, may begin the lateral cutting, and those portions of that foremost cutting edge which are for cutting downward will be at so high a level as only to begin cutting very lightly on the uppermost edge of the plate that is to be rabbeted; and each succeeding cutting edge will be nearer in towards the metal sideways than the preceding edge, so as to penetrate farther into the thickness of the metal for forming the rabbet, and will also be at a lower level so as to cut somewhat deeper down into the metal until the hindmost cutting edge will give the true intended form to the rabbet. It is not requisite for planing rabetted edges that the whole number of cutting edges in each of the compound tools should be formed for cutting all the three sides of the rabbet by three different portions of the same cutting edge, for some of the foremost cutting edges in each compound tool may be for downward cutting, and others for lateral cutting, and those two sorts of cutting edges may be combined in any convenient manner, nevertheless some of the hindmost cutting edges in each compound tool should be of the kind represented in Figures *n*, *r*, and L, *r*, Z, for finishing all three sides of the rabbet at once, in order that such finishing may ensure exactitude in the ultimate completion of the rabbeted edges to the true intended form;

which form must be such that the rabbet cut by one compound tool on one edge of each plate will correspond to the rabbet that is cut by the other compound tool on the other edge of the same plate. Exactitude and correspondence of form, as well as mere straightness of edge, is in all cases of great importance for the close fitting together of the two planed edges of the same plate when those edges have been brought into mutual contact by the turning up of the plate to the form of a tube; also exactitude in the breadth, to which the plate will become reduced by the planing of its edges, is of equal importance. The amount of cutting work to be performed by the cutting edges of such compound tool, in planing the edges of a number of plates in succession to any of the forms herein-before described, will be easily performed without unreasonable risk of breaking or wearing out the cutting edges prematurely, provided that before the plates are put into the planing machine their edges are tolerably straight, and that the breadth of each plate is brought nearly to the standard breadth that it is ultimately required to have to suit the subsequent operation of turning up to form a tube of some given diameter. It has been already stated that the plates are to be prepared for planing by shearing their edges as straight as can be done; but, inasmuch as the edges may vary from straightness in the state in which they are left by the shearing, so the breadth to which the plates are cut by the shearing must exceed the standard breadth to which they are to be ultimately reduced by the planing, in order that the excess in breadth may allow for the waste of metal in reducing the edges to straightness. The plates must be exact to the standard breadth after the planing, and the edges must be rendered straight thereby, or else they will be unfit for turning up. There must be some degree of uncertainty as to the amount of deviation from straightness of the edges by shearing, and therefore the breadth to which the plates are sheared must be sufficiently in excess of the standard breadth to allow by anticipation for the fullest amount of such deviation that is at all likely to take place. The excess beyond the standard breadth is an allowance in anticipation by way of precaution against some accidental or occasional crookedness in the shearing, and all that excess must be cut away in shavings during the planing in order to reduce the plates to the standard breadth ultimately required; and whatever excess may be allowed it must be planed away, even although the edges may prove very nearly straight, because the plate must be reduced to the standard breadth. Hence there are two distinct objects to be attained by the planing of the edges of the plates, one being to render those edges straight and reduce the plates to be required standard breadth, when both edges have been planed straight; and the other object is to cut the straight edges to

the proper form (whether rabbetted or vee grooved and double bevelled or other form) for qualifying one edge of each plate to correspond and fit to the other edge of the same plate after the two edges have been brought into mutual contact by turning up. The first of the above objects (reducing to straightness and to standard breadth) will be attained by action of cutting edges, which cut downwards into the metal of the uppermost edges of the plates; and two such cutting edges (one for each plate, may be held fast to the foremost end of the frame K, K, as shewn at *k* and *k*, Figures 7 and 8, so as to stand in advance of the row of cutting edges in each of the compound tools, and precede the foremost of those cutting edges in each row. The cutting edges *k* and *k* are held at a higher level by the thickness of a shaving than the foremost of the cutting edges in each row, and those edges *k* and *k* will operate first of all to cut away and remove such prominences of the uppermost edges of the plates as may arise from a slight crookedness in those edges, and thereby reduce them sufficiently near to straightness for the foremost cutting edges of the compound tools to begin upon with safety, some of those foremost cutting edges being adapted for cutting downward to complete the straightening of the edges of the plates, and to continue the reduction of the breadth of the plates to nearly their standard breadth. Each of the cutting edges *k* is formed at the lower end of a tool shank, which is applied against the frontmost end of the frame K, K, and is fastened there by being passed through a mortice hole, across a round pin which is fitted horizontally through a hole in the metal of the frame K, K, and a head on the end of the pin is countersunk into that metal within the frame. Also a pinching screw is tapped endway into the pin, with the point of that screw within the mortice hole, so as to pinch against the front of the tool shank, and hold it fast against the frame K, K. Each cutting edge *k* being formed out of the same piece of steel as its tool shank, they will be stronger and better able to endure the abrupt action of cutting away prominences or crookedness than cutting edges on steel teeth *n*, which latter are adapted for finishing the work by uninterrupted cutting away of thin shavings all along the metal, after all prominences have been removed therefrom and straightness of edge obtained. Those cutting edges for cutting downward, before mentioned as the foremost in each compound tool, may also be formed out of the same pieces of steel with their tool shanks. Of the whole number of cutting edges that are operative at once upon the metal of the uppermost edge of each plate a portion must be adapted for the fulfilment of the first-mentioned object, namely, for rendering the edge straight, and beginning to reduce the breadth of the plate towards the standard breadth,

whilst the remainder of the whole number of cutting edges must be adapted for the fulfilment of the other object, namely, the planing of the straightened edge to the intended form. The number of cutting edges that should be adapted for the attainment of each of those two objects will depend upon the kind of metal to be operated upon, and also upon the degree of straightness of the edges of the plates as they are left by the shearing. The number of cutting edges in each compound tool may, if required, be augmented by making tool racks, such as Figure L, Sheet C, of greater length, and with a greater number of cells in them, the two openings in the frame K, K, and the two wedges *l* and *l*, being made long enough to suit such larger tool racks. It is not necessary that all the cells in each tool rack should be filled in cases when a less number of cutting edges will perform the work effectually. In case the shearing should be liable to leave the edges of the plates crooked to such an extent as to require the plates to be sheared with an unusually great excess beyond their standard breadth, then it may be expedient to subject such plates to a preparatory operation of planing their edges straight, and reducing the breadth towards the standard in fulfilment of the first-mentioned object. For this purpose the two compound tools which are to be used in the planing machine should be wholly composed of cutting edges adapted for cutting downward into the metal, and by operation of the machine similar to that which has been described (but with those downward cutting edges) the edges of the plates could be planed straight, and their breadth nearly reduced to the standard; and after planing a number of plates in that manner, the said compound tools being changed for two others composed of cutting edges adapted for planing the edges to the required form, then the same plates being planed over again with those compound tools, the plates would, by such second planing, become finished in the same manner as already described, except as to having been subjected twice to the planing operation. Or such preparatory planing of the edges of the sheared plates to straightness and reduction to breadth might be performed in the manner stated in my former Specification of the First November, One thousand eight hundred and forty-five, namely, for placing and fastening a number of the sheared plates edgeways upwards, side by side, upon the flat surface of the moving table of a common planing-machine, and planing the uppermost edges of the whole number to one flat surface. Then the same plates being turned over on the surface of the table so as to bring the recently-planed edges to rest thereon, and with the other unplaned edges upwards, those other edges could be all planed in turn to a flat surface. By that means both edges of each plate would be rendered

straight and parallel, and the width of the plates would be reduced nearly to the true standard before subjecting the plates to the operations of the compound tools.

MODE OF FORMING THE CUTTING EDGES FOR THE COMPOUND TOOLS HEREIN-BEFORE DESCRIBED.

The steel teeth *n*, Sheet C, which are to be held in the notches at the lower ends of the tool handles *r*, may be formed out of a bar of cast steel tilted nearly to parallel breadth and thickness, and then deeply indented or cut across whilst hot at all places where the bar will ultimately require to be separated for dividing it into short lengths of suitable size and form for the intended teeth, but nevertheless leaving the bar sufficient strength for undergoing the operation of planing, when it is firmly held against a suitable support which is fastened on the moving table of a small planing machine; and by careful planing in such machine the steel may be rendered straight and parallel in thickness at that edge (and at those parts of the flat sides) of the bar which will be uppermost in each tooth when in use, and which will be held in the notches in the tool handles. Also a half-round notch for wire O may be planed out along one side of the steel parallel to and at some precise distance from that said edge of the bar which will be uppermost in each tooth. In case each tooth *n* is to have a hole through it for the screw by which it is to be fastened into the notch at the lower end of the tool handle *r*, see Figure *r*; *n*, then the steel bar must be broader than will be requisite if the teeth are to be without holes. After such planing of those parts of the steel bar which will be uppermost in the teeth, then the contrary edge of the bar which will be lowermost in the teeth, and where their cutting edges will be formed, may be roughly planed to suit the required form of cutting edge, which, for example, suppose to be for rabbeting the edges of the plates, see Figures *r*, *n*, and *n*, *r*. The steel bar may then be separated at the aforesaid indentations to divide it into short lengths suitable for distinct teeth. The notches at the ends of the tool handles for receiving the teeth may be planed out in the small planing machine, wherein all those tool handles which belong to the same tool rack are held in a row endway upwards in an inverted position by means of a temporary tool rack, Figures 9, 10, and 11, Sheet D, which is fastened upon the moving table of such planing machine. That temporary tool rack has the same number of cells in it, and each cell is of the same size, as in the ordinary tool rack L, in order that the same tool handles may be fastened in those cells by suitable pinching screws; and although the temporary tool rack holds those tool handles with the lengthway of one parallel to the lengthway of another,

and in a vertical plane as regards the direction of the endway motion of the moving table, nevertheless it holds all the tool handles somewhat inclined from perpendicular in the vertical plane wherein they are all situated. Also the cells of the temporary tool rack are adapted for holding the tool handles *r* somewhat anglewise, one in respect to another, as compared with their proper and usual positions when held in their own ordinary tool rack L; that is to say, in that ordinary tool rack the bottoms of all the cells conform to an imaginary flat surface, as already stated, and therefore, after the row of tool handles is completed by fastening them in those cells to constitute a compound tool, then the flat sides of the several squares of all those tool handles will conform to two imaginary parallel planes. And an intermediate or medial plane may be imagined parallel to and equidistant between the said two parallel planes; also a central line or axis may be imagined to pass along the middle of the substance of each of the square tool handles *r* lengthways thereof, and the last-mentioned imaginary central lines of all the tool handles will be situated in the aforesaid medial plane. When the temporary tool rack Figures 9, 10, and 11, is fastened in its place upon the moving table, then the central lines of all the tool handles, and the medial plane in which all those central lines are situated, will be a vertical plane conforming in direction with the endway motion of the moving table. The cells in the temporary tool rack are formed for holding each tool handle in a position somewhat anglewise in respect to the other tool handles, as appears in Figure 9, each tool handle standing as if it had been turned 4 or 5 degrees round about its central line in respect to the medial plane. The tool handles, which are to constitute one compound tool, being thus firmly held in the cells of the temporary tool rack with their lower ends upwards, then by very gradual and careful planing action across the said ends (actuating the planing machine by hand, if requisite those ends may be rendered flat, and then the notches may be cut out in those ends for receiving the teeth; and also a small half-round groove may be cut withinside of each notch, in a position therein to correspond precisely to the half-round notch previously made in the flat side of the steel for each of the teeth, so that when those teeth are finally fitted and inserted into the notches, the half-round groove in each tooth and the half-round groove within each notch will correspond one half to the other, so as to leave a round hole for the insertion of the wire O, which will insure that the tooth shall be held in its proper position in the notch, and that it shall have no motion therein after being pinched fast by the lowermost binding screw of the tool handle. When the wires O are thus inserted into the half-round grooves, the uppermost parts of the steel should be in very close contact with the cor-

responding parts of the notches in the tool handles. The several tool handles being thus provided with the steel out of which their cutting edges are to be formed, they can be replaced in the cells of the temporary tool rack, as they were when the notches were planed out, and when so replaced the several pieces of steel in the tool handles will be held fast so as to range in a line one with another, as they did in the original straight bar from which they have been cut off; and the several pieces of steel so fitted and held in the tool-handles may then be planed by a gradual and careful action of the small planing machine (actuating the same by hand if necessary), in order that those parts of the steel which are to become the cutting edges may be rendered all alike, and in order to plane out the rabbeted form that is intended to be given to those cutting edges. In case such rabbeted form had been roughly planed out in the first instance when the steel was in the state of a bar, that rabbeted form can be made quite true at this repetition of the planing of the same steel now it is in separate pieces, which are held in a straight row in the tool handles, and those tool handles are held fast in the temporary tool rack on the moving table; such planing of the steel will be in a direction parallel to the lengthway of the original bar of steel, which has been divided into distinct teeth. The same temporary tool rack may be used for holding the square bars called tool shanks (see Figure *r*) in the small planing machine, in case the steel at the ends of such tool shanks is required to be prepared by planing in the manner already described. Such planing is only a preparation for forming the several cutting edges, which require that the steel should be cut or filed off obliquely in respect to the planed surfaces of the steel across the foremost end of each of the teeth in order to produce sharp cutting edges at the intersections of such obliquely cut surfaces with the several planed surfaces. After sharp cutting edges have been thus obtained, the teeth are hardened and tempered, then ground and whetted to keen edges and re-fastened into their tool handles *r*, and when a row of those tool handles *r* with teeth *n* are placed in the cells of their common tool rack L they will from a compound tool. Those surfaces of the teeth which have been formed by planing the steel will not range in any line in the compound tool as they did when in the temporary tool rack, for the planed surfaces belonging to one tooth will be out of line with the like planed surfaces belonging to one tooth will be out of line with the like planed surfaces belonging to other adjacent teeth in the row. All such planed surfaces in the teeth will stand at an angle of about 4 or 5 degrees of inclination to the imaginary line of the row of cutting edges. It may be termed the angle of clearance of the cutting edges. It is the angle that must be formed during the planing operation between the

flat surface of the steel, and the adjacent flat surface of the metal which is in the act of planing, by the cutting edge at the foremost end of the said flat surface of the steel. The obliquity wherewith the foremost end of the steel of each tooth is to be cut across in respect to the lengthway of the planed parts of that tooth in order to obtain each cutting edge as aforesaid should be such an obliquity as will be best adapted for cutting the particular metal of the plates on which the compound tools are to operate, and the said obliquity should be the same in all the cutting edges belonging to the two compound tools which are to be used at the same time. The sharpening of the cutting edges when they become worn (or the repairing of them when broken) is to be performed by grinding away the hardened steel at the oblique foremost end of each tooth, such grinding being parallel to the original obliquity, but those surfaces of the steel which have been formed by planing are never to be touched in grinding. It may happen in consequence of breaking some of the cutting edges that the grinding away of the oblique foremost ends of the steel for repairing them will greatly exceed the grinding away of the steel of other cutting edges in the same compound tool; such difference in the waste of the steel by excessive grinding away at the foremost ends will cause some irregularity in the distances apart between the several cutting edges along their row. In case of all the teeth *n* being made as in Figure *n*, *r*, Sheet C, any one tooth *r* can be moved endways onwards in its notch at the lower end of the tool handle *r*, after the lowermost pinching screw has been slackened; and when the cutting edge at the foremost end of the tooth has been moved onwards to the intended position, then the tooth can be fastened again by lightening the screw. In case of the tooth *n* having a hole through it for the lowermost screw to pass through, that hole would require to be made oblong in order to obtain a like adjustment. The wire O, in either case, will greatly assist the pinching action of the lowermost screw for holding the tooth fast in the notch.

DESCRIPTION OF THE APPARATUS CALLED ADJUSTING FRAMES, for adjusting the several Cutting Edges in the Compound Tools to which they belong respectively.—See Figures 13, 14, and 15, Sheet D.

After all the cutting edges for the compound tools have been formed suitably for the planing work that is intended to be performed by them, and the steel has been hardened and tempered and then ground to sharp cutting edges so as to be fit for use, the square bars *r* of those cutting edges (whether those bars are tool shanks or tool handles) are put into their places in the cells of the tool rack L, and then one of the adjusting frames is to be used for

adjusting the position of the several cutting edges in their intended row before finally binding or pinching their bars in the said cells. Figure 13 is a front elevation, and Figures 14 and 15 sections, of one of the adjusting frames. It is made of cast iron in one piece U, V, which is planed flat, and its uppermost edge U straight, in order that the tool rack L may be lodged with the prominent border *j* at the back surface of L, resting upon that edge U, and with the back surface of L leaning against the flat surface of U, V, which is fixed in an inclining position when used, as appears in Figures 14 and 15, so that the weight of L will cause it to remain steady. A prominent border V is formed in the same piece with the frame U, V, at the lower part thereof, the border V being straight and parallel to the uppermost edge U. The distance between the parallel upper edges of V and of U is equal to the vertical height in the planing machine, Sheet B, Figure 3, from the level of the horizontal surface of the bottom B, upon which the blocking pieces U, beneath the stops *p*, are fastened, up to the level of those horizontal upper edges of the two openings in the frame K, K, upon which edges the borders *j*, at the back surfaces of the two tool racks L, are to apply when those two racks are steady, pinned, and fastened in the said openings for operation. The border V forms a lodgment for the lowermost edge of a flat plate of cast iron X, the breadth of which is equal to the standard breadth to which one of the plates P or P is to be reduced after the planing of its uppermost edge, which that plate is to undergo in the planing machine, Sheets A and B. A rabbet is formed along the front of the upper edge of the plate X to form a lodgment for a steel ruler Y, which is straight, and of the same breadth as the height of the blocking pieces U or U, together with the height of those bearing stops *p* or *p*, which are used in the planing machine at the same time with that compound tool L, whereof the row of cutting edges is about to be adjusted by aid of the frame U, V, now describing. The required adjustment for such cutting edges as are to cut downwards into the metal is made by slackening those two screws, by which each of the bars *r* is fastened into its cell in the tool rack L, and then allowing each bar *r* to move endway downwards in its cell until the cutting edge at the lowermost end of the bar *r* is stopped by coming in contact with the uppermost edge of the ruler Y. And all the cutting edges in the row being treated in that manner they become arranged to conformity with a straight line (represented by the edge of Y, then by the said two screws belonging to each bar *r* it is fastened in its cell; and after all the bars *r* belonging to the tool rack L have been so fastened the adjustment of the cutting edges for cutting downwards will be complete, and the compound tool will be ready for removal from the frame U, V, into its place in that opening

of the frame K, K, to which it belongs. Two such adjusting frames will be required to be used at once, one for adjusting the cutting edges of all compound tools which belong to one opening in the frame K, and the other for adjusting the cutting edges of all compound tools which belong to the other opening in the frame K. Both those frames U, V, are precisely alike, but are adapted to suit for one or other of the openings in K by small difference in the breadths of the plates X and ruler Y, which are used in each frame respectively. The breadth of the ruler Y is in each case equal to the united height of the blocking pieces U or U, and those stops *p* or *p* which are to be fastened on U or U, at that side of the trough A, B, A, for which the cutting edges of the compound tool are about to be adjusted. The stops *p* at one side of that trough are not so high as the like stops *p* at the opposite side; accordingly, the breadth of Y in one of the frames is somewhat greater than in the other. The breadth of the plate X is to be equal to the standard breadth to which the plate P or P is intended to be reduced by the planing thereof that is to be performed by that compound tool, whereof the cutting edges are about to be adjusted by aid of such plate X and ruler Y. The said breadth of X is to be measured across it, immediately between the hindmost of the cutting edges in the compound tool (see the dotted line in Figure 13); but the breadth of X is greater, if measured across it, immediately under the foremost of the cutting edges in the compound tool. The difference between the two breadths of X, as measured at those two places, represents the reduction that will be made in the breadth of the plate by that planing of one of its edges, which planing is to be performed by the cutting edges about to be adjusted; in fact, the uppermost edge of X is not parallel to its lowermost edge, which is lodged upon the border V. The ruler Y is of parallel breadth, and its uppermost edge is inclined in a small angle of inclination from parallelism to V, consequently, when the cutting edges of the compound tool have been adjusted by contact with that uppermost edge of Y, the imaginery straight line to which all those cutting edges are thereby rendered conformable will be included in that small angle to the border *j*, at the back surface of the tool rack L. From such mode of adjustment on the adjusting frame it follows that, when the compound tool is afterwards fastened into that opening of the frame K to which it belongs, with its border *j* horizontal, the said imaginery straight line of the row of cutting edges will then stand out of level in the aforesaid small angle of inclination, or in other words, that the foremost cutting edge in the row thereof will stand at a higher level than the hindmost cutting edge, which difference of level has been herein-before explained to be requisite to qualify each succeeding edge in the same row for cutting down as much deeper into

the metal than the cutting edge immediately preceding as the thickness of a shaving, and thereby cause the cutting work to be equally divided amongst all the cutting edges. In case the cutting edges, or some of them, in the compound tool are adapted for cutting laterally, then for adjusting such lateral cutting edges an additional straight edge may be connected by hinge joints to the back of the upper part of the ruler Y, Figure 15, so as to be capable of being turned up forwards from behind in order to stand up above the level of the uppermost edge of Y; and whilst the compound tool continues mounted in place upon the adjusting frame, and the two screws for fastening each of the bars *r* in its cell are all slackened for the purpose of adjustment of the downward cutting edges in manner already described, then the aforesaid additional straight edge is to be turned up about its said hinge joints until they stop firm, whereby that additional straight edge will be brought with its front face in easy contact with the lateral cutting edges belonging to the said compound tool; and by examination of all the contacts between the said front face of the additional ruler, and the several lateral cutting edges, it will become apparent which of those lateral cutting edges conform to an imaginery straight line. The adjustment of any of the lateral cutting edges which do not conform to such line is then made in the manner herein-before described by means of the thin wedges Z and screws *q*, Figure L, *r*, Z, Sheet C, also Figure 15; such a wedge Z is interposed between the square bar *r* belonging to each of the lateral cutting edges, and the bottom of the cell in the tool rack L wherein such bar is lodged. And after all the lateral cutting edges have been thus adjusted to their proper relative positions in the row, as well as the downward cutting edges, then the bars *r* are all made fast in their cells in the tool rack L by the aforesaid two screws for each bar. The two compound tools will be ready for use after the complete adjustment in such manner of the cutting edges of each tool upon one or other of the two adjusting frames. When the cutting edges of the compound tools require sharpening, those tools must be removed from the frame K, K, and replaced by two other like compound tools whereof the cutting edges have been previously sharpened, and then adjusted upon the same two adjusting frames as before. Owing to such mode of adjustment the two fresh compound tools will carry on the future planing operations in the same manner as the two former tools which have been removed. The foregoing explanation of the manner of adjusting the cutting edges in each compound tool, by contact of the downward cutting edges with the ruler Y, and contact of the lateral cutting edges with its additional straight edge, will serve to explain the manner of adjusting all other cases of cutting edges for planing peculiar forms, such, for instance, as planing rabbets. In such case the

uppermost edge of the ruler Y must be rabbetted to the form of the rabbet intended to be planed, and the cutting edges must be adjusted by contact with such rabbetted upper edge of Y. In short, the said upper edge of Y is in all cases to be an exact counterpart of what the row of cutting edges is required to be when in place in the planing machine, and the position of that upper edge of Y, in respect to the upper edges of U and V, must be the same as the position that the row of cutting edges is required to have in the planing machine in respect to the horizontal upper edge of the opening in the frame K, and to the surface of the bottom B upon which the blocking pieces *u* and *u*, beneath the stops *p* and *p*, are fastened. The plate *x* being broader at one end than at the other, as already stated, that circumstance qualifies it for being used in the manner of a wedge, in case it may be found requisite to make a very minute alteration of the standard breadth to which the plate P or P will become reduced by the planing of its edges. By moving the plate X endways along its lodgment V for some distance, the uppermost edge of X, and consequently the uppermost edge of Y, will be held somewhat higher up or lower down in respect to the edges U and V than was the case before X was altered in its place upon V. Accordingly the row of cutting edges of a compound tool (after having been adjusted in the adjusting frames, with X so altered) will be held in the planing machine somewhat higher up or lower down, and consequently the standard breadth to which the cutting edges will reduce the plate P or P by their planing action, will be as much broader or narrower than they would have done if X had not been so altered. The actual breadth of the plate P or P after the planing will be equal to the breadth of the plate X, measured as before on the dotted line in Figure 13, drawn across X immediately beneath the hindmost of the cutting edges in the compound tool; that dotted line now passes across at a different place in the length of X to what it would have done if X had not been altered, and therefore the present breadth of X measured on that dotted line will be somewhat broader or narrower than before the alteration. Such mode of minute adjustment, by moving X along V, is only to be used for getting the plates P or P to be planed to a proper standard breadth to suit for the subsequent alteration of turning up, but that standard breadth being once ascertained the plate X is then to be screwed fast to the frame U, V, in order that all plates P or P which may afterwards be planed with compound tools adjusted in the same frame (whilst it continues in the same state), cannot fail to be planed to the exact standard breadth which has been so ascertained. When other plates P and P are required to be planed to a different breadth, suitable for being turned up into tubes of a different diameter, then, as herein-before stated, the stops

p and *p*, in the planing machine, are to be removed from their blocking pieces *u* and *u*, and are to be replaced by other stops *p* and *p* of a different height, suitable for the different breadth to which the plates P and P are required to be reduced by the planing. The plates X and ruler Y are at the same time to be removed from the adjusting frames, and are to be replaced by other plates X and rulers Y of different breadths, suitable for the new standard breadth to which the plates P and P are to be reduced by the planing, the breadth of the ruler Y being equal in all cases to the height of the blocking pieces *u* and *u*, together with the height of the stops *p* and *p*, and the breadth of the plate X (measured at the aforesaid dotted line in Figure 13) being in all cases equal to the standard breadth to which the plate P or P will be reduced by the planing with the cutting edges, which have been adjusted with such ruler Y and plate X in the adjusting frame.

DESCRIPTION of the COMPOUND CUTTING TOOLS, with two distinct rows of Cutting Edges in each such Tool, the Cutting Edges of one of those rows being adapted for Planing during the forward endway motion of the Moving Table of the Planing Machine, and the Cutting Edges of the other row being adapted for Replaning the same metal during the back-endway motion.

It has been herein-before explained that there are two distinct objects to be attained by the planing of the edges of the plates, which are afterwards to be turned up to the form of tubes, one object being to render those edges straight and reduce the plates to the required standard breadth, when both edges have been planed straight and parallel, and the other object being to cut the straight edges to some proper form for qualifying one edge of each plate to correspond and fit to the other edge of the same plate after the two edges have been brought into mutual contact by the turning up. It has also been explained how two additional cutting edges can be applied at *k*, Figures 1, 2, 7, and 8, to assist in the attainment of the first of the above objects. And it has also been explained how the said first object may be attained by a preparatory planing operation either in a common planing machine or else with the planing machine, Sheets A and B, when the cutting edges in the two compound tools used therein are all adapted for cutting downward into the metal of the edges of the plates that are to be planed. A great loss of time would be incurred by such a preparatory planing operation, but by the compound tools now about to be described, with an additional row of cutting edges in each such tool, the same results may be attained with very little loss of time. The tool rack L for each compound tool is made with its cells so-

much deeper than is represented in Figure L, *r*, Z, Sheet C, that each deep cell will be adapted for containing the steel shank of another cutting tool, in addition to the tool handle or square bar *r* already described, so that there will be two reversed cutting edges to each cell. This is shewn in Figure 16, Sheet E, which is a transverse section of the upper part of the trough A, B, A, and shewing the action of the two compound tools on the uppermost edges of two plates P and P. The same letters are used for reference as in Figure 3. And g^1, g^2, are the additional cutting edges to those herein-before described. They are adapted for cutting downward into the metal during the forward motion of the moving table, and are formed at the lower ends of bars or tool shanks *g* of cast steel, of the same size as one of the two bars whereof each tool handle *r* is composed. The tool handle *r* and tool shank *g*, which occupy each deep cell, apply together with their flat surfaces in contact, and both *r* and *g* are fastened into the deep cell, which is common to both, by the same pinching action of two screws tapped through dovetailed bars *y* and *y*. The cutting edges of the steel teeth *n* at the lower ends of the tool handles *r* are the same as herein-before described, being adapted for planing to a rabbetted or other form, but they are reversed so as to plane during the returning motion of the moving table. The cutting edges *g* for cutting downward form an additional row in each compound tool, quite distinct from, but adjacent to, the rabbetting cutting edges *n* at the lower ends of the tool handles *r*, which edges *n* form another parallel row. The two rows *g* and *n* in each tool are only so far apart laterally, that whilst the cutting edges of one row *g*, for instance, are in the act of planing the metal of the uppermost edge of a plate P, the cutting edges of the other row, *n* for instance, will pass clear along one side of that metal P, so as to avoid touching the same. There is only one of the two rows of cutting edges in each compound tool in operation at the same time, but both compound tools are planing with one of the said rows of each tool (*g* for instance), so that two plates P and P, at opposite sides of the trough A, B, A, are undergoing planing of their uppermost edges at the same time. Figure 16 shews that the tool handles *r* 1 for teeth *n* occupy the bottoms of the deep cells in the tool rack L 1 of the compound tools, but the tool shanks *g* 2 occupy the bottoms of the deep cells in the tool rack L 2 of the other compound tool. After the aforesaid planing by the two rows *g* 1 and *g* 2 of downward cutting edges has been performed on the uppermost edges of two plates P 1 and P 2, during the forward motion of the moving table, and whilst the same remains motionless, the whole frame K, K 5, is moved laterally a space equal to the interval between two adjacent rows *g* and *n* of cutting edges in the same compound tool, such

lateral motion being produced by sliding the slider 5 that space along the cross bar 3, and such lateral motion will bring the rows *n* 1 and *n* 2 in each compound tool into the proper positions for replaning the same metal of the uppermost edges of the two plates P^1 and P^2 by those cutting edges *n* during the backward motion of the moving table, which backward motion must be performed with the same slowness as the forward motion, because planing is to be performed during the backward as well as during the forward motion, although performed with different rows of cutting edges in each case. And by such replaning, the said uppermost edges of the two plates P 1 and P 2 will be rabbetted to the intended form. The cutting edge *n* of the tool handle, and the cutting edge *g* of the tool shank, which are held together in the same deep cell of each tool rack L, stand reversed, one cutting edge to the other, as to the direction in which they can perform their respective planing operations. After the said replaning during the backward motion of the moving table, and whilst it remains motionless, then by turning back the double-handed winch handle the clamps E and E are loosened, and the recently finished plate P 2 is removed and carried away as finished; also the recently half-finished plate P 1 is transferred from one side of the trough A, B, A, to the opposite side thereof. Likewise a fresh plate is put into the place of the half-finished plate which has been transferred; then by turning the same double winch handle forwards, the clamps E and E are tightened again, and the aforesaid small lateral motion, but in a contrary direction, is given to the whole frame K, K 5. And by such contrary lateral motion the two rows *g* 1 and *g* 2 of cutting edges in each compound tool will be brought into the proper positions for planing the metal of the uppermost edges of two plates P^1 and P 2 during the ensuing forward motion of the moving table as before. The effect of such planing will be to render the said uppermost edges of the two plates straight, and to reduce the breadth of those plates towards their standard breadth, the cutting edges *g* being for that purpose adapted for cutting downwards. The effect of the subsequent replaning during the backward motion of the moving table will be to plane the same edges of the plates to their intended rabbetted form. The requisite lateral motion of the frame K, K 5, may be given by the hand of the workman every time that the moving table has moved through its appointed space and become motionless; it may be so given by turning the usual screw motion work that is provided for moving the slider of the cross bar 3, stop pins being fixed in that bar to limit the extent of such motion of the slider 5 on that bar. Or such lateral motion may be given by suitable self-acting parts applied to the planing machine for the purpose, which parts may come into operation as

soon as the hindmost of the cutting edges in each compound tool have passed beyond the ends of the plates P 1 and P 2, and then those parts may produce the required small extent of lateral motion before the moving table becomes motionless. Those cutting edges of each compound tool which have been herein-before distinguished as the foremost, because they come first into operation on the metal, will, in the arrangement now describing, be situated at one end of one of the rows of cutting edges in each compound tool, and at the opposite end of the other adjacent row of cutting edges in the same compound tool. The adjustment of the several cutting edges in their two rows in each compound tool is to be made in the adjusting frames, Figures 13 and 15, with a steel ruler Y, whereof the upper edge is rabbetted, so as to form a counterpart of the rabbetted cutting edges *n*, which are to be adjusted in their row by contact with such rabbetted upper edge of Y. Also an additional straight edge is to be fastened to Y, so as to stand at a suitable relative position to the rabbetted edge thereof, for adjusting the cutting edges *g* in their row by contact with the uppermost edge of that additional straight edge, one end of which must stand at a level as much higher than the other end as is suitable for adjusting a row of downward cutting edges. That end of the additional straight edge which is highest will be the lowest end of the rabbetted edge of Y, but that rabbetted edge will have very little difference in the level of its two ends, because the cutting edges *n* are not required to cut downwards, except to a very small extent; their cutting action for the rabbetting being lateral, nearly all the downward cutting work will have been performed by the edges *g* during the forward motion before the edges *r* come into operation. Note, when any of the thin wedges Z are used for lateral adjustment of any of the cutting edges *n*, the other cutting edges *g* which belong to the same cells will partake of such lateral adjustment, but it will have no effect on the downward cutting action of the edges *g*. Note, it has been heretofore proposed for planing wood for general purposes, and for striking mouldings and for cutting wood into thin scale boards, to use tools of the nature of carpenters or joiners planes, containing several cutters to operate at the same time, but at different places along the lengthway of the wood, each cutter removing a distinct shaving of its own. And also it has been proposed to apply a planing machine for planing metal for general purposes, a tool holder with many blades mounted therein on distinct centre pins, and formed to as many distinct cutting edges for operating at the same time but at different places along the lengthway of such metal, each such edge removing a distinct shaving of its own. But neither such planes nor such tool holder can be made available for the purpose

of planing the edges of metal plates so as to give those edges some proper form (such as rabbetted or vee grooved and double bevilled, or other interlocking form) suitably for qualifying the two edges of the same plate to fit one to another when they are brought into mutual contact after the plate has been turned up into the form of a tube.

ON the PREPARATION of the FLAT PLATES of METAL previous to the planing of the Edges thereof, in the manner herein-before described.

In rolling the metal for the plates which are to be afterwards turned up to the form of tubes, two margins of each plate immediately adjacent to the two edges thereof may have a greater thickness of metal than the middle part or flat plate intervening between those two margins. Such greater thickness of the two margins will give more strength of metal at the two edges which are to meet together in close contact, when the plate is turned up to the form of a tube, than may be requisite for the remainder of the circumference of the tube. Such greater thickness of metal may be obtained by prominence of the two margins of each plate at one surface only of that plate, the opposite surface being flat across the whole breadth. The latter is the outermost surface in the turned-up tube, then the outside of the tube will be cylindrical, and will not shew the extra thickness of metal at the junction of the edges, because the prominences which cause such extra thickness will be at the interior of the tube. If the flat surface of the plate is innermost in the turned-up tube, then the inside of the tube will be cylindrical, and will not shew the extra thickness of metal, the prominences which cause such extra thickness being at the outside of the tube. Or the plate may be rolled with prominence of the margins on both surfaces of the plate, in which case such margins will be only half as prominent on each surface as in the former case, and such slight prominences will appear equally at the outside and at the inside of the turned-up tube. To form a pair of laminating rollers for rolling the plates, with such prominent margins at one surface only of such plates, supposing an ordinary pair of cylindrical rollers, the upper roller should be turned away and reduced in diameter towards each of its ends, leaving untouched so much of the length of the roller intervening between the two reduced parts as will be equal to the breadth required in the plate to intervene between its prominent margins; that is, in case of the metal being rolled to a breadth suitable for only one plate. If the metal is to be rolled wide enough to be afterwards cut along its mid-breadth, so as to become two plates, then the upper roller (which must in such case be of adequate length and strength) must also be reduced in diameter at its mid-length (as well towards each of its ends), in order to produce a broad plate, having three prominent parts of greater thickness, one of them extending along its mid-

breadth, and the others along each margin of such broad plate. And when that broad plate is cut by shearing along its thick mid-breadth and along each of its thick edges, it will form two plates, each such plate having two margins of greater thickness than the thickness of the flat plate intervening between those two margins. Such plates, whether obtained by rolling them singly or of double breadth, and cutting along into two, may be treated in the same manner as plates of uniform thickness would be treated. The change of thickness in each plate, from its flat middle part to the greater thickness of each margin, should not be an abrupt change at any one place in the breadth of the plate, but should take place by an easy gradation from one of those thicknesses to the other. Care must be taken in the operation of rolling such plates, to avoid lateral deviation from a straight line motion of the metal whilst it is passing endways through between the rollers, in order by such care to avoid lateral crookedness (as much as possible) in the lengthway of the plates, because the thick edges of each plate must be afterwards planed straight, and therefore each of the thick margins will require to be broader in case of lateral crookedness than would be requisite if straightness in the lengthway of the plates can be attained in the rolling. The breadth of each of the thick margins must be sufficient to admit of so much lateral crookedness as cannot be expected to be avoided by care in the rolling operations; and, notwithstanding such crookedness, there must be no risk of deficiency of the thick metal at any part in the length of each of the edges of each plate after those edges have been planed.

Mode of Flattening the Metal Plates.

The plates after being rolled, whether of single breadth or of double breadth, and whether of uniform thickness or with thick margins, must be made flat and out of winding before shearing their edges or dividing the double breadth into two. And for so rendering the plates flat and out of winding, they are to be passed and repassed, as many times as may be found requisite, through between three rollers, combined in a binding or flattening machine, in the well known manner of flattening metal plates for making machine or other steam boilers which are to have flat surfaces, the plates being heated in such machine according to the ordinary practice of engineers and boiler makers who are accustomed to make steam boilers, tanks, or other vessels requiring flat metal plates.

Mode of Shearing the Edges of the Metal Plates.

And after the plates are by that (or by other) means rendered flat and out of winding, then their edges are to be sheared as straight as can be done; and

in case the plates are rolled of double width, each one must be divided into two by shearing along the mid-breadth. The shearing may be performed in any of the modes of shearing commonly practised; but I prefer to use machinery wherein pairs of revolving circular shears are combined as described, and claimed in my former Specification of the First of November, One thousand eight hundred and forty-five; that is to say, either two such pairs of revolving circular shears combined for shearing the two edges of a plate at the same time, or else three such pairs of revolving circular shears combined for shearing the two edges of a plate which has been rolled of double breadth, and at the same operation also shearing along the middle of that breadth, in order to divide the double breadth plate into two plates. And at the time of passing a plate through between such two (or three) combined pairs of revolving circular shears, the foremost end of that plate is to be fastened to a moveable slider or carriage, which is retained to move horizontally along a straight groove in the direction of the lengthway of the plate, in order to prevent lateral deviation of the foremost end of the plate from a straight line motion in so passing through between the two (or the three) combined pairs of revolving circular shears; and by such prevention, causing the edges of the plates to be sheared straight. And in my former Specification the two (or three) pairs of combined revolving circular shears are described as being mounted upon two horizontal axes, disposed one above the other in the same vertical plane, each such axis having fastened upon it two (or three) of those circular cutting wheels, which form the halves of the two (or of the three) pairs of the revolving circular shears, the distance apart between the cutting edges of those measured along the axes being equal to the breadth to which the plate (or plates) is (or are) to be reduced by shearing with the said pairs of such wheels. When plates are required to be sheared broader or narrower for turning up to tubular forms of larger or smaller diameter, then the two horizontal axes must be removed from the machine and replaced by two other like axes, except as to the two (or three) circular cutting wheels which are fastened thereon, being at greater or lesser distances apart one from another, so as to suit the breadths to which the plates are required to be sheared. To avoid the trouble and loss of time that must be incurred in changing the said axes, and to avoid the expense of providing the requisite number of such axes, the machinery described in my former Specification may be constructed with the following alterations, namely, each of the circular cutting wheels which is to serve for a half of one of the pairs of circular shears is to have a distinct horizontal axis of its own, and two such distinct axes are to be mounted one above the other in a frame of their own, to constitute one pair of circular

shears. The base of that frame is to be fitted into a horizontal dovetailed groove in the fixed bed plate of the machinery; and such frame, being moved along (by a suitable adjusting screw) in the dovetailed groove, will carry the two axes horizontally endways in the directions of their own lengths, in order to bring the cutting edges of the pair of the circular shears opposite to that place in the breadth of the plate, where it is required to shear along all the length of the plate, when it is passed endways through the pair of circular shears. A complete shearing machine should contain three such pairs of revolving circular shears, with the two horizontal axes for each pair mounted in a distinct frame, such frames for two pairs (out of the three) having their bases fitted into dovetailed grooves as aforesaid, and being moveable therein by distinct adjusting screws, the dovetailed groove being in one line. The complete machine will be qualified for shearing the two outermost edges of plates which have been rolled of double breadth, and also at the same operation shearing along the mid-breadth of the broad plate to divide the same into two plates. And the same machine will be qualified for shearing the two outermost edges of plates which have been rolled narrow to form one plate. In the latter case it will only be required to use two pairs of circular shears; and that third pair thereof, which in the former case would shear along the middle of the breadth of the double breadth plate, must be rendered inoperative, which may be done by raising up or removing the uppermost axis and cutting wheel of that pair; and the aforesaid frames of the other two pairs of circular shears are to be approached near enough one towards the other (by moving each of them along in the dovetailed grooves by their adjusting screws) to adapt those two pairs for shearing the two outermost edges of a single breadth plate instead of the like edges of a double breadth plate. The horizontal axes of the last-mentioned two pairs of circular shears are disposed with the direction of the lengthway of the axes of one pair in exact coincidence with the direction of the lengthway of the axes of the other pairs, and therefore the two pairs of circular shears will operate in the same manner as if the four circular cutting wheels constituting those two pairs were fastened on, only two horizontal axes mounted one above another in one frame to serve for both pairs of shears, as is described and represented in my said former Specification. The object having four distinct axes instead of two (or, in other words, of having two axes mounted in a frame of their own for each pair of circular shears, as now describing) is for the facility of adjusting the distance apart of the cutting edges of the two pairs of shears, to suit the breadth to which the outermost edges of the plate are to be reduced by the simultaneous shearing with those two pairs of shears. After the basis of

the two frames have been moved in their dovetailed grooves by their adjusting screws, as may be required, then those bases are clamped very fast in their dovetailed grooves by binding screws, in order to render the frames immoveable during the operation of shearing. Each of the circular cutting wheels for the two pairs of shears is fastened upon one end of the axis belonging to each such wheel, that end of the axis protruding out beyond the bearing collar wherein the neck of the axis revolves, the collar, as well as a bearing for the other end of the same axis, being sustained in the frame for each pair of shears in a similar manner to the corresponding parts of a strong turning lathe (called headstock frame, with mandril and collar). The circular cutting wheel is fastened by bolts upon a chuck formed out of the protruding end of the axis. The frame for each pair of shears differs from the headstock of a lathe, inasmuch as that two such axes are mounted one above another in that frame, and the two circular cutting wheels on the protruding ends of those two axes meet together laterally with the circumference of one such wheel overlapping that of the other, in a suitable manner for operating together as a pair of circular shears for shearing the plate of metal, which is passed between the said meeting and overlapping circumferences of the two circular cutting wheels when the same are turned round both together. For that purpose spur pinions are applied upon the two axes with the teeth of the pinions gearing together. Those pinions are fitted upon the axes to which they belong, so as to be capable of sliding freely along those axes in the direction of their length, as far as the space within the frame will admit the axes having projecting fillets upon them, in order that the pinions may turn the axes round with them. The pair of circular cutting wheels upon the protruding ends of their axes enables the cutting edges of those wheels to shear as far within the outermost rough edges of the plates as the waste required to be sheared off from those edges. The strips of waste metal that are sheared off are received in horizontal grooved guides, which are affixed to the frames to prevent such strips from getting entangled. When such complete machine is to be used for shearing plates which have been rolled of double breadth, and dividing them into two plates at the same operation, then the third pair of revolving circular shears, already mentioned as having been rendered inoperative, must be put into proper condition for shearing. The two cutting wheels constituting that third pair are fastened on near the mid-lengths of two long axes, which are mounted horizontally one above the other between two standards which are fastened to the fixed bed plate and stand up therefrom, for sustaining the bearings for the ends of the two long axes, so that the two cutting wheels will act together as a pair of circular shears

adapted for cutting along the mid-breath of the double breadth plate. The said two cutting wheels are in place of the third pair of circular shears described and claimed (although not represented) in my former Specification; the two long axes for such third pair are there described as having the cutting wheels for the other two pair of circular shears fastened on them near their ends, so that all the six cutting wheels for the three pairs of circular shears are described as being on two axes. In the arrangement now describing, the two long axes have only one pair of circular shears thereon, and they are situated further along in the direction of the lengthway of the plate that is to be sheared than the two pairs of circular shears which are to cut along the two outermost edges of the same plate. When a double breadth plate is presented endway foremost to the two pair of circular shears, they begin both together to shear the two outermost edges of the plate at the foremost end, and after the plate has advanced some distance between the cutting edges of the two pairs (and they have sheared that distance along the two outermost edges of the plate), then the foremost ends will reach the third pair of circular shears, which will begin to shear along the mid-breadth of the plate. The six horizontal and parallel axes for the six circular cutting wheels of the three pairs of circular shears, are all compelled to turn round with a like velocity of motion by means of three pairs of equal spur pinions, one such pinion upon each of the six axes. The driving motion is communicated to the pairs of pinions from two other like spur pinions, which are fastened upon a horizontal driving axis and gear with the lowermost pinions of all the three pairs of shears, the driving axis being so situated that the two driving pinions thereon are intermediate between the lowermost pinions belonging to the two first pairs of shears for shearing the edges, and the lowermost pinions belonging to the third pair of shears for cutting along the mid-breath of the plate. In that manner the driving axis and pinions communicate motion to the whole of the machinery, being turned round by the power of the millwork, acting by wheel and pinion work and fast and loose pullies for an endless belt. The pinions belonging to the two pairs of shears, for the edges of the plates, are fitted upon their axes with fillets, as already stated, in order to avoid giving any lateral motion to those pinions when endway motion is given to their axes, but those pinions are always to be kept laterally in their proper places for gearing one with another in pairs and with the two driving pinions on the driving axes. Lateral adjustment is not required for the third pair of shears, because the lateral adjustments for the two first pairs are made independently one of the other, so that they can be adjusted to shear along the two outer edges of the broad plate at the required distances on each side of that middle part of

the plate where it will be sheared by the third pair. The two pairs of shears may be so adjusted laterally in respect to the third pair, and the place where they shear along the middle part of the broad plate, as to divide the same into two plates of unequal breadths if such are required. The machine will shear the two edges of each plate to parallel breadth from end to end, but in order to insure that the sheared edges shall be straight lines, the hindmost end of the plate, previous to presenting the foremost end to the two pair or three pair of circular shears) is fastened by a suitable clamping screw to a sliding carriage adapted to move horizontally along a groove, the hindmost end of the plate will be thereby retained, so that it cannot deviate from a straight line in the direction of the lengthway of the plate all the time, whilst the plate is moving along endway forwards through the two (or the three) pairs of circular shears, the cutting action of those shears being sufficient to draw the plate endways onwards after the shears have taken hold and began shearing along it. That sliding carriage may be loaded with weight to cause some resistance of friction, and thereby retard its motion along the groove, in order that the plate, having to overcome the said resistance and drag the carriage after it, may be kept extended during the shearing. Or, for greater certainty of cutting straight, another similar carriage and groove and clamping screw in that carriage (but without provision for causing friction to retard its motion) may be applied before the foremost end of the plate in addition to the aforesaid carriage and groove behind the hindmost end, the two grooves being in the same horizontal straight line like one long straight groove, and those two carriages are connected with the two ends of a long horizontal toothed rack, which is adapted to be moved along within the long groove by a pinion on a horizontal axis turned round by wheelwork from the driving axis. And when the two pairs or three pairs of revolving circular shears are in motion, the rack and two carriages will be moved, and will carry the plate endway forwards in the direction in which it is to advance through the circular shears; the foremost end of the plate being previously clamped to the foremost carriage and the hindmost end to the hindmost carriage, they will both concur in retaining the two ends of the plate to the required straight-line motion. The two carriages are connected with the rack by means of clamping screw bolts, which will permit of so connecting either of the carriages with almost any place along the length of the rack towards each end thereof, in order that the two carriages may be kept connected by intervention of the rack at a proper distance one from the other, to suit the length of the plate nearly; also the clamping screws, for holding the ends of the plate, should be fitted on the carriages to which

they belong by means of a slider and tightening screw for each carriage, so as to draw such slider and clamping screw forcibly endways in respect to the carriage in the direction of the lengthway of the plate, after its two ends have been fastened by the clamping screws to the sliders of the carriages. And by such tightening screws the plate can be kept forcibly extended in length and its two ends retained in the intended straight line, whilst it is carried endway forwards through the two or the three pairs of circular shears by the motion given to the two carriages by the rack. In case of thus holding the plate at both its ends, and keeping it extended whilst it is carried endway forward, the machine will require some kind of reversing motion work, such as is used in planing machines, and which may be applied to the wheel and pinion work, whereby the power of millwork is caused to turn the driving axis for giving motion to the whole of the machinery. With such reversing motion work the machine will operate with endway motion in contrary directions alternately, that is to say, after a plate has been carried endways in one direction through the machine, and been sheared from end to end, and after the motion has been stopped, then a fresh plate is put to the two carriages, and both its ends fastened thereto by their clamping screws, and its length extended by the tightening screws, the machinery being then put in motion in a contrary direction to that of the preceding endway motion, the fresh plate will be carried with endway motion in that contrary direction through the machine, in order that it may be sheared. The machine must be provided with self-acting parts (similar to planing machines) for stopping the machine as soon as the rack and the two carriages have moved somewhat more than the whole length of the plate, those self-acting parts being adjustable to suit the length of the plate; but such self-acting parts are merely to stop the motion of the machine, leaving it motionless, without recommencing the motion in a contrary direction; that must be done by the hand of the workman, after such pause as may be found requisite for removing the plate which has been sheared and replacing the same by a fresh plate. The importance of shearing the edges straight has been already mentioned; in fact the quantity of metal that must be removed by the planing depends materially upon the straighness wherewith the shearing can be performed, to a certainty of not exceeding the amount of crookedness that has been previously allowed for by anticipation in adjusting the circular shears. Any plates that are sheared crooked more than the amount so allowed for will be spoiled, and such allowance must be more or less according as it is found that the shearing can be performed with certainty of not being crooked beyond the amount previously allowed

for by anticipation. The less the quantity of metal that is to be removed from the edges of the plates by planing with the compound tools the greater the number of plates that may be planed with such tools before the cutting edges will require to be sharpened.

The second part of my present improvements relates to the mode described and claimed in my former Specification, of the First of November, One thousand eight hundred and forty-five, of turning up flat plates of metal to the form of tubes, by forcibly pressing such a flat plate into the hollow of a gutter-shaped mould by pressure with a suitably formed solid tool, and thereby bending the plate to the form of a gutter or trough with a concave bottom. For a first stage of the intended turning up, the bending of the two marginal portions of the plate adjacent to its two edges being thereby completed to the curvature of the intended form of the tube; and then, for a second stage, forcibly pressing the middle part of the said concave bottom by a suitable solid tool into the hollow of a semicylindrical mould of proper size for the intended form of tube, and during such pressing the two edges of the plate will be turned up and brought one towards the other (as near as they can go without touching the supporting part of the said solid tool) so as to bring the plate to an incomplete oval curvature; and then, for a third and last stage, compressing the said ovally bended plate between the two semicylindrical halves of a mould (the undermost of which halves may be the same semicylindrical mould before mentioned), which two halves, when they come together, will form a hollow cylindrical mould of the proper size for the exterior of the intended form of tube, and by very forcible compression between the said two halves of such mould the two edges of the plate are brought into close contact one with the other, and the turning up to the form of a tube is completed. The two edges of a plate which has been so turned up to form a tube will have acquired a strong tendency to spring together and keep in close contact, in consequence of the middle part of the concave bottom of the gutter that was formed at the first stage having been somewhat overbended at the second stage, that is, bended to the curvature of a rather smaller circle or cylinder than is ultimately required for the intended form of tube, but such overbended part became rebended at the third stage to the proper curvature, and the metal was set somewhat on a strain by the rebending, with a tendency to close the two edges nearer together than their contact will allow, and therefore they will not separate or quit contact after the final compressure is over, but a considerable force would be required for separating them from their contact, all which is described in my former Specification, where it is also

explained that the moulds are to be used in some kind of pressing machinery actuated by any kind of mechanical power commonly used in machinery for pressing or bending metals, and which power will be capable of exerting sufficient force of pressure for the purpose. And it is also explained that in case of only one pressing machine being provided for performing all the three stages of turning up, then the proper moulds required for performing each stage (the first stage for instance) must be put into such machinery, and a number of plates bended to the first stage with those moulds, bending one plate after another; then one (or both) of the said moulds must be removed from the pressing machinery, and another mould (or other moulds) put therein, in order to adapt it for performing the second stage of turning up upon the same plates which have already undergone the first stage, and, after they are all done, then in like manner one (or both) the moulds must be changed for another (or for others) adapted to perform the third stage upon the same plates which have already gone through the first and second stages; and it is stated that if there are three of the aforesaid pressing machines, then one of them, with the proper moulds, may be performing the first stage, another, with suitable moulds, the second stage, and the other pressing machine, with proper moulds, the third stage, whereby the trouble and loss of time that would be incurred by changing the moulds (as must be done if there is only one pressing machine) can be avoided. This second part of my present improvements is, for one thing, to apply a flat bar of iron horizontally along within the middle part of the hollow of the gutter-shaped mould wherein the first stage of turning up is to be performed, that flat bar extending all the length of the mould, and coming into operation during that first stage of the bending of a flat plate, which plate has been previously introduced into its proper place over the hollow of the mould, with the under surface of the plate close above the said flat bar (which was then at rest in its highest position within that hollow), and with the upper surface of the plate close beneath the solid upper tool by which the plate is to be bended into that hollow, and immediately after the bending action has commenced (by force of the pressing machinery) so that the solid upper tool has caused the middlemost part of the breadth of the plate to be bended a very little way towards the hollow of the mould, then the under surface of that middlemost part of the plate will be brought into contact with the upper surface of the flat bar along all the length thereof. That bar is not fixed, but is upheld in its resting position by reaction of several loaded levers, which will nevertheless permit the bar to give way before the plate as fast as the further bending thereof requires; but in the act of so giving way

the bar will exert a strong upheaving force beneath the middlemost part of the plate, in order to keep the plate firmly in contact with the undermost part of the solid upper tool, and thereby prevent any lateral deviation of the plate from its proper intended position within the hollow of the mould during all the time of bending it into that hollow. And this second part is also to form the hollow of the mould, wherein the first stage of the operation of turning up is to be performed, with two distinct moveable side-pieces, which are so applied as to form the sides of the hollow, but they are capable of moving laterally in the hollow, one towards the other, for a very small distance, and when the plate has been pressed into the hollow of the mould nearly (but not quite) as far as it is intended to enter therein, then those two moveable sides of the hollow are caused to approach one towards the other so much as will best assist in the bending of the two marginal portions of the plate to the curvature intended to be given to them at the first stage. And this second part is further to dispose all the several moulds and tools which are to be used for performing all the three stages of turning up, one such mould or tool above another, in the same pressing machinery, and in their proper relative positions for performing their respective stages, and all the moulds and tools are closed, one towards another, by the same motion of the pressing machinery, and every mould and tool having had a plate of metal previously put between them, the set of moulds and tools when so closed one towards another will perform all the three stages of turning up at once upon as many different plates, that is to say, one plate will be undergoing the first stage between the lowermost mould and tool, whilst another plate (which has previously gone through that first stage) will be undergoing the second stage between the next mould and tool above, and another plate (which has previously gone through the two first stages) will be undergoing the third and last stage between the uppermost pair of moulds. In that manner the bending of all the three stages will be performed at the same time and with the same pressing force, but with a suitable increase of the space through which that force is to act.

And this second part furthermore consists in forming the hollow of one of the semicylindrical halves of that pair of moulds which is used for the third stage with a small recess beyond its true cylindrical form, for the purpose of facilitating the meeting and contact of the two edges of the plate together, in cases when the plates are feather edged, and one of those edges is intended to overlap the other edge. The manner of performing this second part of my present improvements is represented in Sheets F, G, H, and I, of the Drawings: Sheets F and G being sections (drawn half the real size) of a complete set of moulds and tools for performing all the three stages, disposed one mould

and tool above another; Sheet F shewing them in the positions they assume before they are closed one towards another; and Sheet G shewing them after they have been so closed; and in Sheets H and I it is shewn how the said set of moulds can be applied in the pressing machinery for performing all the said three stages.

DESCRIPTION of the APPLICATION of a FLAT BAR WITHIN THE HOLLOW OF A MOULD, wherein the First Stage of Turning up is to be performed.

A, *d*, *d*, A, Sheets F and G, is the lowermost hollow mould, fastened by screw bolts upon the moveable follower S, T, V, of the pressing machinery, and B, B, is the solid upper tool disposed over the hollow, being suspended by screw bolts from the under side of the fixed end R, R, of the pressing machinery, the mould A, *d*, *d*, A, and tool B, B, being in suitable relative positions for commencing the first stage of bending the plate *a*, *b*, into the hollow *d*, *d*, of A, A. L is the aforesaid flat bar of iron, extending horizontally along the middle part of the hollow *d*, *d*, all the length thereof, and when the pressing machinery is relaxed, so as to stand with its follower S, T, V, and the mould A, *d*, *d*, A, at the lowest or resting position, as in Sheet F, then the uppermost surface of the bar L is on a level with the highest parts of the two sides *d*, *d*, of the hollow, and by that uppermost surface, as well as by those highest parts, the flat plate *a*, *b*, is supported, when it is slided endways into its proper place over the hollow *d*, *d*, and beneath the lowermost part of B, B. During such sliding in endways the two edges *a* and *b* are guided laterally between two fixed guiding rulers *t* and *t*, which are screwed upon the two sides of the mould A, A, in proper positions for so guiding the plate, and for ensuring that it will be afterwards retained in its proper place over the hollow *d*, *d*, without allowing any lateral deviation therefrom at the commencement of the bending of the plate *a*, *b*, into that hollow. The bar L is supported upon the uppermost ends of four vertical sliding rods M, see Sheet H, disposed at equal distances apart in the whole length of the moulds. The rods M are retained in their intended vertical positions by being fitted into holes through the moveable followers S, T, V, and the lower ends of M are fitted into holes in the base frame Q. The rods M can slide freely endways up and down in order to raise or lower the bar L, which is wholly supported on the upper ends of the four rods M. And a strong tendency to move endway upwards, and raise up the bar L, is given to those rods M by loaded levers K, two such levers to each rod M forming a pair of loaded levers, see Sheets F, H, and I. The centres of motion for all those eight levers K, are centre pins supported in forked joints at the lower ends of as many upright rods U, whereof the upper ends are fastened to the under sides of the followers S, T, V, and

descend therefrom. The innermost ends of the two levers, which form each pair of loaded levers K, K, enter side by side into a mortice hole through that one of the upright rods M to which the pair belong, and the outermost ends of the several levers K are loaded with heavy ball-shaped weights W, Sheets H and I, of cast iron, which, being fastened on the levers K at greater distances from their centres of motion than the distances from those centres to the upright-rods M, each pair of loaded levers K, K, operates with a force of leverage to raise their rod M endways upwards, and by the combined action of all the eight weights W, the bar L exerts a considerable upheaving force at all times, excepting so long as the followers S, T, V, and the mould A, A, are at the resting position, Sheet F, for then an adjustable stop nut on each rod M is in contact with the under side of the follower S, T, or V, and also the loaded ends W of the several levers K are resting upon suspending stops, which descend from the followers S, T, V, and so long as the stop nuts on the rods M are in contact with with the followers, the loaded ends W of all the levers K are resting on their stops, the bar L will be retained at its resting position, as in Sheet F, the upper surface of L being on a level with the highest parts of the two sides *d*, *d*, of the hollow of the mould A, A, and the lowermost part of B, B, so much above that level as to leave a sufficient space for the flat plate *a*, *b*, to be introduced endways into its place over the hollow of the mould. When the followers S, T, V, and the mould A, *d*, *d*, A, together with the plate *a*, *b*, resting on the uppermost parts of the sides *d*, *d*, and on the bar L, begin to move upwards in preparation for commencing the pressing action, then the plate *a*, *b*, is carried upwards upon *d* and *d*, and the bar L, until the upper surface of the plate is brought into contact with the lowermost part of B, B, and after that the two edges *a* and *b* of the plate continue to be carried upwards at the same time, whilst the mid-breadth part of the plate is kept down by B, B, consequently the plate becomes bended into the hollow *d*, *d*, of the mould. At the commencement of such bending the under surface of the mid-breadth part of the plate *a*, *b*, will be pressed upon the upper surface of the bar L, and the further bending of the plate *a*, *b*, into the hollow *d*, *d*, will cause the bar L to be pressed further into that hollow, whereby the loaded ends W of all the levers K will be raised up so as to take them off their stops (on which they have been previously resting); and then the force of leverage of all the eight weights W will become operative to upheave the bar L beneath the bended plate, for holding it securely in contact with the lowermost part of B, B, so as to prevent any lateral deviation of the plate *a*, *b*, from its intended position over the hollow of the mould *d*, *d*. The bar L will continue to do so during all the time of bending the plate completely into the

hollow *d*, *d*, of the mould, as appears in Sheet G, for completing the first stage of turning up. Sheet G shews that there is sufficient space at the bottom of the mould to admit the bar L. At the commencement and earliest period of the bending the edges of the two guiding rulers *t* and *t* will retain the plate *a*, *b*, securely in place, and prevent any lateral deviation therefrom, but as the bending goes on, and the edges of the plate *a*, *b*, quit the rulers *t*, *t*, (so that they can no longer act as retainers for the position of the plate laterally), the bar L comes into operation for holding the plate, and therefore it is always kept retained securely in its proper intended position over the hollow of the mould during all the progress of the first stage of turning up, from the beginning to the end thereof.

DESCRIPTION of the APPLICATION of TWO DISTINCT MOVEABLE SIDE PIECES *d* and *d*, to FORM THE HOLLOW OF THE MOULD A, *d*, *d*, A, wherein the First Stage of Turning up is to be performed.

That hollow is the space left between the two moveable side pieces *d* and *d*, Sheets F and G. They are lodged within the trough A, A, of the mould, to form a sort of lining thereto, touching the interior on the bottom near to the angles at *m* and *m*, and also touching the upright insides at about half the depth of the trough up those insides at *n*, *n*; but they do not touch the middle part of the flat bottom, being upheld by helically curled springs of steel *u*, *u*, which are lodged in holes through that bottom. The side pieces *d* and *d* thus lodged are not fastened in the trough A, A, but are retained in their positions, Sheet F, by pins *r*, *r*, which are screwed horizontally into *d* and *d*, and pass freely through holes in the upright sides of A, A, and nuts are screwed on the outer ends of *r*, *r*, with helically curled steel springs *s*, *s*, interposed in place of washers around the pins *r*, *r*, between the nuts and the outsides of A, A. Each side piece *d* and *d* has five such pins *r*, *r*, and curled springs disposed at equal distances apart in the whole length of the mould, see Sheet H; and the effort of all the springs *s* and *s* to draw the pins *r*, *r*, endways, retains the side pieces *d* and *d* in their positions, Sheet F, until the time when the bending of the plate *a*, *b*, is begun by pressure with the lowermost convex part of the solid tool B, B, to force the mid-breadth part of that plate into the hollow between the two sides *d*, *d*. The first commencement of such pressure is operative at the uppermost rounded parts of the inner edges of *d* and *d*, with some tendency to force those parts outwards one from the other, and they are at liberty to recede if that tendency prevails. And when the plate *a*, *b*, is bended so far into the hollow as to come into contact with the lower part thereof at the innermost parts of the two side pieces *d* and *d*, then the further

continuance of the bending of the plate *a*, *b*, will cause those two side pieces *d* and *d* to move within the trough A, A, so as to approach their uppermost parts one towards the other a very small distance, and thereby complete the bending of the two marginal portions of the plate *a*, *b*, to the curvature that is intended to be given to those portions at the first stage. The motion of the two side pieces *d* and *d*, within the trough A, A, is limited by their lowermost and innermost edges coming in contact with the flat bottom of the trough A, A; and when that is the case, the uppermost rounded parts of the inner edges of *d* and *d* will have completed the intended bending of the two marginal portions of the plate. The two sides of the upper tool B, B, may be slightly hollowed out at the parts where each of the extreme edges *a* and *b* of the plate will then be opposite, in order to avoid hard pinching of the metal at those extreme edges, in case of any small excess in the thickness of the plate beyond the regular thickness that it is intended to have, but which regular thickness cannot always be insured owing to irregularities in rolling the plates in the first instance.

DESCRIPTION of the DISPOSITION of ALL the MOULDS and TOOLS constituting a complete set thereof for performing all the Three Stages of the Turning up One Mould above another in the Pressing Machinery.

The solid upper tool B, B, has been herein-before stated to be suspended by screw bolts to the under side of the fixed head R, R, of the pressing machinery (and although it might be so if the upper side of B, B, were flat), nevertheless, it is represented in Sheets F and G, that the solid tool B, B, carries another tool D on its uppermost part to correspond to the hollow E in the under part of the mould E, Y, for the performance of the second stage of turning up between D and E. The mould E, Y, as well as having the hollow E formed along its undermost part, also has the lower semicylindrical half mould Y', formed along its uppermost part to correspond to the upper semicylindrical half mould X for the performance of the third stage of turning up between the said two halves X and Y, so that the complete set of moulds and tools which are disposed over over another, as in Sheets F and G, consists of four principal long pieces of cast iron, in which the aforesaid moulds and tools are formed, see also Sheets H and I. The lowermost piece A, *d*, *d*, A, is fastened by screw bolts and nuts upon the upper surfaces of the three followers S, T, V, as already mentioned. There are six such bolts on each side of A, A; they pass down through ears which project from the outsides of A, A, and nuts are screwed on the bolts beneath the followers S, T, V. The next piece B, B, D, has the solid upper tool B, B, formed out of its lowermost part for performing

the first stage of turning up between A, *d*, *d*, A, and B, B, but B, B, also carries the solid tool D on its uppermost part. D might be one piece with B, B, if it were not more convenient to make D in a separate piece, and fasten it by screws into a groove in B, B, so as to unite them firmly together like one piece B, B, D. The next piece E, Y, has the hollow mould E formed along its undermost part to correspond to the solid tool D for performing the second stage of turning up, and the same piece E, Y, has the semicylindrical half mould Y formed along its uppermost part. The uppermost X of the four pieces has the corresponding semicylindrical half mould X formed along its under part, and the two halves X and Y, when closed together, as in Sheet G, form between them the hollow cylindrical mould of the same size as the exterior of the intended form of tube that is to be produced by the turning up. In that cylindrical mould X, Y, the third stage of turning up is to be performed. The uppermost piece X is applied beneath the flat under surface of the fixed head R, R, of the pressing machinery, and is suspended by eight screw bolts in close contact with that flat surface. Those bolts pass through lugs which project out laterally from each side of X, four such bolts at each side; and nuts are screwed on the bolts above the upper side of the fixed head R, R. The lowermost A, A, of the four pieces is thus fastened to the follower S, T, V, and the uppermost X to the head R, R, of the pressing machinery, by bolts and nuts through the lugs, so that the moulds will be exactly over one another. The two intermediate pieces B, B, D, and E, Y, are suspended from the head R, R, at suitable heights by vertical screw bolts, having eyes at their lower ends to admit screw pins which are tapped horizontally into the sides of each of those pieces. There are two such screw pins and eye bolts at each side of each piece B, B, D, and E, Y, see Sheet H. The upper ends of the eight bolts pass up through the head R, R, with double nuts screwed on the upper end of each bolt above the head; and those double nuts are so adjusted, that when they are stopped above the head R, R, they will suspend the weight of the two pieces B, B, D, and E, Y, at the respective heights shewn in Sheet F; nevertheless, the eight eye bolts will not prevent those two pieces from ascending when they are lifted upwards during the pressing and bending actions, for the said bolts will then slide endways upwards in their holes through the head R, R. To retain the two pieces B, B, D, and E, Y, to a vertical motion when they are so lifted up, six vertical guide pieces *k*, *k*, are firmly fastened by screws to each side of the piece E, Y, at each end and at the mid-length thereof, see Sheet H; the upper ends of *k*, *k*, applying to the two sides of the uppermost fixed piece X, and the lower ends of *k*, *k*, apply to the two sides of the piece B, B, D, so as to prevent lateral

deviation, but permitting of free motion vertically. The outsides of the lower ends of four of the said vertical guide pieces *k*, *k*, at the end of the piece of E, Y, are included between the vertical inner edges of four strong brackets J, J, two at each end, which are firmly fastened by screw bolts and nuts upon the follower S, T, V, so as to stand up therefrom. By means of the guiding pieces *k*, *k*, and brackets J, J, it is ensured that the several pieces of which the set of moulds consists will always be retained exactly over one another. When the follower S, T, V, and the lowermost piece A, *d*, *d*, A, of the set, are down at their resting position, Sheet F, then the two intermediate pieces B, B, D, and E, Y, will become suspended by their eye bolts *x* and *y* at the heights there represented, suitably for the plates of metal which are to be bended and turned up to be introduced into their places between the several moulds and tools, as they appear in Sheet F. After that, when the followers S, T, V, and piece A, *d*, *d*, A, are raised upwards, the several pieces of the set of moulds and tools will approach one towards the other, for commencing the bending operations on those plates; namely, the lowermost piece A, *d*, *d*, A, will approach towards the piece B, B, D, for commencing the first stage of the bending on a flat plate *a*, *b*; also the piece B, B, D, will approach towards the piece E, Y, for commencing the second stage on a plate which has been previously bended to the first stage; likewise, the piece E, Y, will approach towards the uppermost piece X for commencing the third stage upon a plate which has been previously bended to the second stage. When the several pieces of the moulds and tools approach each other as aforesaid, the guiding pieces *k*, *k*, and brackets J, J, ensure that all the said pieces will preserve their intended relative positions without lateral deviation. After the pressure of the pressing machinery is relaxed, and the followers S, T, V, and piece A, *d*, *d*, A, have descended again to the lowest position, Sheet F, then the three plates, which have been recently bended, are to be withdrawn, and others put into their places; that is to say, the uppermost is to be withdrawn endways from between the two semicylindrical half moulds X and Y, and is to be removed from the machinery as finished, because that plate will have been completely turned up to the intended form of a cylindrical tube, with the two edges of the plate in very close contact one edge with the other. The next lowest bended plate is to be withdrawn endways from beneath the hollow E, and off from the upper part of the solid tool D, over which it will remain hanging, having been bended to the second stage of an imperfect oval; and that plate, after being inverted, is then to be returned endways into the space between X and Y, with the open part of the oval upwards. The lowest bended plate is in like manner to be withdrawn endways from the hollow *d*, *d*, of the

mould A, *d*, *d*, A, where it will be lying, having been bended to the first stage of a gutter shape; and that plate, after being inverted, is to be returned endways into the space between E and D, with the inverted gutter hanging on the uppermost part of D.

Lastly, a fresh flat plate, with its two edges prepared, is to be introduced endways into the space between the two fixed guiding edges *t* and *t*, and beneath the lowermost part of B, B, and above the upper side of the flat bar L, in manner herein-before described. The three plates will then be in their proper places as in Sheet F. In order to expedite the operations of withdrawing and returning the plates, the attendants who are to perform those operations on the two uppermost plates may be doing so at opposite ends of the moulds at the same time, with motion in contrary directions, without interfering one with the other. The set of moulds and tools being charged with the three plates, as in Sheet D, are ready to begin bending by the gradual raising up motion of the followers S, T, V, and lowermost piece A, *d*, *d*, A. The first contact that will take place in consequence of such raising motion will be between the uppermost surface of the flat plate *a*, *b*, and the lowermost part of B, B, that contact operating with a tendency to bend the flat plate *a*, *b*, into the hollow *d*, *d*, beneath it. At present there is only the weight of the piece B, B, to keep it down, and therefore the bending will begin very easily, and will not proceed far until the resistance of the flat plate to such bending will begin to lift up the piece B, B, D, and that will cause another contact to take place between the middle part of the upper surface of the inverted gutter (that is hanging on D) and the two edges of the hollow E above the said upper surface, with a tendency to bend the gutter in between the two edges of E; but as there is only the weight of the piece E, Y, to keep it down, the tendency to such bending of the plate will begin very easily, and cannot proceed far before the piece E, Y, will be lifted up, and that will cause a third contact to take place between the upper concavity of the semi-cylindrical hollow in X, and the two edges of the incomplete oval bended plate, which is lodged in the hollow Y. The three contacts having been so produced, then the effective bending operation commences, and as fast as the ascending motion of the followers S, T, V, and piece A, *d*, *d*, A, proceeds to the bending operations, proceed on all the aforesaid three plates at the same time, for bending each one to that stage to which it is intended to be bended; namely, the lowermost flat plate *a*, *b*, is bended at its mid-breadth until its under surface presses the bar L farther into the hollow, and although the bar L yields to such pressure, yet by reaction of its loaded levers K, W, it bears the plate upwards beneath the

undermost part of B, B, with the united upheaving force of all the eight loaded levers K, W, so as to prevent any lateral deviation of the plate from its true intended position over the hollow *d*, *d*, during all the time whilst the plate is in the act of being pressed into the hollow *d*, *d*. The mid-breadth part of the bended plate assumes the easy curvature of the convexity of B, B, but the two marginal portions of the plate adjacent to the two edges *a* and *b* take their curvature from the concavities of the two moveable side pieces *d* and *d*. When the bending has proceeded so far that the lowest convex part of the bended plate comes in contact with those two inner edges of the side pieces *d*, *d*, which are at the bottom of the hollow of the mould, then the further continuance of the bending will cause the two side pieces *d* and *d* to move within the trough A, A, so as to approach their uppermost part, one towards the other, a very small distance, and thereby complete the bending of the two marginal portions to the intended curvature of the form of tube that is ultimately to be produced by the turning up, when the undermost parts of the two side pieces *d* and *d* are in contact with the flat bottom of the trough A, A. After that, those two side pieces become firm supporters to the convex part of the plate which has been bended to conformity with the under part of B, B, and the plate becoming a support to B, B, D, the latter is enabled to transmit the upward motion and pressing force of the follower S, T, V, in order that the upper part of D may begin to press the middle part of the inverted gutter into the hollow E, that is above D, so as to bend the middle part of the gutter further, and change it from its said gutter shape, so that of the third stage of incomplete oval curvature, that form being derived from the upper part of the solid tool D, which is a semicylindrical form of smaller radius or diameter than the interior of the form of tube which is ultimately to be produced by the turning up. When the middle part of the plate has been so pressed into the hollow E, as far as to cause that part of the plate to bend and wrap over the upper semicylindrical part of D, and thereby to assume the small sized semicylindrical form of that part), then the two edges of the bended plate will have become approached one edge towards the other edge as near as they can do, to avoid touching the then upright supporting part of D. The bending will become completed to the second stage of incomplete oval curvature as soon as the horizontal border edges of the two pieces B, B, D, and E, Y, of the mould have come into contact, which they are adapted to do and fit one to another. By such contact the further upward motion and pressing force of the follower S, T, V, is transmitted to the semicylindrical half mould Y, in order to compress the uppermost of the three bended plates, which is the state of incomplete

oval curvature, and is lodged between the pair of semicylindrical half moulds X and Y. By such compressure between X and Y, the two edges of the oval curvature become closed together until they meet in contact edge to edge, in order to produce the required form of a tube. When the border edges of the two semicylindrical half moulds X and Y meet together, then the third and last stage of the turning up is completed. It has been already stated respecting the bending, that the middle part of the plate has undergone at the second stage by wrapping over the upper semicylindrical part of the solid tool D, as already described, that such middle part is over bended, that is to say, it is bended to a smaller radius or diameter than that of the ultimate form of tube. It is now to be observed, that after the two edges have been brought into contact between the two half moulds X and Y, as in Sheet G, then the further continuance of the pressing force being very powerful, will cause the bended plate to apply itself closely to the interior of the cylindrical hollow that is left between the two half moulds X and Y; and in consequence of the bended plate being compelled by great force of compressure to apply all around that interior so as to completely fill up the said hollow, the part which was overbended to a smaller diameter as aforesaid will become rebended to the true intended and larger curvature of the intended form of tube. It is in consequence of such overbending at the second stage, and then rebending at the third stage, that the two edges of the bended plate, after having been brought into contact in the form of a tube, acquire a tendency to spring together, and keep in close contact, as is fully described in my former Specification, and has been herein-before partly recited therefrom. Although the three stages of the bending operation have been described as taking place in succession one stage after another, that is to be understood as a mode of describing each stage distinctly; but the bending to one stage will not be completed before the bending for another stage commences, so that the bending for more than one stage will be going on at the same time, and the whole of the pressing operation is performed in a very short time. The greatest force of pressure must be exerted near to and at the final conclusion of each stage of the bending, and the pressing machinery being adapted for exerting that greatest force, its motion will not be materially retarded by the resistance of the bending at the commencement and during the early part of the progress of the bending, but such resistance increases with that progress, so that the motion of the pressing machinery will at last be stopped in the position, Sheet G, and then its greatest force will be exerted for the final completion of the bending to each of the three stages. As soon as the greatest force of the pressing machinery has been so exerted, (as is

shewn by its motion becoming stopped), then the pressing force is to be discontinued and the pressure relaxed. The weight of the moving parts and of the set of moulds will cause the return with a descending motion to the resting position, Sheet F. During such descending motion the double nuts at the upper ends of the vertical eye bolts X and Y, belonging to the pieces E, Y, and B, B, D, will come to rest above the head R, R, so as to keep those pieces suspended in the proper relative position, as in Sheet F. And then the three bended plates are removed, and changed, or transferred as already described, namely, the uppermost of the three, which has been completely bended to the third stage, and turned up to the intended form of a tube, is withdrawn from between X and Y, and carried away from the machinery as finished. The middlemost of the three, which has been bended to the second stage of incomplete oval curvature, is withdrawn from off D, and is immediately returned between X and Y, with the two edges of the bended plate upwards. The lowermost of the three, which has been bended to the first stage of gutter form, is then withdrawn (it may be so withdrawn at the same time whilst the middlemost is withdrawing, but with a contrary direction of endway motion), and the gutter being inverted, is returned between D and E so as to hang upon D, with the edges downwards. A fresh flat plate *a*, *b*, is then introduced between *d*, *d*, and B, B, with its two edges *a* and *b* between *t* and *t*. The set of moulds being thus charged anew with three plates, as shewn in Sheet F, is ready to begin bending those three by repetition of the action of the pressing machinery in the same manner as three preceding plates were bended. One tube completely turned up is withdrawn from the set of moulds at every ascending and descending movement of the followers S, T, V, of the pressing machinery, as the amount of work performed thereby. When it is required to turn up tubes of a larger or a smaller diameter than the set of moulds and tools are adapted for, then that set must be removed from the pressing machinery and replaced by another set adapted to turn up the size required; the same screw bolts will serve to fasten or suspend the several pieces of any set of moulds which may be adapted to be worked in the same pressing machinery. A set of moulds being of considerable weight, the removal and replaceing thereof may be facilitated by aid of some suitable kind of wind-up tackle of pullies and wheelwork, mounted on a four-wheeled railway carriage, which runs along two parallel horizontal rails disposed over the pressing machinery, and in the direction of the lengthway thereof, the said rails being fastened upon long beams of timber which are supported horizontally by suitable framework, in the well known manner of the travelling cranes commonly used of late years in the erection of stone buildings,

and in the fitting together of the metal part of large steam engines or other heavy machinery. The railway carriage for such purpose may contain a horizontal roller with a spur wheel on one end of it, to be turned by a small pinion having winch handles on the two ends of its axis, for men to turn it round, and thereby turn the said roller with a slow motion so as to wind up a chain around the roller, that chain being the tackle fall of a pair of double or treble sheave pulley blocks, whereof the uppermost block is fastened to the framework of the carriage at the highest part thereof, above its wheels, and the lowermost block depending by the chain has a strong hook for suspending the set of moulds by a suitable sling. After withdrawing the fastening bolts the whole set of moulds is slided endways along the surface of the follower rather more than half their length, so that the sling can be got round the whole set at the mid-length thereof, and hoisted up by the hook of the lower pulley block until the weight of the whole set of moulds becomes suspended from the railway carriage, which being then wheeled along the railway, will carry away the set of moulds to the place where they are to be deposited, and from whence another set is to be brought to the pressing machinery. The vertical guiding pieces *k*, *k*, are always kept fastened by their screws to the piece E, Y, of the set of moulds, in order to retain the several pieces of the set in due place, one piece above the other, whilst they are in the act of being removed and changed as aforesaid.

Respecting the Recess herein-before mentioned as being formed within the Hollow of the Semicylindrical Half Moulds X or Y for Turning up Plates which have been prepared with two feathered edges and one such edge is to overlap the other.

Such a recess is represented at *w* in the section Figure X, Y, Sheet G, wherein the two half moulds Y and X are closed together, with their border edges in contact, as they will be when they are completing the third stage of turning up; when so in contact the hollow left between the two half moulds is cylindrical, and the recess *w* is cut away in the hollow of the upper half mould X all the length thereof beyond the interior of the semi-cylindrical form of that hollow, in order to leave space for that one of the feather edges of the plate which is intended to overlap the other feathered edge. When the feather edged plate is in the state of incomplete oval curvature, to which it has been brought by the second stage of bending between D and E, and after it has been withdrawn endways from between D and E, and then inverted and returned endways into the space between X and Y, as already described, (but that description does not refer to feather

edged plates), then, in the case now describing, that one of its feather edges which is to be the outermost, and is to overlap the other feathered edge, is placed beneath the said recess *w*, in the upper half mould X, in order that when the further bending of the bended plate commences between Y and X, that the said outermost feather edge which is beneath the said recess W may have space to receive it without being pressed closed into the cylindrical form as the other or innermost feather edge must be; consequently, when the approach of Y towards X, and the further bending thereby produced, has brought the two feather edges near together, but before actual contact, the innermost edge will be sure to pass clear beneath the outermost; in other words, the latter cannot fail to become the overlapping edge when the two feather edges are brought into contact, and the bending is completed to the third stage, and the border edges of X and Y come into contact, as in Figure X, Y. In the form of tube thus turned up the outermost or overlapping feather edge will be prominent beyond a cylindrical form as much as the aforesaid recess *w* has been cut away beyond the semi-cylindrical form in the hollow of X. If that prominence is thought objectionable it may be pressed into conformity with the cylindrical form, or nearly so, by relaxing the pressure and lowering the follower with the pieces A, A, B, B, and Y, of the set of moulds, until the newly turned up tube is left at liberty between Y and X, then turning that tube so far round about its own horizontal central line as will remove the prominent overlapping edge away from beneath the recess *w*, and carry that edge beneath a different part of the hollow in X, where that hollow is conformable to the cylindrical form; after that, the pressure being repeated, it will operate upon the prominent overlapping edge to press the same into conformity with the cylindrical form, or nearly so.

The turning up of plates with overlapping edges is most suitable for the case of preparing iron tubes which are afterwards to be welded, and then the prominence of the overlapping edge may not be thought objectionable, because it will be pressed into conformity with the cylindrical form (or as near thereto as may be required) by the pressure to which the overlapping and overlapped edges must necessarily be subjected in the subsequent operation of welding them together. The mode of overbending the plate during the second stage of turning up, and the subsequent rebending of the overbended part during the third stage, in order to give the edges of the turned up tube a tendency to keep forcibly in close contact, is not applicable (or only in a very slight degree) to the case now describing of using the recess *w* for overlapping further edges, because the innermost of such edges

would slide within the outermost edge on the application of the requisite force of compressure between Y and X for rebending. The semicylindrical upper part of the solid tool D, instead of being a smaller diameter than that of the interior of the intended form of tube, as herein-before described, should, for the case now describing, be very nearly the full diameter of that interior. The tendency of the edges to keep forcibly in close contact is not of much consequence in the case of turning up iron in preparation for being welded. In case it should be desired to give such a tendency to turned up tubes with overlapping feather edges, then the rebending requisite for that purpose may be effected by aid of a solid tool, called a mandril, introduced into the interior of the turned-up tube before it undergoes the repetition of compressure betwen Y and X, such mandril will prevent the innermost of the feather edges from sliding within the outermost edge during such repetition of compressure; that is to say, the plate with feather edges having been somewhat overbended between D and E during the second stage, and afterwards introduced between Y and X, with the outermost feather edge beneath the recess *w*, and then the turning up being completed to the third stage, a form of tube is obtained having some prominence of the overlapping edge as aforesaid, but the overbended part will not have been yet rebended, and after the pressure has been relaxed and the newly turned up tube turned round in the hollow of X, so as to remove its prominent overlapping edge from beneath the recess *w*, as already described, then the mandril is to be inserted endway into the interior hollow of the newly turned up tube whilst the same is laying in the hollow of Y, in order that the upper part of the mandril may afford internal support to the underlapping feather edge during the repetition of the compressure between Y and X, the under part of the mandril applying to the interior of the part which requires rebending. With the aid of such an internal support the repetition of the compressure will cause the rebending of the previously overbended part, because the upper part of the mandril will prevent the innermost feather edge from yielding upwards when the outermost edge is pressed forcibly upon it, and the rebending will be greatly facilitated by the contact of the lower part of the mandril against the part which is to be rebended. That lower part of the mandril is formed to the curvature that is to be obtained after the rebending. When a mandril is to be used, the recess *w* should be somewhat different from what is represented in Figure X, Y, which is as it should be in case of no mandril being used. The recess *w* should be so newhat farther away from the highest part or vertex of the hollow in X, in order that the outermost overlapping edge may be brought beneath that vertex when the tube has

been turned round in the hollow of X, in preparation for the repetition of the compressure between Y and X. It is necessary, for the above action of the mandril, that it should be of the full diameter of the interior of the form of a tube intended to be turned up, but as it would be difficult to introduce the full size mandril, it should be contracted when it is to be introduced, and after having been introduced, it should be expanded to its full intended diameter. For this purpose the mandril should be composed of two long wedge-like pieces, reversed one to the other, and fitted to slide one upon the other. Such wedge pieces being moved one in respect to the other in the direction of their thickest ends foremost, then the mandril will become contracted in its diameter so as to be easily introduced into the interior of the recently turned up tube; but after having been so introduced, then by moving one of the said wedge pieces in respect to the other in the direction of the thinnest ends foremost, the mandril will become expanded to the full intended diameter of the interior of the tube so as to fit tight therein. The requisite endway motion of the long wedge-like pieces, one in respect to the other, may be communicated by a long screw, formed on the end of one of them, and received through an eye formed on the end of the other, with nuts on that screw at each side of such eye. By turning those nuts the mandril can be contracted or can be forcibly expanded until the further relative motion of the wedge-like pieces is arrested by some suitable stop, and then the mandril will be of the exact diameter of the interior of the intended form of tube. It is not necessary for the mandril to be a complete cylinder, because the internal support that it is to afford is not required beyond one twelfth part of the circumference at the highest part or vertex of the semicylindrical hollow in X, and as much diametrically opposite or at the lowest part of the hollow in Y. Each of those highest and lowest parts of the mandril must conform to the required cylindrical form, but the mandril may be flat at each side, the two flat sides being parallel vertical planes, and those vertical sides may be included between two plates, fastened by cross bolts to one of the wedge-like pieces, so as to retain them laterally in place one above the other. A section of such a mandril is given at the lower part of Sheet G.

The third part of my present improvements relates to a mode of applying the force of steam pressure for actuating pressing machinery which is of the kind commonly known as hydrostatic or hydro-mechanical. Such pressing machinery is represented in Sheets F and H (although not herein-before particularly described), as the means of actuating hollow moulds and tools between which flat plates of metal are to be bended and turned up to the

form of tubes; but this third part is also applicable for other purposes where pressure is required. In my former Specification, of the First of November, One thousand eight hundred and forty-five, a hydro-mechanical hydrostatic press is described, by way of an example of one kind of pressing machinery, which may be used for the purpose of bending or turning up flat plates of metal to the form of tubes, by using suitable hollow moulds and tools in such pressing machinery; and three hydrostatic cylinders are described as combined into one press, for acting in concert, to produce like pressure along every part of the length of the long hollow moulds and tools. The hydro-mechanical press now to be described also contains three hydrostatic cylinders, combined in a very similar manner to what is described in my said former Specification, excepting as to the use of a forcing pump with valves for injecting water through a conveyance pipe with branches to each of those three cylinders; but such forcing pump with valves being as usual in hydrostatic presses, is not minutely described in my said former Specification, although it is mentioned that such pump may be worked by power of a steam engine or other power, a loaded safety valve being applied to some part of the pump or of the conveyance pipe, in order to limit the pressing force by permitting the escape of all surplus water into the open air, in case of the pump being continued to be worked by the steam or other power, after the intended amount of pressing force has been exerted. Instead of a forcing pump with valves for injecting water into the hydrostatic cylinders, by repeated strokes of such pump, this third part of my improvements is, to use water cylinders without valves, fitted with water pistons or plungers, which are suitably connected with large steam pistons fitted into corresponding steam cylinders. And when high-pressure steam is admitted from a boiler into such steam cylinders, so as to impel the said large steam pistons to move therein, then the said water pistons or plungers being at the same time moved in their water cylinders, water will be forced out therefrom through communicating pipes with branches (but no valves), and injected into the hydrostatic cylinders in sufficient quantity for producing the required extent of forcible motion of the rams and followers of the pressing machinery at one stroke of the steam pistons in their steam cylinders, and consequently one stroke of the water pistons or plungers in their water cylinders. And after the said forcible motion of the rams and followers has been so exerted, then the further influx of high-pressure steam from the boiler to the steam cylinders is stopped, and that steam which has been admitted is allowed to escape from the steam cylinders into the open air (or into a condenser), and by the reaction of counterweights, which are applied to the

steam pistons and to the water pistons or plungers, a returning motion of the said moving parts will take place as fast as the steam makes its escape, and also the aforesaid quantity of water will return from the hydrostatic cylinders, through the communicating pipes and branches, into the water cylinders, there being no valves to prevent such return; but there is at all times an open communication through those pipes between the water cylinders and the hydrostatic cylinders. By this third part the forcible motion of the hydro-mechanical pressing machinery is exerted by effort of steam power with promptitude and facility, by merely admitting high-pressure steam into the steam cylinders, and afterwards the pressure is relaxed with equal promptitude and facility by allowing that steam to escape; the force that will be exerted by the steam depending conjointly on the size and the number of the steam pistons, and the pressure of the steam by which they are impelled, that force being augmented hydro-mechanically in the proportion that exists between the united areas of the rams of the pressing machinery and the united areas of the water pistons or plungers. The extent of motion of the rams in their hydrostatic cylinders is less in the same proportion as the force is so augmented hydro-mechanically. The manner of performing this third part of my improvement, as regards the application thereof to manufacturing metal tubes, is represented in Sheets H, I, and J, of the Drawings. Sheet H contains a side elevation, and a corresponding horizonal plan of the hydro-mechanical pressing machinery, with moulds and tools therein, those moulds and tools having been already described. Sheet I contains a corresponding end elevation, together with a section of one of the steam cylinders fitted with its piston, and one of the water cylinders fitted with its water plunger. And Sheet J contains a lateral elevation, and a corresponding end elevation, of all the three steam cylinders and water cylinders, with counter-weights applied for producing the returning motion of the steam pistons and water plungers. The three hydrostatic cylinders, which are marked N, O, P, are lodged in a very strong horizontal frame Q, Q, to which upright pillars *v*, *v*, are firmly fastened at their ower ends, and the upper ends of the same pillars *v*, *v*, are in like manner fastened to the upper horizontal part or head of the press R, R. Each of the cylinders N, O, P, has a solid plunger *r* (commonly called the ram of the press) fitted into it, with a collar of leather applied for close fitting around the ram *r*, within a circular groove inside of the upper end of each cylinder N, O, P, and a strong plate, called a follower, is fitted on the upper end of each of the three rams *r*, as at S, T, V, and upon these three followers the lower mould A, A, is laid and fastened by screw bolts. The conveyance pipe by which water is injected into the cylinders N, O, P, communicates equally by

branches with all three of them, in order that the whole quantity of the water that is injected may distribute itself equally amongst the three cylinders, and then the three rams *r* thereof will be forced up with equal force and with equal motion, because they are all three precisely of the same diameter (namely thirteen inches), and they all act by their followers S, T, V, beneath the lower hollow mould A, A, at equal distances apart along the length thereof, and the resistance opposed by the plate to the bending and turning up between the moulds and tools) will be equally operative at all parts of the length of the mould A, A. And thus far the hydro-mechanical and pressing machinery is precisely the same as is described in my said former Specification. And the manner whereby the several moulds and tools are applied and used in the said pressing machinery has been herein-before described in reference to Sheets F, G, and H, as belonging to the second part of my present improvements.

DESCRIPTION of the STEAM CYLINDERS with their PISTONS, and the WATER CYLINDERS with their PLUNGERS, according to this third part of my present improvements.

C, C, C, are three steam cylinders, like those of a steam engine; they stand side by side on a strong base T, T, as appears in Sheet J, and have pistons filled into each of them, as shewn by F, in Sheet I. Each piston has two piston rods *p* and *p*, Sheet J, passing up through stuffing boxes *b*, *b*, in the cylinder cover *l*, at opposite sides of the centre thereof, that centre being occupied by the water cylinder H, which has the water plunger G fitted into it, with a collar of leathers within a groove at the upper part of H, to fit close around the plunger G, and prevent the escape of any water, although the plunger moves freely up and down through that collar, being connected with the two piston rods *p* and *p*, by a cross head *q*, Sheet I. When high-pressure steam is admitted from a suitable boiler into the upper end of each steam cylinder C, it operates between the cover *l* and upper side of the piston F to impel the piston downward in the cylinder C, and by the connection through the two piston rods *p* and *p*, and cross head *q*, the water plunger G is caused to accompany the piston F in all its motions, so that the plunger G is forced downward into the water cylinder H, when the piston F is impelled downwards by the steam in the cylinder C. The lower end of the cylinder C is in communication with the open air through the eduction pipe *h*, which is always open, and leads to the base of the chimney for the steam boiler. The water plunger G, being forced downward into the water cylinder H, water is expelled from H, which, at its lower part, is connected, as is shewn in Sheet I, by a water pipe *w*, with the hydrostatic cylinder N, O, or P, of the pressing

machinery, that water pipe *w* being always open without any valves or cocks that can obstruct the free passage of water, either from H to N, O, or P, when the steam piston F and water plunger G descend, or the same water to return in a contrary direction, from N, O, or P to H, when F and G ascend, so that there is always a free water communication between the water contained in the water cylinder H and in the hydrostatic cylinder N, O, or P; consequently, when water is expelled from H, as aforesaid, by the descent of G, that water passes through the pipe *w* into N, O, or P, and produces an ascending and forcible motion of the ram *r* of the pressing machinery, the force of that ascending motion being greater than the force wherewith the plunger G is forced downward into H, in the same proportion as the area of the ram *r* exceeds the area of the plunger G. The high-pressure steam is conveyed from the boiler through the steam pipe Z, and by branches thereof into the valve box *g*, containing a sliding valve *i* (see Sheet I), for admitting steam into the upper end of the cylinder C, when that valve *i* is slided downwards in its box *g*, or for permitting the escape of the same steam when the valve *i* is slided upwards in its box *g*. Such motions of the valve are communicated to it by an upright valve rod *o*, which passes down through a stuffing box at the bottom of the box *g*, and the lower end of *o* is jointed to the end of a lever arm which projects out from a horizontal rocking axis I, and a long upright lever on the end of that axis I is connected by a long rod *z*, with a short lever arm *c* on the same axis with the working lever handle *j*, shewn dotted in Sheet I. The action of the pressing machinery is commanded by means of that working handle *j*, which an attendant moves with his hand whilst the handle *j* is in a horizontal position, as appears dotted in Sheet I. The machinery will remain at rest, with all parts in the positions there represented, the steam valve *i* being then at the midway of its sliding motion, and closing the steam entrance from the box *g* into the upper end of the cylinder C. When the handle *j* is raised up by the attendant above horizontal, it causes the valve *i* to descend in its box *g*, so as to permit steam to enter above the upper end of the valve into the upper end of the cylinder C, and thereby produce the descent of the piston F and of the water plunger G, and the consequent ascent of the ram *r*, for exerting the hydro-mechanical pressure by the pressing machinery; and then, if the handle *j* is put down by the attendant below the horizontal, it causes the valve *i* to ascend in its box *g*, so as to bring the hollow within the valve *i* into communication with the entrance into the upper end of the cylinder, and permit the steam to make its escape therefrom into the open air, because that hollow within the valve is always in communication with the side pipe *f* leading to the lower end of the cylinder C, which end, (as already men-

tioned) is always open to the eduction pipe *h*. As the steam escapes from the upper end of the cylinder, the piston F is drawn up therein, and the water plunger G is drawn up within the water cylinder H, by the reaction of counter-weights, which may be applied, as shewn in Sheet J, by chains fastened to the cross head *q*, and passing up over pullies X 1, have the counter-weights X 2 appended to the lower ends of those chains. Those counter-weights come to rest upon fixed beams between each counter-weight, and thereby limit the height to which the piston F can be drawn up towards the cover *l* of the cylinder, when at the resting position. The collective quantity of water then contained within the water cylinder H and water pipe *w*, and hydrostatic cylinder P, must be so much as will allow the ram *r* to descend within P, until it comes to rest, with all parts of the pressing machinery, in the position, Sheet F. And a small injecting force pump of the usual kind, with valves, as commonly applied to hydro-mechanical presses, should have its forcing pipe connected with some part or branch of the water pipe *w*, in order, by means of such pump, to augment the said collective quantity of water, in case it may be requisite for adjusting the resting position of the pressing machinery to be as in Sheet F, at the same time when the resting position of the steam piston and water plunger is as shewn in Sheet I; such small force pump is not to be used during the hydro-mechanical action of the pressing machinery, but merely for producing adjustment before such action commences.

The representation in Sheet I of one steam cylinder C, and one water cylinder H, and one hydrostatic cylinder P, with parts accessory thereto, may be considered as a complete example of this third part of my improvements. The combination of three hydrostatic cylinder N, O, P, in one pressing machinery, as in Sheet H, is no part of my present improvements. The three steam cylinders C, C, C, and three water cylinders H, H, H, shewn in Sheet J, correspond to the combination of three hydrostatic cylinders N, O, P, but one very large steam cylinder, with its piston F, equal to all the three in area, and one water cylinder, with its plunger G, equal in area to all the three which are shewn combined in Sheet J, would produce the same effect. The three water pipes *w*, between each water cylinder H and the corresponding hydrostatic cylinder N, O, or P, are all connected by a cross branch pipe, so that the water forced out from the three water cylinders H, H, H, can distribute itself equally into all the three hydrostatic cylinders N, O, and P. And in like manner the high-pressure steam that is admitted into the upper ends of all the three steam cylinders C, C, C, can distribute itself equally into all those three upper ends through communicating branch pipes Z 1 and Z 1, which are applied upon the covers *l* of the cylinders, in order to establish an

open steam communication at all times between the interiors of the three cylinders at their upper ends, above their pistons. The action of the steam for exerting pressure by the pressing machinery is wholly under control of the attendant, who, if he raises the working handle *j* only a little above horizontal, may admit the high-pressure steam gradually into the cylinders, and the pistons will be moved slowly; or if he raises that handle *j* higher above the horizontal, the motion will be more rapid. An index is applied to the handle *j* to point to divisions on a circular dial plate for the guidance of the workman as to extent of motion he should give to the working handle *j*. The force of the high-pressure steam is to be regulated by safety valves on the boiler in the usual manner, and additional safety valves may be applied to the steam pipe Z, or to the covers *l* of the cylinders, for more complete regulation. The load on the safety valves will limit the intensity of the pressing force that can be exerted. Instead of allowing the steam to escape into the open air, or into the chimney through the eduction pipe *h*, that pipe may convey the steam into a suitable condensing apparatus, where it will be condensed, and cause exhaustion within the lower part of the cylinder beneath the piston, that exhaustion being always maintained. The operation of the steam to impel the piston will be the same as already described, but, as the piston will be impelled with more force, in consequence of the exhaustion in the cylinder beneath it, the pressure of the steam in the boiler may be less and yet produce the same pressing force. Such condensing apparatus may be the condenser and air pump of an ordinary condensing steam engine, in case such an engine is required to be kept working for other purposes in the immediate vicinity of the machinery; but the said condenser and air pump should be suitably enlarged beyond the usual proportions for ordinary condensing steam engines.

Respecting the application of this third part of my present improvements to other purposes where pressure is required, it is a common practice in what is termed stamping of metals to press flat plates of metal into the hollows of suitable moulds, for bending such plates to the forms of tea boards, waiters, dish covers, and other articles, the machinery for such stamping operating either by the fall of heavy weight, or by the power of screw press or fly press, and, in some cases, by the power of hydro-mechanical pressing machinery. The arrangement shewn in Sheet I is an example of the mode of working hydro-mechanical machinery according to this third part of my improvements, and supposing the moulds and tools there represented to be changed for other moulds and tools, such as are commonly used for stamping metals, that arrangement would be applicable for the stamper's trade, the machinery being constructed of such dimensions, strength,

and force as will be best adapted to the work to be performed. One steam cylinder and water cylinder and hydrostatic cylinder will be sufficient for most such cases, and they may be of smaller dimensions than represented. Another application is to compress the power of earthy materials used in the manufacture of earthenware into the hollows of suitable moulds, for giving to such compressed powder the forms of flat or ornamented tiles, slabs, bricks, or other articles, the compressing force producing sufficient cohesion of the earthy materials for retaining such forms without subsequent drying or finishing in form, before subjecting them to the usual process of burning into articles of earthenware. The arrangement, Sheet I, with suitable moulds, is applicable to such purpose, the alteration already mentioned for stamping metals being made. And another application is for actuating what is commonly called rivetting machinery for compressing the ends of metal rivets, in order to effect the rivetting together of plates of metal. This application is explained by Sheet K, wherein the same letters of reference being used as in the foregoing description, less detail will be necessary, observing that the steam cylinder and water cylinder are inverted. C is the steam cylinder; *p* and *p* its two piston rods; *q*, their cross head; G, the water plunger, fitted into the water cylinder H, which is fastened to the centre of the cover of the cylinder; T is the frame for supporting the cylinder; *w* is the water pipe, without valves in it, communicating always between the water cylinder H and the hydrostatic cylinder P, which, for this purpose of rivetting is held in a horizontal position by two standards A, A, standing up from a very strong base B, B, on each end of which other stronger standards D, D, are erected to hold the reacting tools *x*, *x*, by which the rivets are to be sustained during the compression that they are to undergo for effecting the rivetting. The hydrostatic cylinder P has two rams *r*, *r*, fitted into it, one at each end, and both are protruded together by the same hydro-mechanical action, for the purpose, if required, of compressing two rivets at the same time, by aid of two sets of workmen to insert the rivets and hold the plates that are to be rivetted together. The steam pipe Z and valve box G, with the valve within it, and the rod *o*, for moving the valve, are very similar to the like parts in Sheet I, except as they are affected by the inverted position of the parts. *h* is the eduction pipe. The advantage of the cylinder being in an inverted position is, that the weight of the piston rods, cross head, and water plunger will cause the returning motion without any counter-weights, chains, and pullies, as in Sheet J. The returning motion of the horizontal rams *r* and *r* will be produced by atmospheric pressure during the returning motion of the water plunger G. Although

there are two rams *r* and *r*, for compressing two rivets at once, one of the rams *r* may be blocked fast by interposing a solid piece of metal between the end of that ram and the corresponding reacting tool *x*, and then the machine will become a single machine for compressing one rivet at a time. No claim is made to any direct application of the force of a piston urged by high-pressure steam to the purpose of rivetting, unless it is by intervention of water, so as to augment the force of such steam piston by hydro-mechanical motion. The inverted position of the steam cylinder in Sheet K is applicable to the other cases herein-before described of this third part of my present improvements. Instead of the steam cylinders shewn in Sheets I and J, inverted steam cylinders, such as in Sheet K, might be substituted, and then counter-weights would not be required.

The fourth part of my said improvements relates to the mode of applying metal tubes in steam boilers or other vessels requiring metal tubes to be applied within them. It has been heretofore a common practice to insert hoops of metal (called ferrules) into the ends of tubes, for the purpose of fastening those ends into the tube plates of the boilers. This fourth part of my improvements is to apply a hoop of metal around the end of the cylindrical tube, so as to be interposed between the exteriors of that end and the interior of the conical hole through the tube plate, see Sheet L, which contains a section of one end of a tube and of the tube plate, with the hoop inserted in its proper place. The hoop is cut through or left open at one part of its circumference, in order to render it capable of contracting a very little in its diameter, when it is forced into the conical hole through the tube plate and in the act of contracting upon the end of the cylindrical tube so as to fit closely around that end, and into the conical hole through the tube plate of the boiler or other vessel. A loose piece is fitted into the hole *z* in the hoop, which loose piece is shorter than the hole in the hoop, so as to admit of the hoop contracting a little, but the width of the loose piece is of the same width as the hole, and fits therein so as to prevent leakage. The advantage of this fourth part is, that it enables the tubes to be withdrawn from the boiler or other vessel in order to remove incrustations from the interior surfaces of the tubes, and then the cleaned tubes may be put back into their places in the boiler or other vessel, for after the hoop is withdrawn it leaves a vacancy around the end of the tube which can be easily drawn out through the larger conical hole in the tube plate, even although the outside of the tube should have incrustations around it.

Having now described my said improvements, I, the said Richard Prosser, do hereby declare that the new Invention, whereof the exclusive use is granted

to me by the herein-before recited Letters Patent, of the Eleventh day of April last, consists in the following implements, namely:—

Firstly, in the improvement herein-before described, in reference to Sheets A, B, C, D, and E, of the Drawings hereunto annexed in the mode of planing the edges of flat plates of metal, which are afterwards to be bended or turned up to the form of metal tubes; this first part comprising the new parts applied to the moving table of a planing machine, for the purpose of holding two flat plates edgeway upwards in parallel vertical planes, which new parts are marked in Sheets A, B, C, D, and E by the letters of reference A, *a*, B, *b*, *c*, D, *d*, F, *f*, and E, *e*, W, *w*, *z*, also R, G, S, *i*, I, H, J, T, M, N, O, Q, which parts are herein-before described; together with the manner of combining them, and of using the combination of them for the said purpose. This first part also comprising the compound cutting tools applied to a planing machine for planing the edges of such flat plates, by a number of distinct cutting edges operating at the same time, but at different places, along the lengthway of such edges, so as to concur together one with another in cutting away and removing the superfluous metal from those edges in a succession of thin shavings by the several cutting edges of each compound cutting tool, which compound tools, together with their accessory parts, are marked in Sheets A, B, C, and D, by the letters *h*, K, *k*, L, *j*, *l*, *m*, *s*, *t*, *v*, *r*, *n*, *o*, *q*, *z*, *y*, and also U, V, X, Y, in Figures 13, 14, and 15, which parts are herein-before described, together with the manner of combining and adjusting them, and of using the combinations of them. The compound cutting tools, which I hereby claim as comprised in this first part, are distinguished from any other cutting tools by the mode herein-before described of constructing and combining and adjusting and fastening together the several parts of each compound tool, so that, although each cutting edge is held fast in its intended position in respect to the other cutting edges in the same compound tool; nevertheless, when the steel of any one or more of such cutting edges in the course of working is become broken, and in repairing is ground away and reduced more than the steel of the other cutting edges in the same tool is ground away, then the said reduced cutting edge or edges (after having been repaired and sharpened) can be adjusted either up or down or laterally in respect to the other cutting edges in the same compound tool, as may be necessary, in order to bring such reduced cutting edge or edges to its or their exact position in the entire row of cutting edges, and it or they can then be made fast in the newly adjusted position. This first part also comprising the application of two rows of reversed cutting edges in each compound tool; one row for planing during the forward motion, and the other during the backward motion of the

moving table of the planing machine, in manner herein-before described in reference to Figure 16, Sheet E, where the two rows are marked *n* and *g* 1.

Secondly, in the improvement herein-before described, in reference to Sheets F, G, and H, of the Drawings, in the mode of bending or turning up flat plates into the form of metal tubes; this second part comprising the long moveable bar for retaining the plate that is to be bended in its intended place over the hollow of the mould, wherein the plate is to be bended to the first stage of a long gutter form; that long bar and its accessory parts are marked in Sheets F, G, and H, by the letters L, M, K, U, W, which parts are herein-before described, together with the manner of combining them and of using the combination. This second part also comprising the two moveable side pieces to the hollow of the mould wherein the first stage of bending is to be performed; those moveable side pieces completing the bending of the two marginal portions of the plate adjacent to the two edges thereof to the intended curvature, which moveable side pieces, together with their accessory parts, are marked in Sheets F, G, and H, with the letters *d*, *d*, *m*, *n*, *r*, *s*, *w*, which parts are herein-before described, together with the manner of combining them and of using the combination. This second part also comprising the disposition and combination of all the several moulds and tools which constitute a complete set for performing all the three stages of turning up, with one such mould or tool above another in the pressing machinery in their proper relative positions, and the bending and turning up to all those three stages being performed by one motion of the pressing machinery; that disposition and combination of the moulds and tools is marked in Sheets F, G, and H, by the letters A, *d*, *d*, B, D, E, Y, X, *k*, J, *x*, and *y*; that disposition and combination is herein-before described, together with the manner of constructing and combining the moulds and tools, and of using the combination of them. This second part also comprising the recess within the hollow of one of the semicylindrical half moulds, wherein the third stage of turning up feather edged plates to the form of a tube is to be performed, which recess is marked *w* in Figure X, Y, Sheet G; and the mandril, which may in certain cases be used with such recess, is represented at the lower part of Sheet G. That recess and mandril are herein-before described, together with the manner of constructing and using the same.

Thirdly, in the improvement herein-before described, in reference to Sheets I, J, and K, of the Drawings, in the mode of applying steam power for actuating pressing machinery of the hydrostatic or hydro-mechanical kind; this third part consisting in employing the forcible motion of a piston, which is fitted into a large steam cylinder, so as to be impelled therein by pressure of

high-pressure steam; and such forcible motion being communicated to a piston or plunger fitted into a water cylinder, having an uninterrupted water communication with the hydrostatic cylinder of the hydro-mechanical pressing machinery, the parts being combined and arranged so that one stroke of the steam piston in its cylinder, and one corresponding stroke of the water piston or plunger in its water cylinder, will inject into the hydrostatic cylinder as much water as is requisite for giving the intended extent of forcible motion to the ram of the hydrostatic cylinder for performing the pressing work; the returning stroke of the steam piston and water piston or plunger permitting the return of the same water, and consequently of the ram (there being no valves or cocks to prevent such return of the water from the hydrostatic cylinder to the small water cylinder. The parts of the new combination comprised in this third part are marked in Sheets I, J, and K, with the letters C, F, G, H, I, T, Z, X 1, X 2, Z 1, *c*, *f*, *g*, *h*, *i*, *j*, *o*, *p*, *q*, *w*, *z*, which parts are herein-before described, together with the new manner of combining them, and of using the new combination as part of the machinery or apparatus for manufacturing metal tubes, that is to say, for pressing flat plates of metal into the hollows of suitable moulds, so as to bend and turn up such plates into the form of metal tubes. The said new combination comprised in this third part being also applicable for other purposes where pressure is required; such, for instance, as for pressing flat plates of metal into the hollows of suitable moulds for bending such plates to other required forms than tubes; for example, such forms as are commonly required in the trade denominated stamping of metals. And for another instance, compressing powder of earthy materials, used in the manufacture of earthenware, into the hollow of moulds, suitable for giving to such compressed powder the form of flat or ornamented tiles, slabs, bricks, or other articles to be afterwards burned into earthenware. And for another instance, compressing the ends of metal rivets for rivetting together of plates of metal by rivetting machinery. This application of the aforesaid new combination is herein-before described in reference to Sheet K.

Fourthly, in the improvement herein-before described, in reference to Sheet L of the Drawings, in the mode of applying metal tubes in steam boilers or other vessels requiring metal tubes to be applied within them; this fourth part being the application, in manner herein-before described, of a hoop of metal fitting tight around the exterior of the end of each metal tube, and also fitting tight into the interior of the hole through the end plate or tube plate of the steam boiler or other vessel into which the tube is to be applied. The said hoop being interposed between the exterior of the end of the tube (which end is cylindrical) and the interior of the hole through the end plate or tube plate

(which hole is slightly conical); the said hoop being made to fit with close contact to both the cylindrical exterior of the end of the tube and the conical interior of the hole. For that purpose, the hoop is left open at one part of its circumference, with an interlocking joint at that open part, in manner herein-before described, in order that such joint may permit a very small contraction to take place in the diameter of the hoop during the act of forcing it into the conical hole, and by such contraction of the hoop to cause it to grasp firmly around the cylindrical end of the tube when the conical exterior of the hoop becomes tightly fitted into the conical interior of the hole. By withdrawing such hoop from its place in the conical hole, the tube can be drawn out endways through that hole, so as to remove it from the boiler or other vessel.

In witness whereof, I, the said Richard Prosser, have hereunto set my hand and seal, this Eleventh day of October, One thousand eight hundred and fifty.

RICHARD PROSSER. (L.S.)

AND BE IT REMEMBERED, that on the Eleventh day of October, in the year of our Lord 1850, the aforesaid Richard Prosser came before our said Lady the Queen in Her 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 stamped according to the tenor of the Statute made for that purpose.

Enrolled the Eleventh day of October, in the year of our Lord One thousand eight hundred and fifty.

SLANEY, Extra.

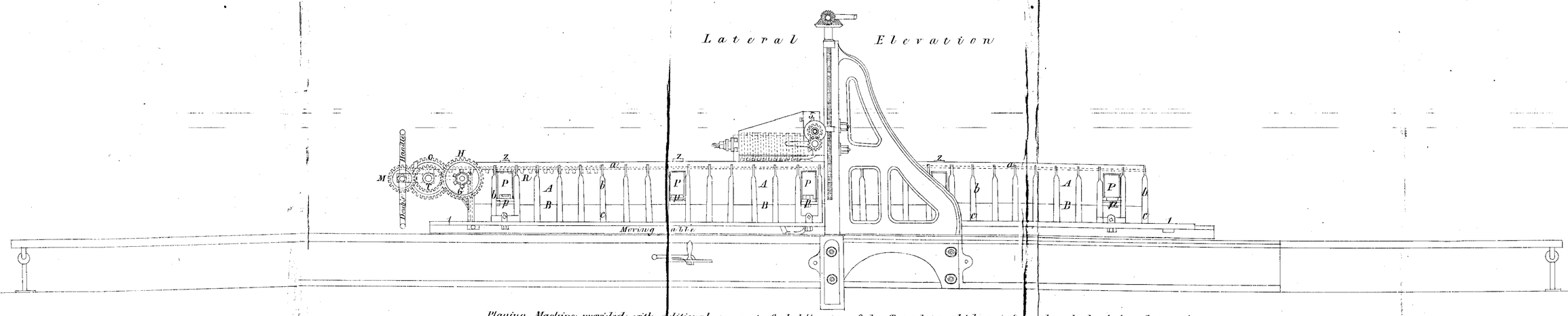
LONDON:
Printed by GEORGE EDWARD EYRE and WILLIAM SPOTTISWOODE,
Printers to the Queen's most Excellent Majesty. 1856.

A. D. 1850. April 11. Nº 13035.
PROSSER'S SPECIFICATION.

(12 SHEETS)
SHEET 1.

FIGURE 1.

Lateral Elevation



Planing Machine provided with additional new parts for holding two of the flat plates which are afterwards to be bended and turned up to form metal tubes, and also provided with new compound cutting tools for planing the edges of these two flat plates.

Figures 1 and 2 are drawn to a Scale one sixteenth of the real Size.

FIGURE 2.

Horizontal Plan.

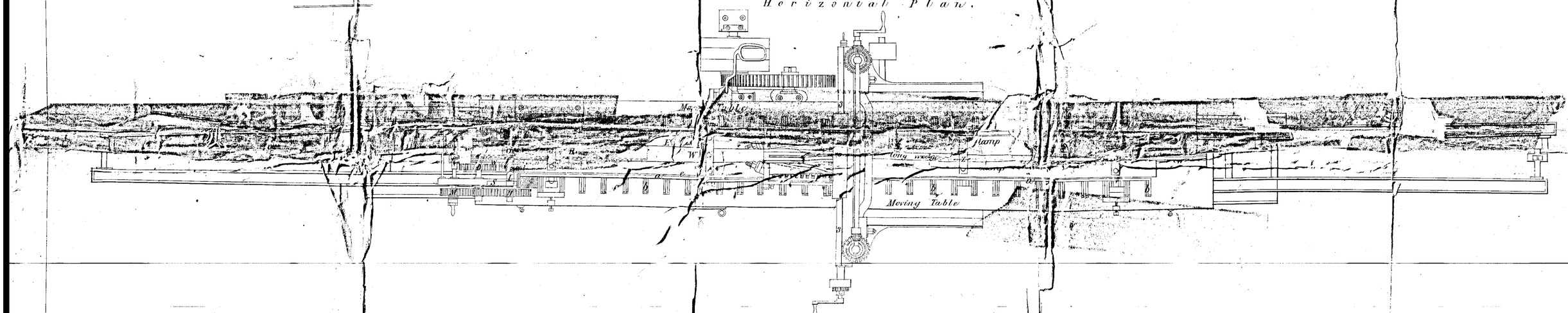


FIGURE E.

Edge view of one of the clamps E, shewing the springs e lodged in the groove along that edge.

FIGURE E, W, E.

Horizontal plan of the two clamps E and E with the wedge W between them.

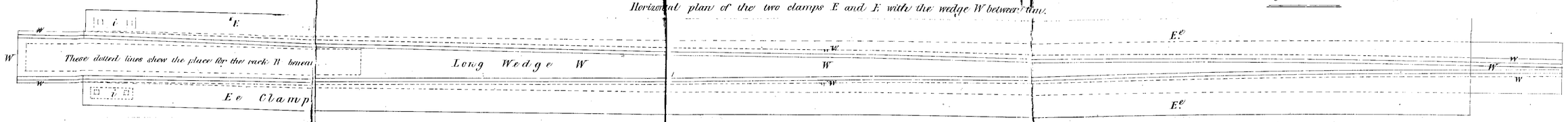
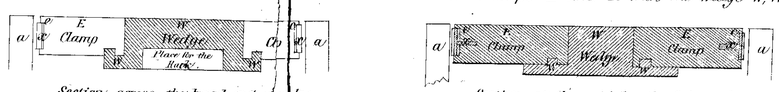


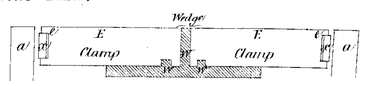
FIGURE E, W, E.

Transverse Section of the two Clamps E and E with the wedge w, W, w between them.



Section across the broad end of wedge.

Section at the mid-length of the wedge.

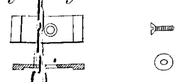


Section at the narrow end of the Wedge.

These Figures are drawn one fourth of the real size.

FIGURE e.

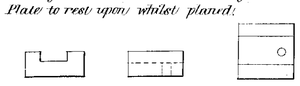
Springs to be lodged in the groove along the edge of each clamp E.



These Figures are drawn one eight of the real size.

FIGURE p.

Bearing step for the lowermost edge of the Plate to rest upon whilst planed.



end view *side view* *Plan*

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Drawn to a scale of one fourth of the real size.

FIGURE 3.
End Elevation and Section
The upper part is an end elevation of the frame for holding the two compound cutting tools.

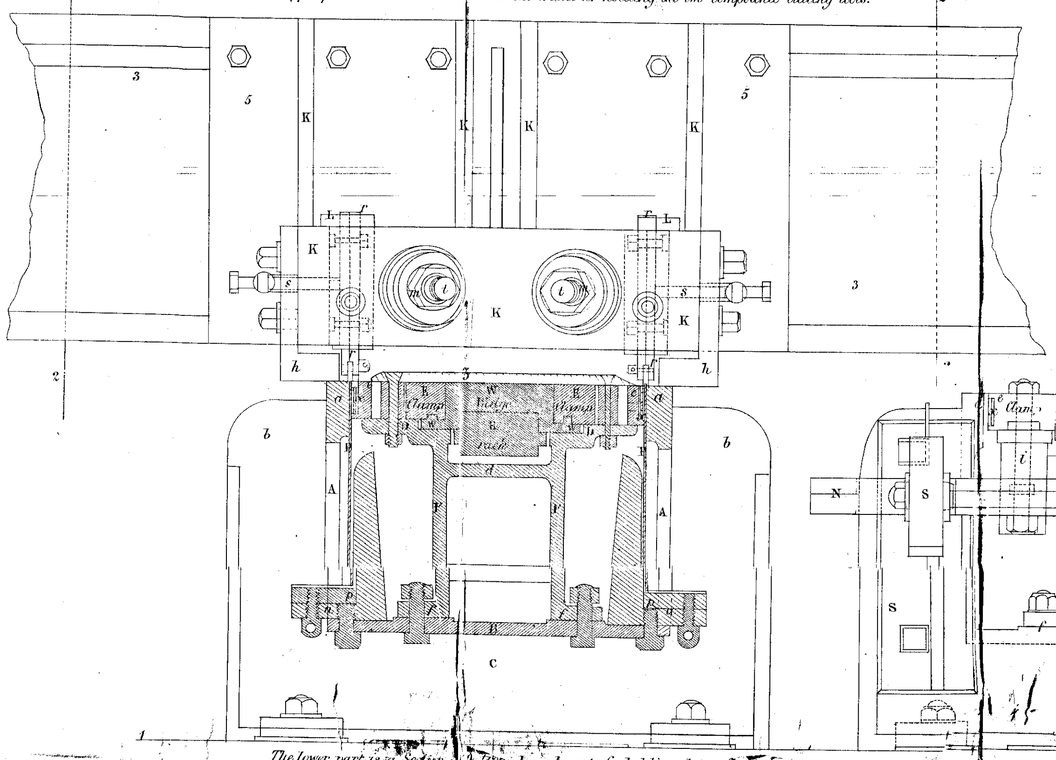


FIGURE 4.
End Elevation of the trough and parts for holding the two flat plates.

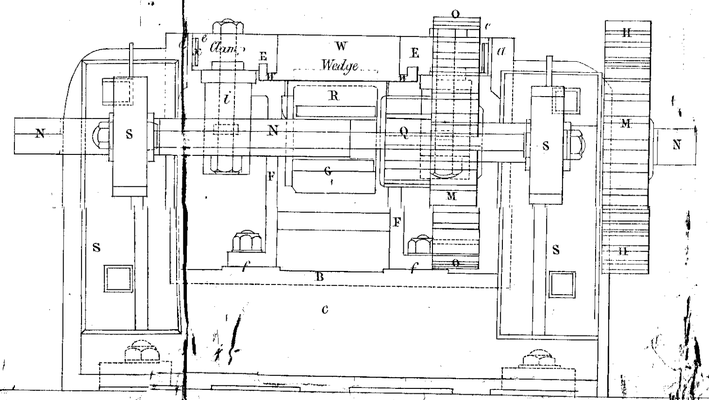
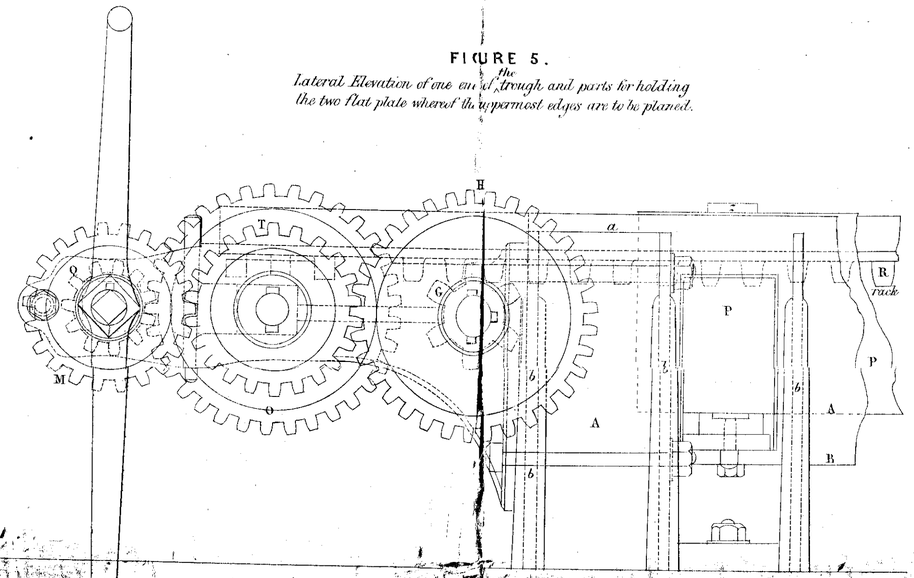


FIGURE 5.
Lateral Elevation of one end of the trough and parts for holding the two flat plate whereof the uppermost edges are to be planed.



The lower part is a section of the trough and parts for holding the two flat plates

FIGURE 8.
Horizontal Plan of the frame holding the two compound cutting tools.

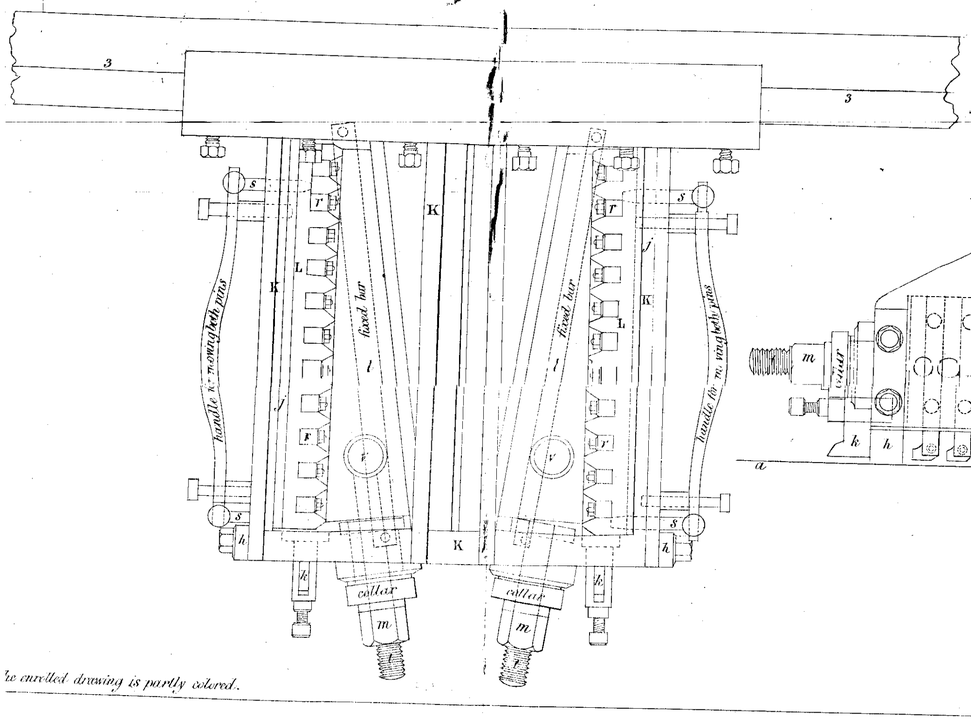


FIGURE 7.
Lateral Elevation of the frame for holding the compound cutting tools.

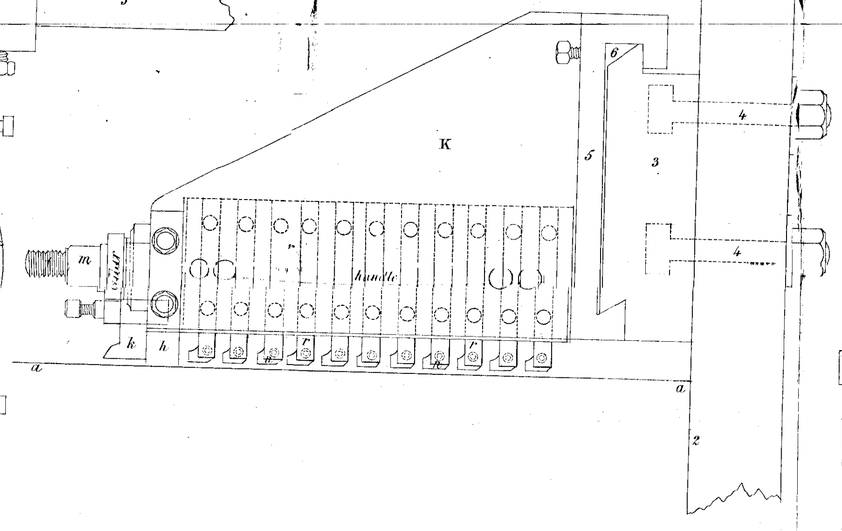
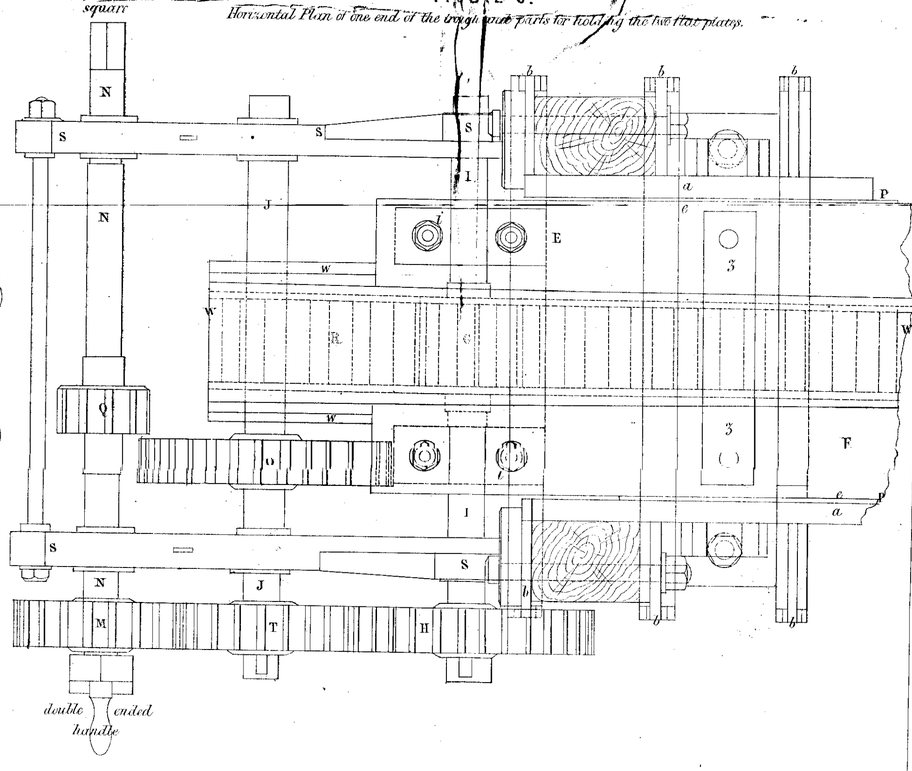


FIGURE 6.
Horizontal Plan of one end of the trough and parts for holding the two flat plates.



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SHEET C.

Drawn the real size.

FIGURE L.

Plan and Elevation of the Tool Rack.

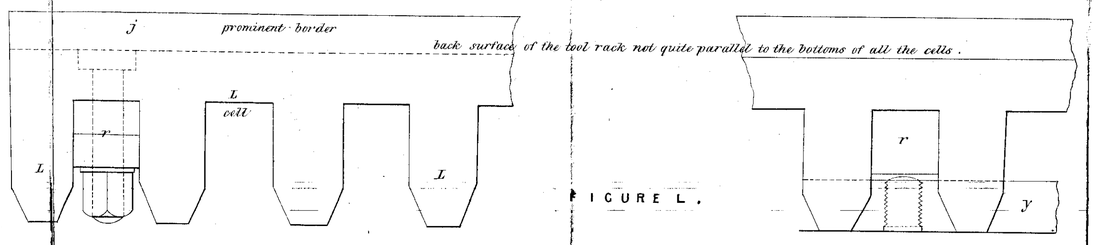
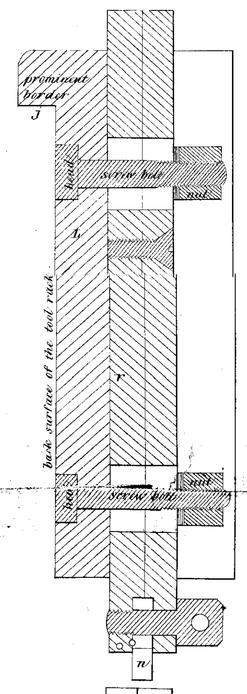
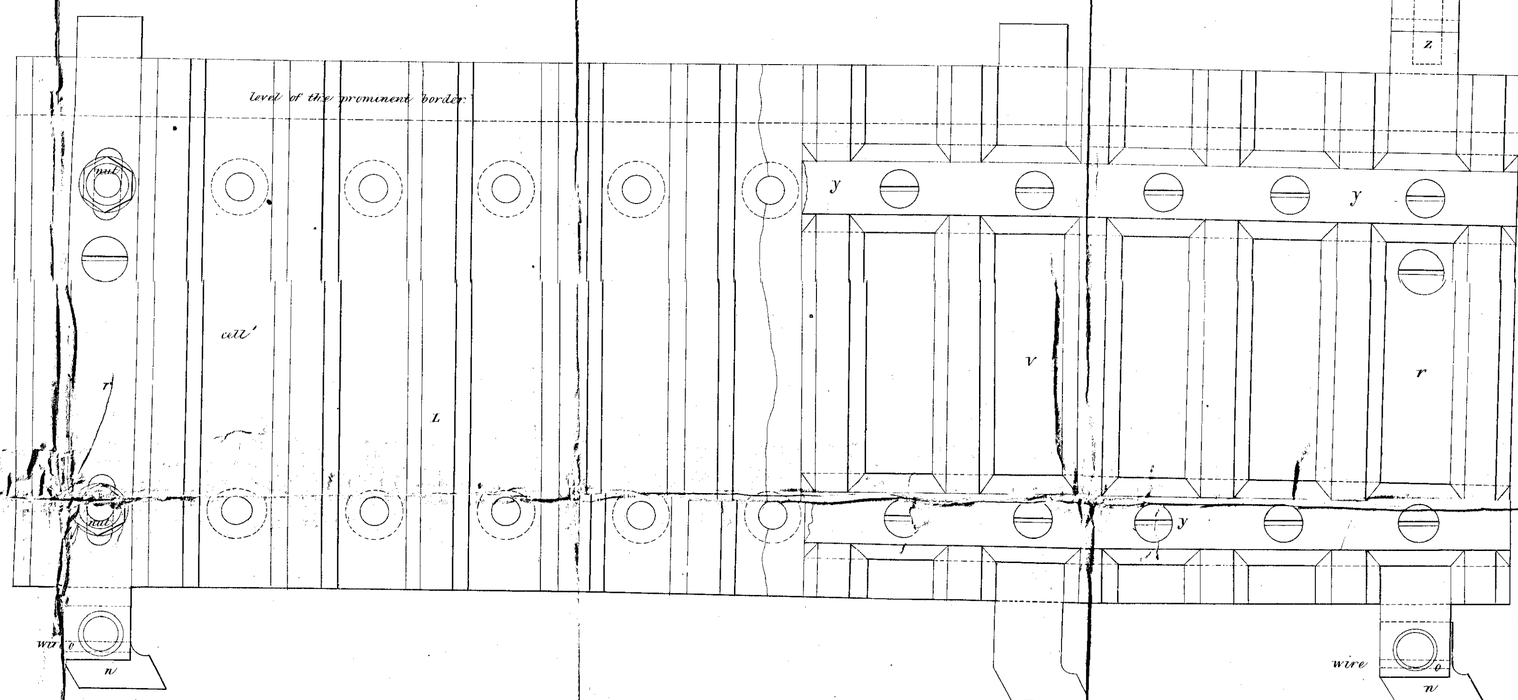


FIGURE L.r.

Vertical Cross Section of a Compound Tool for cutting downward.





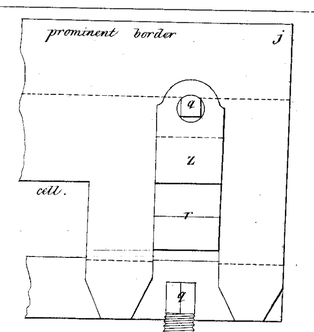
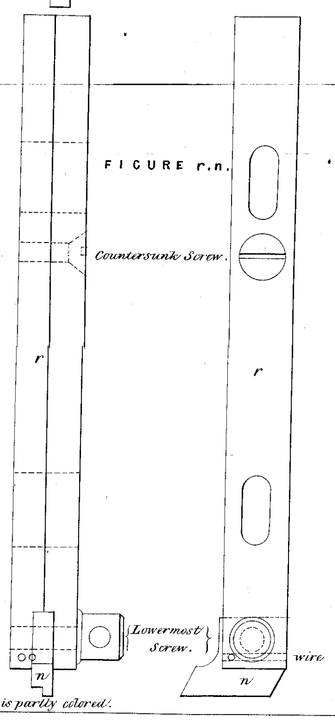


FIGURE r.n.



Key wrench for the nuts

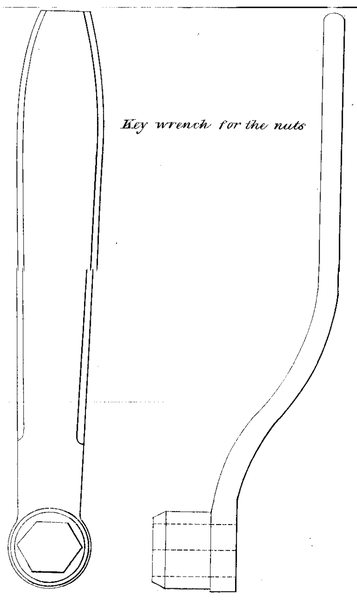


FIGURE r.

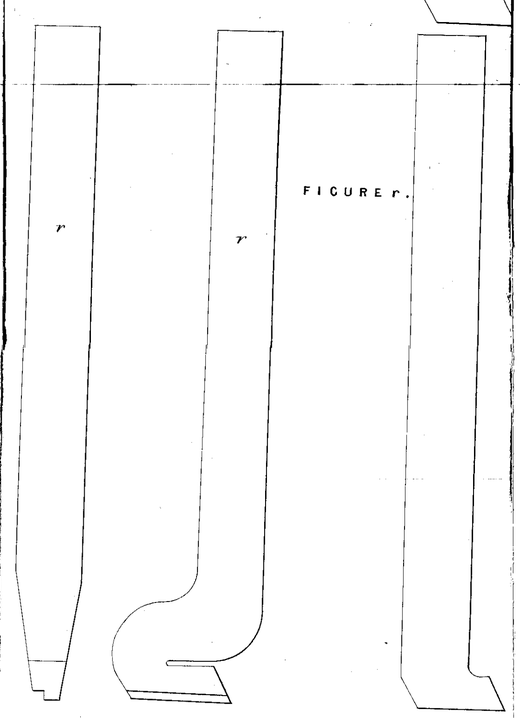


FIGURE r.z.

Vertical Cross Section of a Compound Tool for cutting laterally.

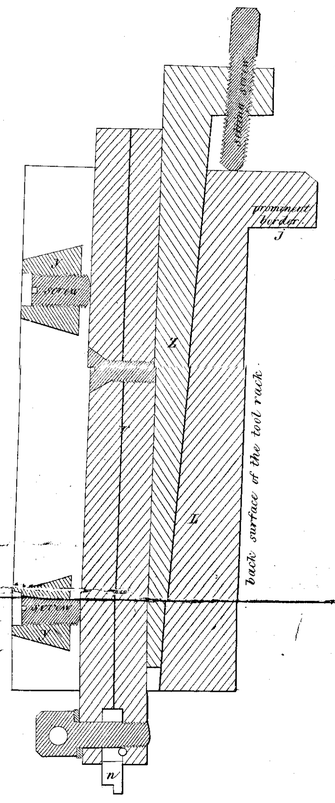


FIGURE n.r

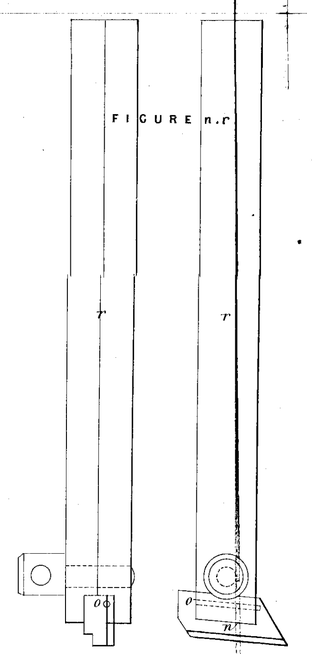


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FIGURE 9.

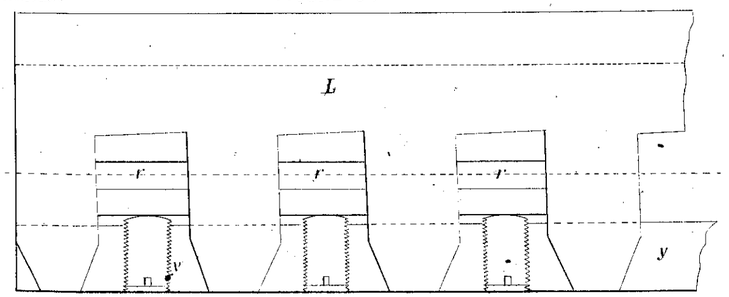
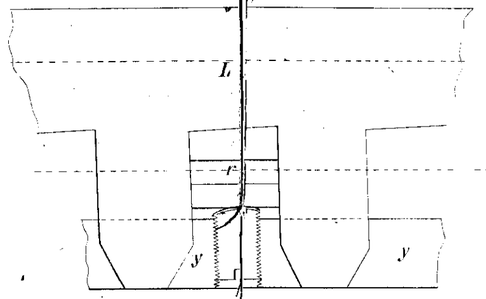


FIGURE 10.



Temporary Tool Rack.

FIGURE 11.

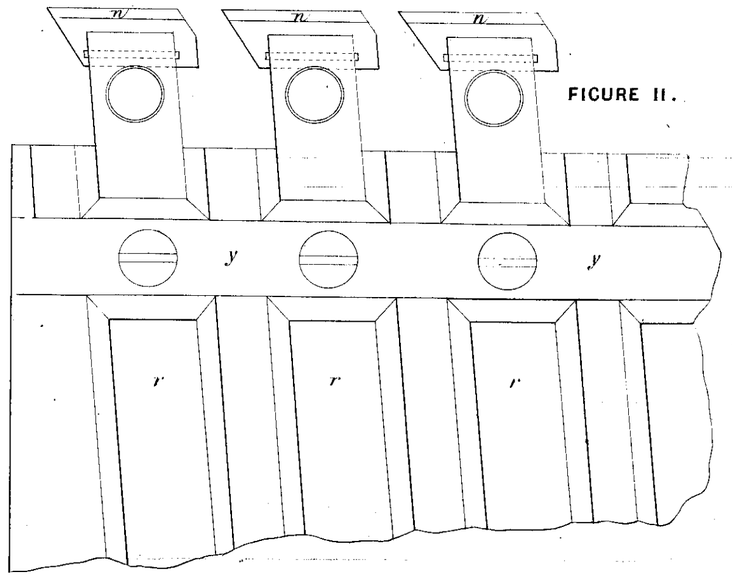


FIGURE 12.
Ordinary Tool Rack.

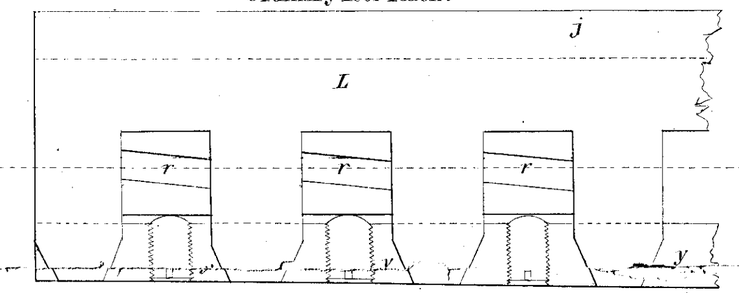


FIGURE 13. Side View.

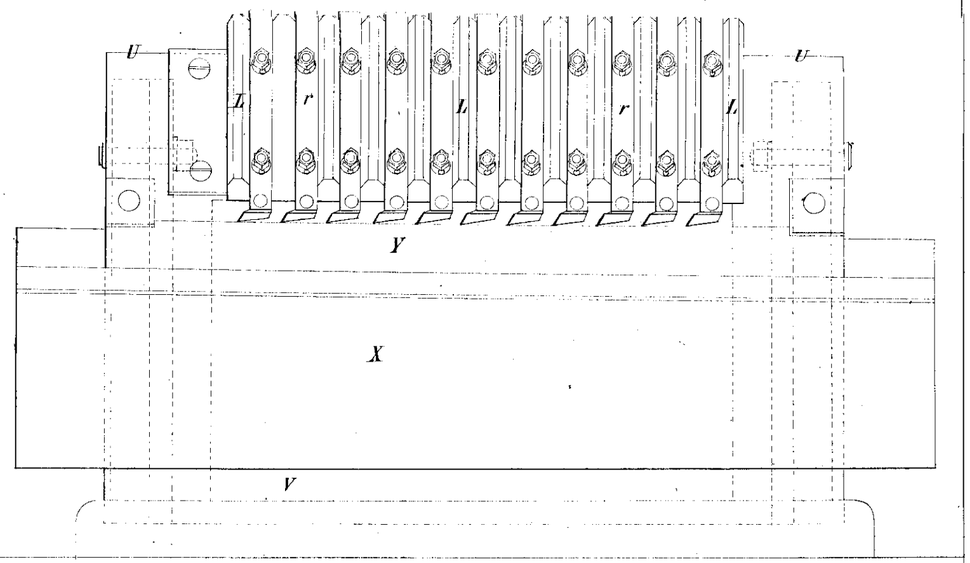
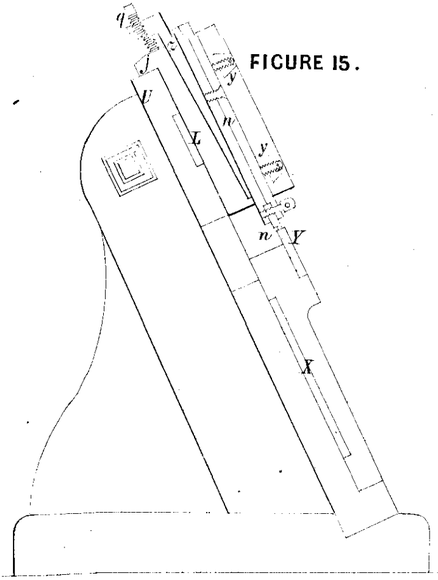


FIGURE 15.



End View.

FIGURE 14.

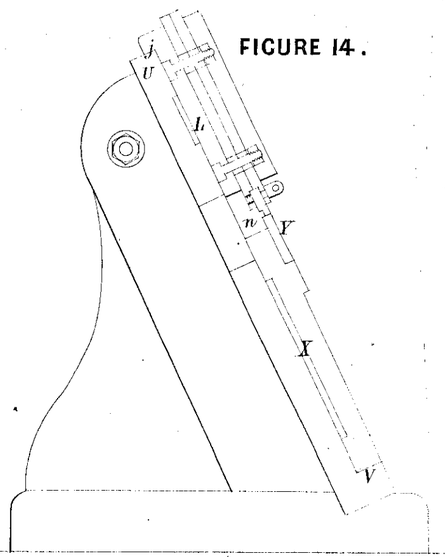


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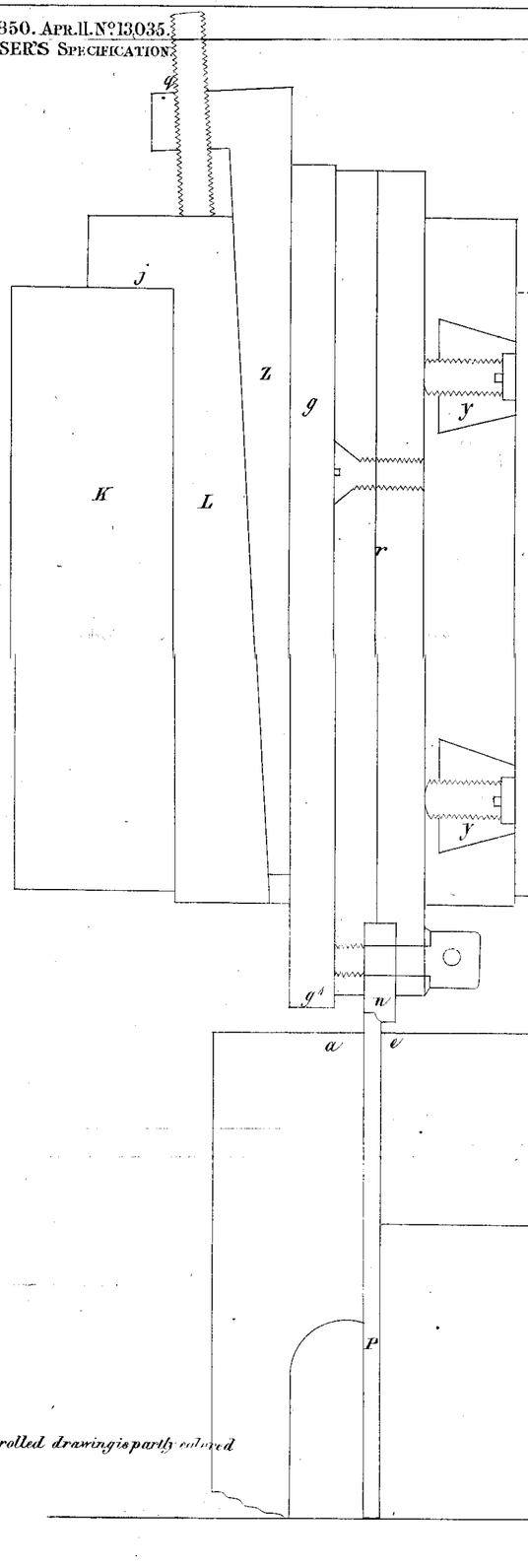
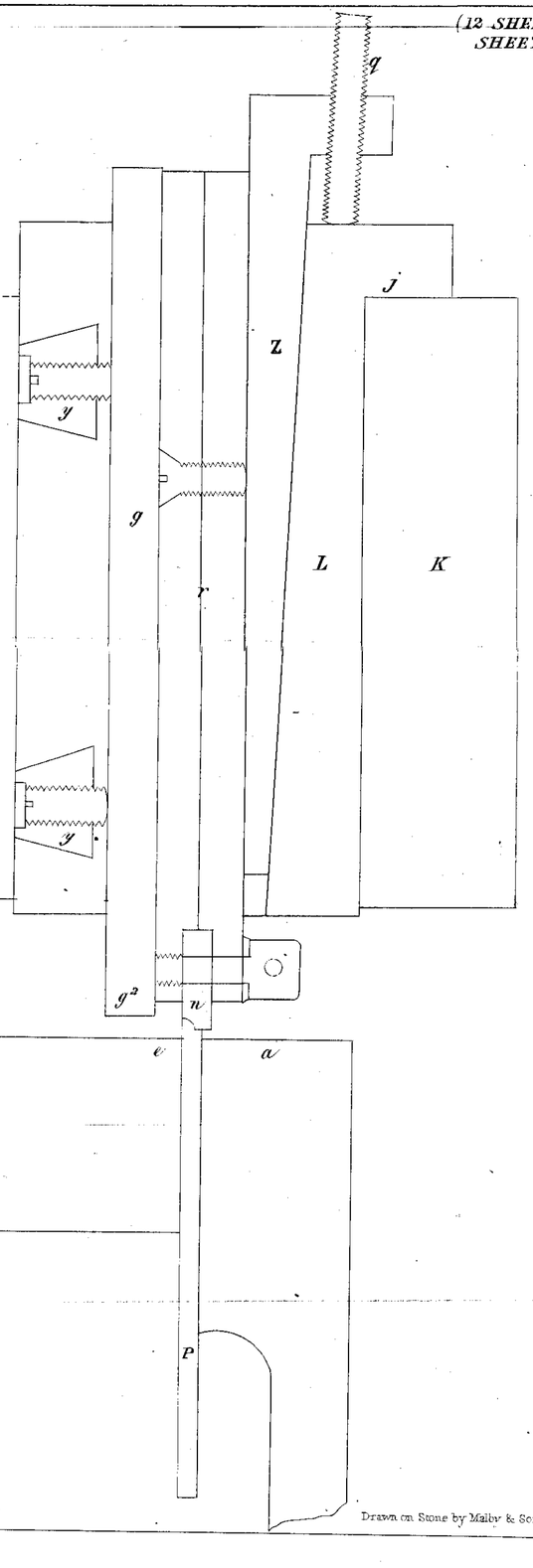
FIGURE 16.

Vertical Transverse Section of two compound cutting tools with two distinct rows of cutting edges in each such tool.

Level of the upper edges of the two openings of the frame K.





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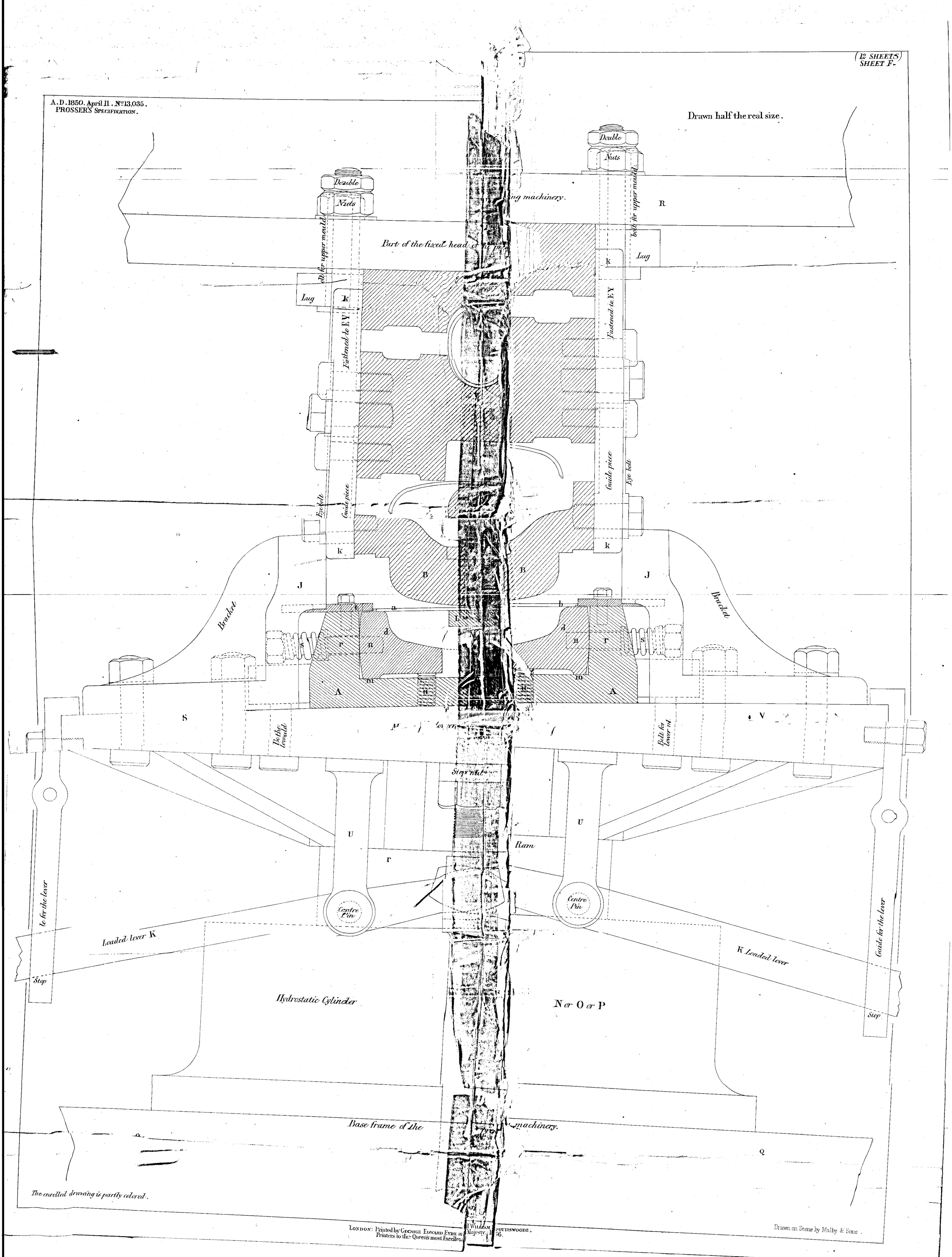

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Drawn half the real size.

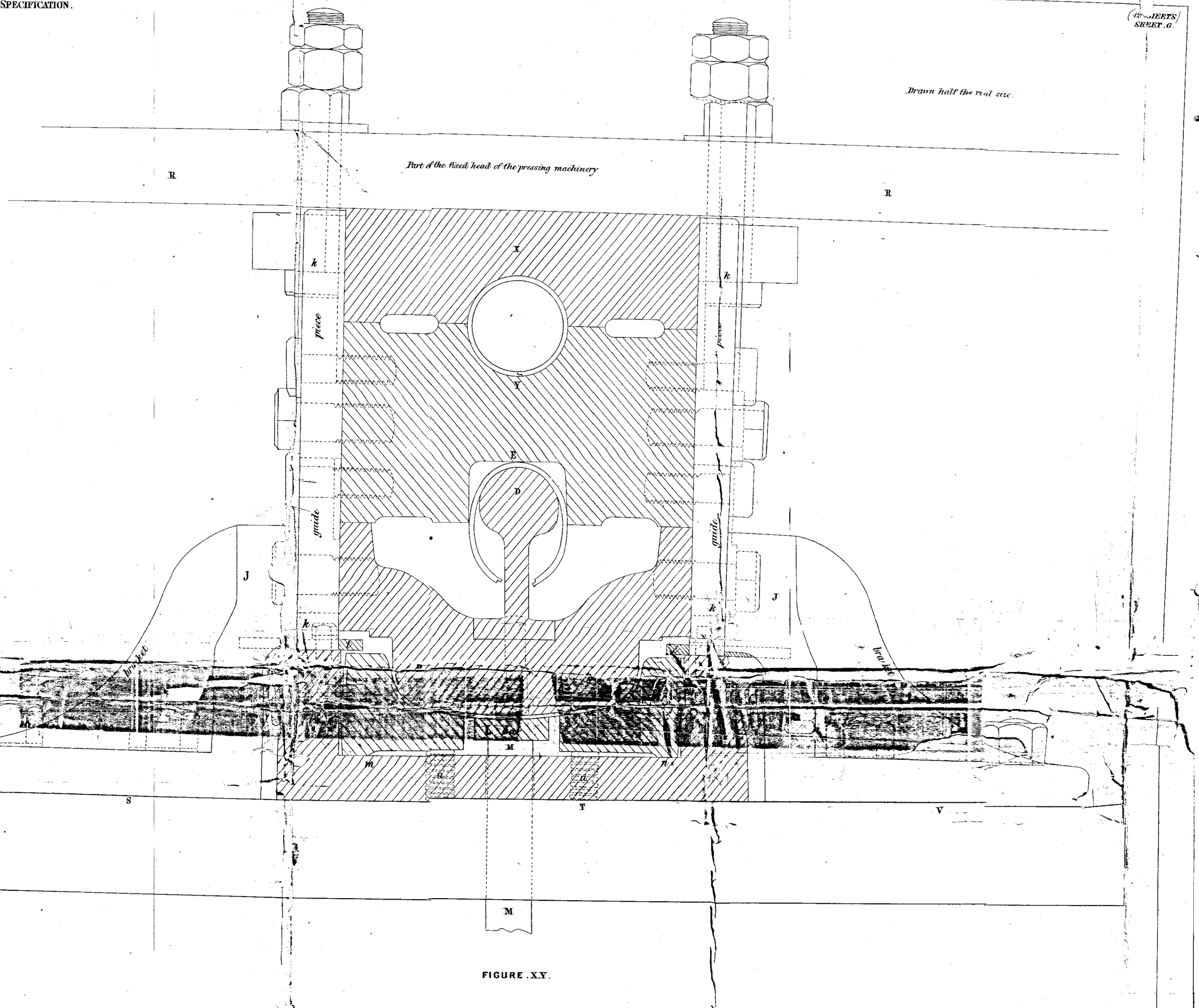
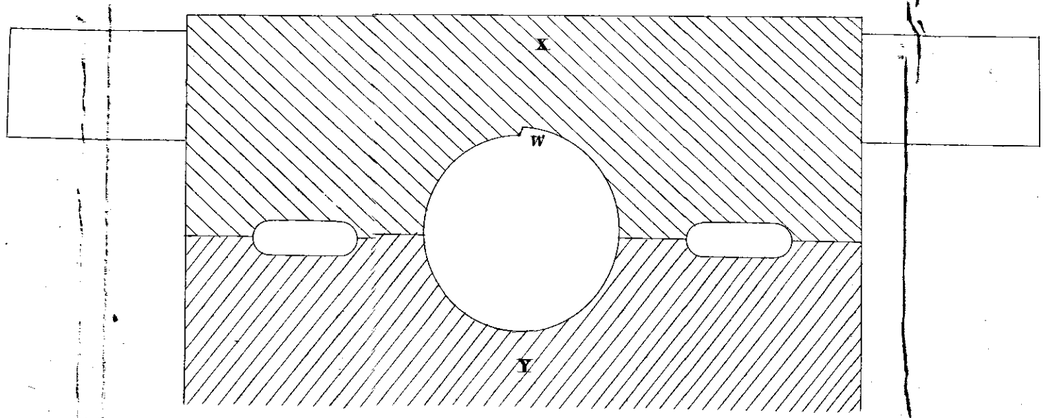
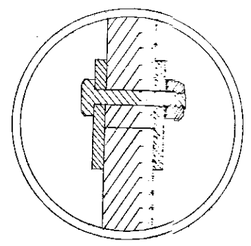


FIGURE. XY.



Section of a mandril within the Tube.



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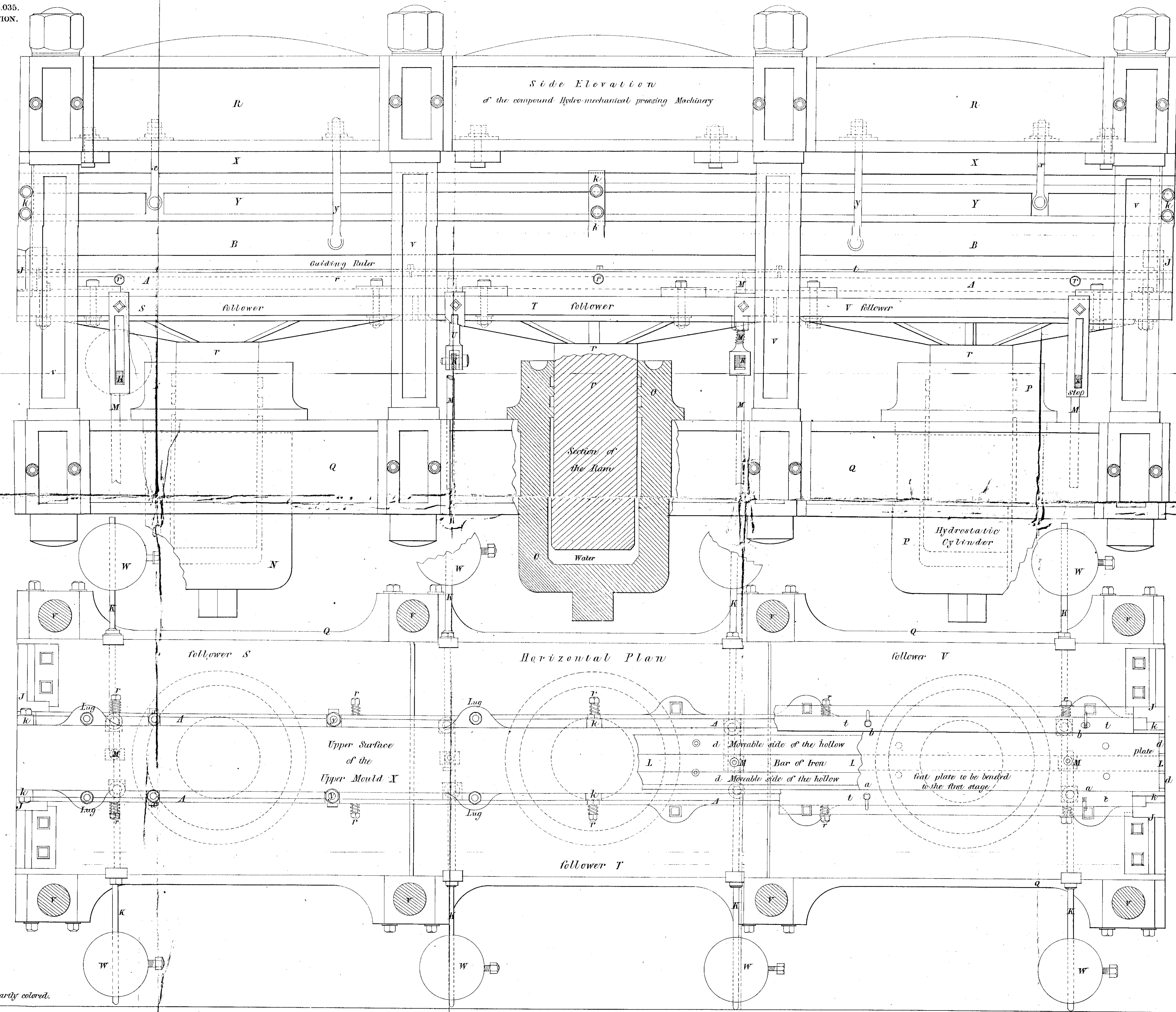

Drawn 1/3 of the Real Size.

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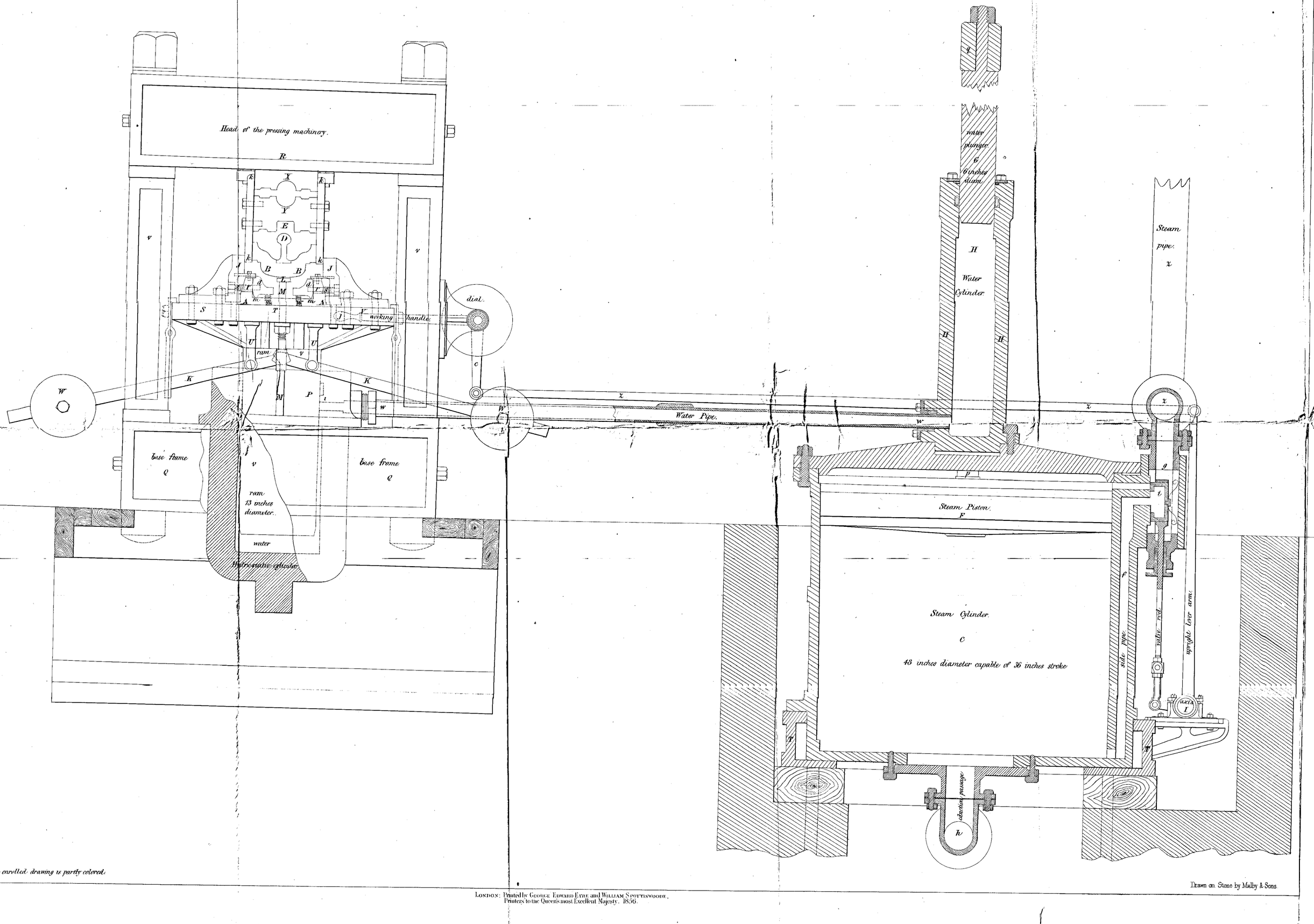
SHEET 1.



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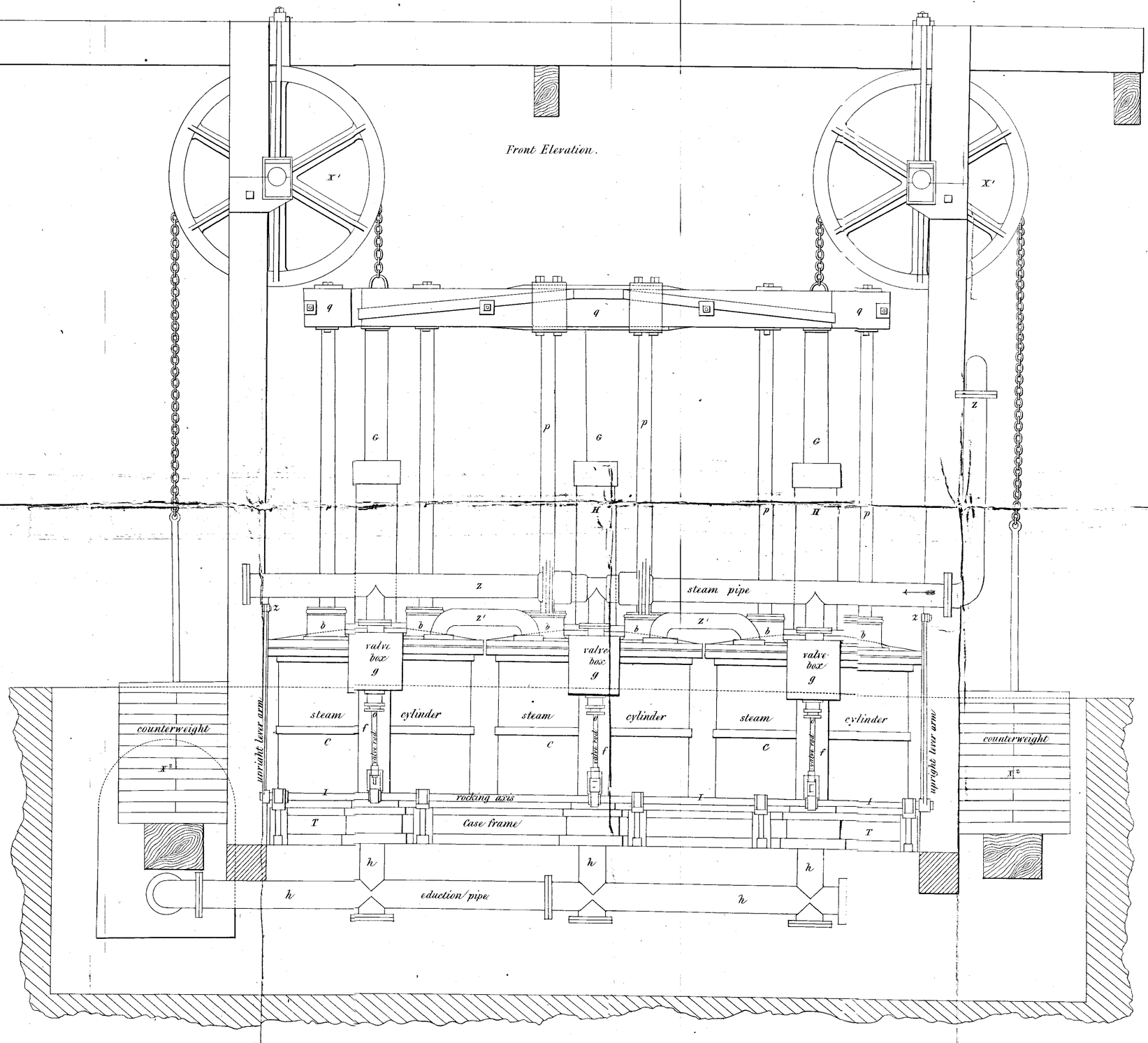
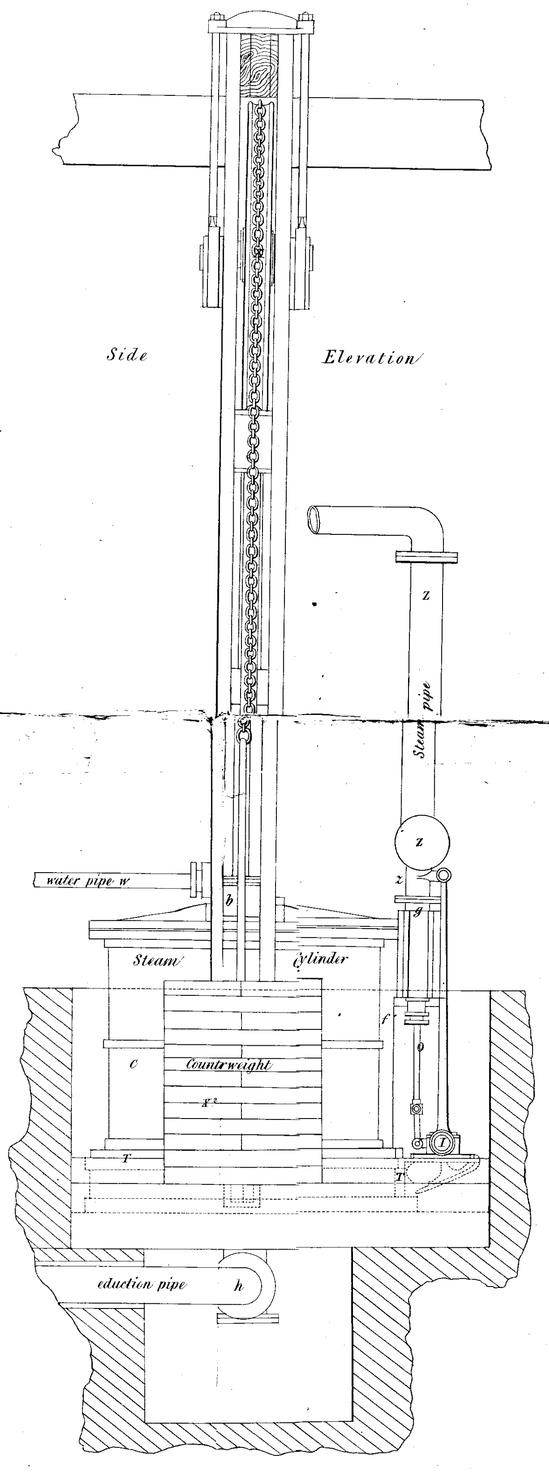
(12 SHEETS)
SHEET J.

Front Elevation.

Side Elevation.





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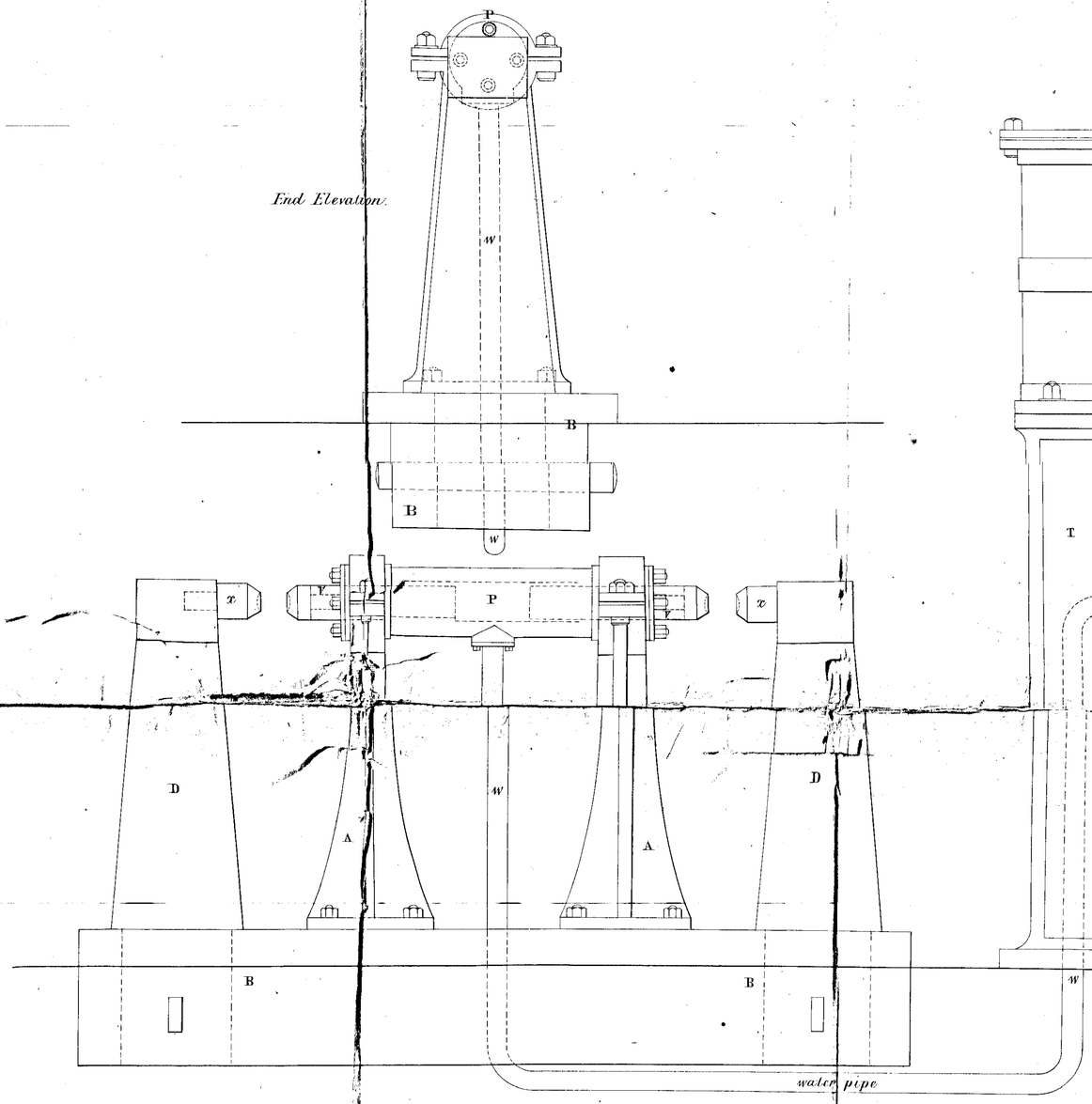
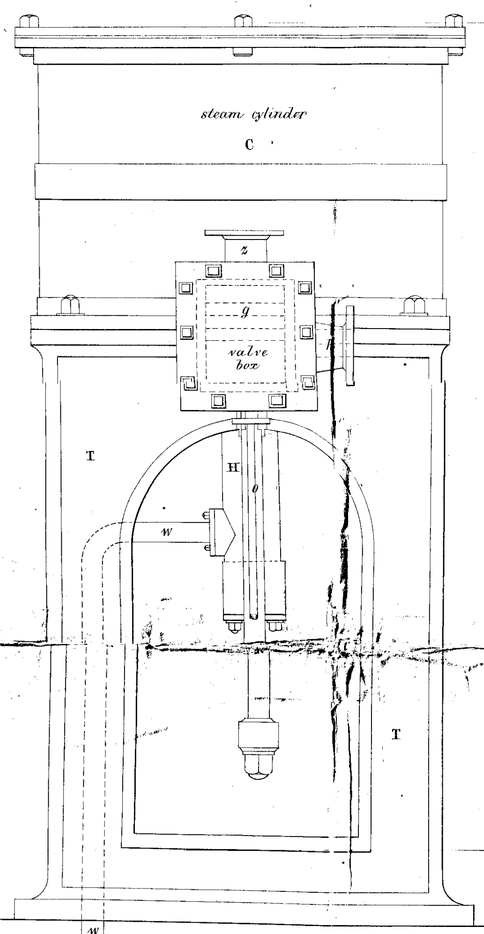
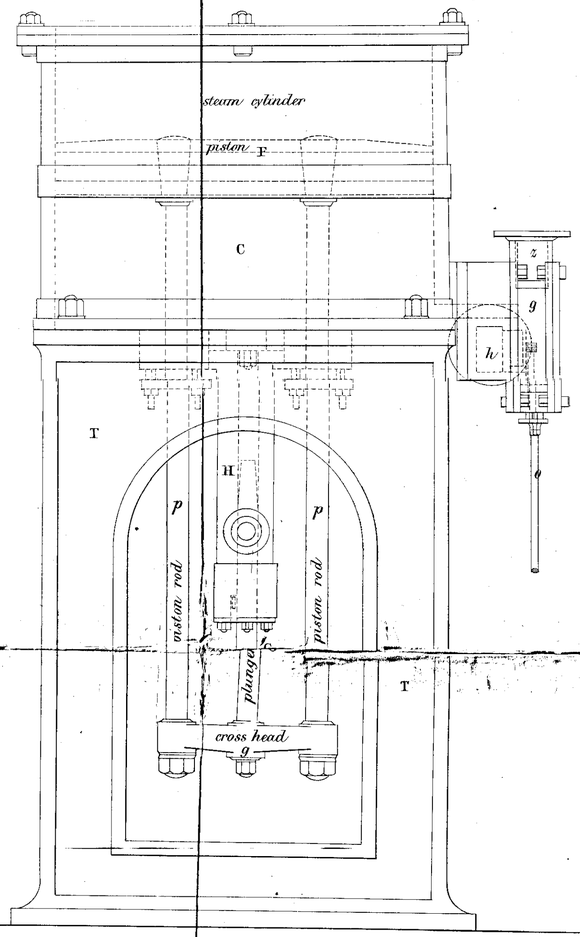
End Elevation.

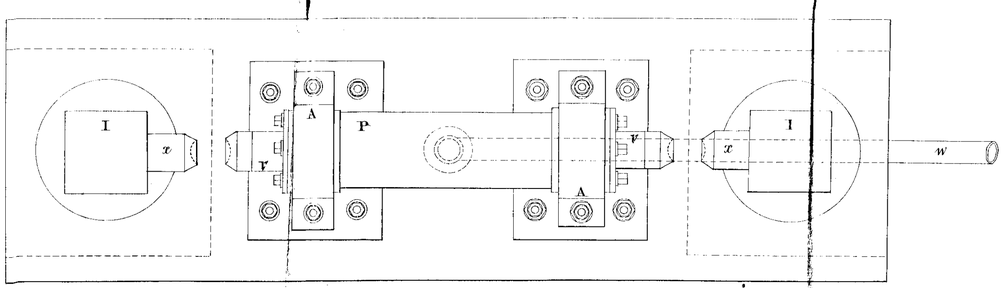


Lateral Elevation.

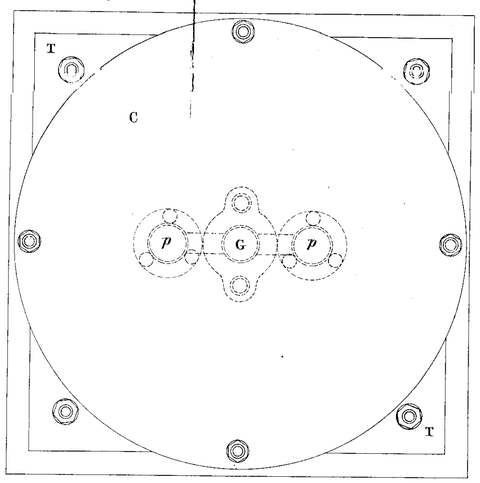


End Elevation.





Horizontal Plan.



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