A.D. 1845 . . . . . N° 10,649.

Manufacture of Metal Tubes.

PROSSER'S SPECIFICATION.

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

WHEREAS I did, by Petition, humbly represent unto Her present most Excellent Majesty Queen Victoria, that I had invented "IMPROVEMENTS IN THE MANUFACTURE OF METAL TUBES, AND IN THE MACHINERY AND APPARATUS FOR PRODUCING THE SAME," and Her said Majesty being willing to give encouragement to all arts and inventions which 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 First day of May, (One thousand eight hundred and forty-five), in the eigth year of Her reign, for Herself, Her heirs and successors, to give and grant unto me, the said Richard Prosser, my executors, administrators, and assigns, Her especial licence, 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 or they 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, and in the Islands of Jersey, Guernsey, Aldersey, Sark, and Man, and also in Her said Majesty's Colonies and Plantations abroad, in such manner as to me, my executors, administrators, and assigns, shall seem meet; and as 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 for that end Her said Majesty requires and

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strictly commands all Her subjects whatsoever, within England, Wales, and Berwick, and in the Islands, Colonies, and Plantations aforesaid, that they shall not, neither directly nor indirectly, make, use, or put in practice my said Invention, or any part thereof, nor in anywise counterfeit, imitate, or resemble the same, nor make any addition thereto or subtraction therefrom, whereby to pretend himself or themselves to be the Inventor or Inventors thereof: 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 inrolled 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 is described and ascertained in manner following, and by the aid of the fourteen Sheets of Drawings hereunto annexed, that is to say:—

The first part of my said improvements relates to the preparing of the edges of flat plates or skelps of metal for being turned up (as it is technically termed) into the form of tubes, with the said edges meeting or nearly meeting. In order that a correct tube may be formed it is requisite that the flat plate of metal or skelp which is to be turned up into the form of such tube should be of uniform thickness and breadth. The usual process of rolling between revolving rollers in the ordinary course of manufacturing such flat plates or skelps, when carefully performed, will reduce the thickness to the requisite uniformity, and at the same time the breadth may also be rendered tolerably uniform if every part of the said rolling process is very carefully performed; but in order to obtain more precision in the breadth the two edges of the plate or skelp may be clipped with shears, or otherwise cut or dressed by some subsequent operation. And the two edges of each plate or skelp have been in some cases further prepared for turning up by drawing the flat plate or skelp, by power of a machine called a draw-bench, with an endway motion through between the cutting edges of a pair of fixed tools, which edges are set so as to cut away a shaving from off each edge of the flat plate or skelp, in order to render the breadth thereof uniform, and so as to prepare the said two edges for fitting together, when the plate or skelp is afterwards turned up into the form of a tube, with the said edges in contact, or very nearly in contact, one with the other, in order by their contact and union by subsequent soldering, brazing, or welding to form the longitudinal joint or seam of the

tube. The edges which are so to be brought in contact (or nearly in contact) have hitherto been prepared either by forming the plate or skelp with square edges; that is to say, the edges are at right angles to the flat surface of the plate or skelp, suitably for those square edges meeting edge to edge after the turning up, in which case the longitudinal joint or seam of the tube is termed by workmen a butt joint or seam. See Figure A, Sheet I. Or else the said edges have been prepared with what is termed feather-edged or bevilled edges, suitably for overlapping with one feather edge over the other after the turning up, in which latter case the longitudinal joint or seam of the tube is termed a lapped joint or seam, otherwise a scarf joint or seam. See Figure B. The first part of my said improvements consists in preparing the edges of the flat plates or skelps, by cutting out in the thickness of one of the edges of the metal plate or skelp a concave groove or channel extending along all the length of that edge, and forming the other edge of the same metal plate or skelp with a corresponding convexity suitable for fitting into and filling up such groove or channel when the two edges are brought into contact, or nearly in contact, by the turning up of such prepared plate or skelp into the intended tubular form. See Figure 1, Sheet I. I prefer to make the said groove or channel of an angular form, such as workmen term a vee groove, from its resemblance to the letter V, the corresponding convexity of the other edge being in that case what workmen term a double-bevelled edge. But the precise form of the concavity and convexity is immaterial, provided they are fitted one to the other, so that when the flat plate or skelp is turned up or nearly turned up, and that the two edges have been brought one towards the other, so as to meet and begin to come in contact, that they will do so by entering one edge into the other, with a tendency to guide each other properly in the act of being brought into close contact, and thereby cause the two edges to meet evenly, without either edge being more or less remote from the central line of the tube than the other edge. And when the said edges which have been so prepared with vee-grooved and double-bevelled edges for fitting one to the other (according to this part of my improvements) have been brought into contact (or very nearly in contact) by the turning up of the prepared plate or skelp into a tubular form, the said edges by entering one into the other will tend to hold each other mutually in place, so that each edge is enabled to resist displacement of the other edge from its proper place in the circumference of the tube, which is not at all the case with a butt joint, and is not so completely the case in a lapped joint; for instance, that edge which is innermost in a lapped joint may be forced inwards towards the centre of the tube, or the other edge, which is the outermost in a lapped joint, may be forced outwards

from the same centre. And when the said vee-grooved and double-bevelled edges of the turned-up plate or skelp are united together by soldering, brazing, or welding, as the case may be, the surfaces which are so united together will be of greater extent than would be the case if the same tube had been made with a butt joint, being nearly of the same extent as if it had been made with a lapped joint. The vee-grooved and double-bevelled edges aforesaid may be formed at the two edges of each plate or skelp, when the same is in its flat state, by the usual mode of drawing the flat plate or skelp, by power of a draw-bench, with an endway motion through between the cutting edges of a pair of fixed tools, with suitable fixed guides for retaining the two edges of the plate or skelp as they move onwards, so that they cannot fail to come properly in contact with the said cutting edges, which are suitably formed for cutting out the intended vee groove in one edge, and for cutting double bevils on the other edge of the same plate or skelp, which mode of cutting is somewhat similar to that which is commonly practised for preparing flat plates or skelps with feather edges suitably for being turned up to form lapped joints, the only difference from what is commonly practised is that the cutting edges of the tools must be suitably formed for cutting the vee-grooved and double-bevilled edges instead of feather edges.

In Sheet II. part of a draw-bench is represented with suitable cutters for preparing the two edges of plates or skelps according to this first part of my improvements. Figure 2 is a side elevation of one end of the draw-bench, Figure 3 an end elevation, and Figure 4 a horizontal plan. A, A, in all the Figures is one end of the long bench. B, a long-toothed rack which is moved endways by means of a toothed pinion in a horizontal cross axes, not represented, but which is turned round by the power of millwork in the usual and well-known mode of those draw-benches which act by rack and pinion. D is the slider fastened to the rack B, and moving therewith along the bench A. The tongs E for taking hold of the end of the plate or skelp are carried by the slider D, and the force wherewith the slider D is moved by the rack B is made to operate by means of a roller *d*, in order to close the tongs E so as to bite the end of the plate or skelp F with a very firm hold for drawing it endways, all which is as usual in draw-benches in common use. G, G, is a strong frame fixed on one end of the drawbench A, for sustaining pivots at the ends of two horizontal axes *a* and *b*, one situated over the other, in the same vertical plane, and each axis *a* and *b* carrying two circular wheels *e*, *g*, and *f*, *h*; the circumferences of those two wheels *e*, *f*, and *g*, *h*, which are one above the other, meet together and overlap each other a little with close lateral contact, so that the two form a pair of what is commonly

called circular shears, such as *e*, *f*, or *g*, *h*, each of which pair of circular shears will cut one of the edges of the plate or skelp F, when the same is drawn with a slow endway motion through between the said two pairs of circular shears *e*, *f*, and *g*, *h*, by the pulling action of the tongs E of the drawbench. *k*, *k*, are vertical setting screws at the upper part of the frame G, G, for adjusting the bearings for the pivots at the ends of the two axes *a* and *b*. Those axes, with the wheels which they carry, are freely at liberty to turn round according to the motion which the edges of the plate F will give to them, as it is drawn endways through between the two pairs of wheels *e*, *f*, and *g*, *h*; the circumferences of those wheels are of steel, and truly formed at their circular edges and at their flat sides. The two wheels *e* and *g* on the uppermost axis *a* are just so far apart that the space between them is the width to which the plate is to be reduced by the cutting or paring of its two edges; the other two wheels *f* and *h* on the lowermost axes are nearer together, as is shewn in Figure 3, which also shews the lateral contacts between the overlapping circumferences of the wheels *e*, *f*, and *g*, *h*, which cause them to act in the manner of circular shears, for cutting or paring away a narrow shaving from off each of the edges of the plate F as it is drawn through between the said two pairs of overlapping circumferences, and by such cutting or paring the plate or skelp F is brought to an uniform breadth, with its two edges cut smooth and straight, and square to the flat surfaces of the plate. This first cutting of the two edges is only preparatory to the vee grooving and double bevelling of the same edges, which is performed immediately afterwards at both edges at once by means of steel tools L, M, which, as they appear in Figure 4, resemble circular cutters with eight teeth, see also Figures 5 and 6; but they are not revolving cutters, for they are fixed immoveably, and operate with only one of the eight teeth of each, that tooth applying its cutting edge to one of the edges of the plate F, and those two teeth which are operative perform in the same manner as two fixed tools would do to cut the edges of the plate F as it is drawn onwards with endway motion against the cutting edges of the said teeth, by the action of the draw-bench. One of the said cutters L is for cutting a vee groove along one edge of the plate F, at the same time that the other cutter M is cutting a double bevil along the other edge of the same plate F. The said cutters are represented on a larger scale in Figures 5 and 6. Each cutter is made of a circular plate of steel, and they are turned in a lathe to prepare their circumferences with grooves around them, and the bottom of those grooves formed, one with a vee groove and the other with a double bevil, as shewn by the edge views L and M, Figure 6; and after being

so turned the said circumferences are cut out into teeth, as shewn in Figure 5. The cutting edge of each tooth which is so formed will have a projection above and another below the cutting part, which projections result from the grooves which have been turned in the lathe as aforesaid, and they will include the thickness of the edge of the plate F between them, one projection applying above the upper surface of the plate and the other projection applying below the under surface of the plate, and thereby they guide the edge of the plate F as it passes between them, so that the vee groove or the double bevil, which is cut by the cutting edge of the tooth, will be in the middle of the thickness of the edge of the plate. The cutters L and M are each firmly fastened upon a fixed upright pin, which stands up from a horizontal cross slider N, Figure 2, that is moveable by a setting screw, in order to advance the cutter towards the edge of the plate, until its acting tooth will cut that edge in a proper manner. The cutter L and M cannot turn round about their said fixed upright pins when they are in action; but after the cutting edge of one tooth of either cutter is become blunt, then that cutter can be put so much further round about its said fixed pin as to bring the cutting edge of the next tooth into action in place of the former tooth, and there the cutter is again made fast, wherefore each cutter L or M answers the purpose of eight fixed tools to be used one after another as they become worn; but the cutting edges of all the eight will be precisely alike in form, because of the mode of their formation in the first instance by turning in a lathe, as already mentioned. In case of the edges of the plate F cannot be cut sufficiently for completing the vee groove and double bevil at one time of passing the plate through between the cutters L and M in the draw-bench, in manner aforesaid, the plates may be repassed a second or third or a fourth time, as may be necessary, with the said cutters advanced by the setting screws of their cross sliders, such as N, Figure 2, so as to cut the edges more and more until they are sufficiently cut, with vee groove and double bevil corresponding one to the other, in preparation for being turned up. And note, fixed guides may, if required, be fixed to the frame G, G, so as to bear against the two edges of the plate or skelp F, in order to retain the same in place sideways as it is drawn endway forwards by the draw-bench. Or the edges of the plates or skelps may be cut with vee grooves and double bevils in a planing machine, the long moveable table of which is provided with a long narrow flat bed for receiving the flat plate or skelp (which must be previously set truly flat), with suitable means of fastening the flat plate down on the said bed, which should be somewhat narrower than the breadth of the plate, and raised above the moveable table of.

the planing machine, in order that the edges of the plate may overhang the narrow bed at each side thereof, suitably for being acted upon by the cutting edges of two tools, which must be held in suitable tool holders, sustained by the fixed part of the planing machine in a suitable manner, and in the proper position 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 bevils 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 may be requisite. The said means of fastening the flat plate down on the long narrow bed must be such as will be comprized within the space over the flat plate, leaving the two edges thereof exposed, in order that the fastenings may not interfere with the tools or their tool holders. For this purpose the flat plate may be fastened down on 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 in the bar being screwed down, their ends will press on the upper surface of the flat plate at suitable places along the length thereof for fastening the flat plate down on the bed in a proper manner for being acted upon by the tools on each side as aforesaid, without any part of the fastenings for the flat plate being in the way of those tools. And in place of cutting tools, such as are most commonly used in planing machines, two revolving circular cutters of steel may be used, with suitable teeth around their circumferences, for cutting the metal of the plate or skelp. They may be such revolving circular cutters as are used in machines for cutting or notching out the teeth of metal cog wheels; but one such circular cutter being adapted for cutting one edge of the plate or skelp with a vee groove, and the other such circular cutter adapted for cutting the other edge of the same skelp at the same time with a double bevel. The said two revolving circular cutters must be fastened on two vertical axes, which may be applied in the planing machine, by being mounted in suitable bearings formed in frames or carriages, which may be sustained by the fixed part of the planing machine in place of the usual tool and tool holder thereof; the said two axes and the circular cutters thereon being turned round with a proper velocity by any suitable toothed wheelwork and pulley-work with endless bands, in the usual manner of mounting, sustaining, and turning similar circular cutters in other cutting machinery. And each of the said revolving circular cutters may have two projecting circular rims, one above and the other below the toothed parts of the circumference of the

circular cutter, those rims being smooth for applying against the flat surfaces of the plate at each of the border edges of its breadth, the spaces between the said two projecting circular rims forming a circular groove around the cutter for receiving the said border edge of the plate, which groove is truly adapted to the thickness of the plate, in order to ensure that the vee groove and double-bevelled edge shall be respectively cut in the true middle of the thickness at each of the two edges of the plate. And the vertical axes of each of the circular cutters may be left at liberty to move a little up or down endways in the bearings wherein the axis revolves, so that each of the cutters may be able to accomodate itself to become opposite to the true middle of the edge of the plate which it is to cut, according to the guidance which each cutter will receive from its said two projecting circular rims, whereof one applies in contact with the upper surface, and the other in contact with the lower surface of the plate, at the border, edge, or margin thereof. And in case of using circular cutters in a planing machine, in manner aforesaid, the ordinary endway motion of the moveable table of the planing machine must be reduced to a slow motion suitable to the rapidity wherewith the circular cutters can cut the two edges. Or a machine, resembling a planing machine, but simpler in its construction, may be made for the purpose, with no other parts than are requisite for operating in manner aforesaid, with revolving circular cutters at the two edges of the plate, at the same time for cutting out a vee groove in one edge, and for cutting the other edge to a double bevel, such cutting proceeding with a slow progress from one end to the other end of each of the said edges respectively. The toothed circumferences of the revolving circular cutters may be formed of steel segments or portions of a circular cutter fastened by screws or otherwise into grooves formed in suitable disks of iron or steel, which are mounted on the axis so as that a set of such segments shall form the toothed circumference of a circular cutter, and the said disks or parts thereof may form the two projecting circular rims before mentioned as being one above and the other below the toothed part of the circumference of each circular cutter. And instead of the flat plate being moved endways, in order to bring every part of its length in succession opposite to the said two revolving circular toothed cutters, for cutting the edges thereof as aforesaid, the table and bed whereon the plate is fastened down, as already explained, may be stationary, and the two circular toothed cutters, with their vertical axes and the frames or carriages in which they are mounted respectively, may be applied in a suitable moving frame or sledge, which is supported upon horizontal straight-edges fixed on each side of the table and bed, parralel to the length thereof; and the said sledge being moved along those edges with a suitably slow progressive

motion, will convey the two circular toothed cutters along all the length of the plate, in order to cut along every part of the two edges from one end to the other end thereof. And whereas the teeth of revolving circular cutters soon loose their sharpness if the metal upon which they operate has a rough scaly surface, such as the edges of the plates or skelps would have when they come from the rolling without subsequent clipping or dressing of the edges, it will be best to have the edges of the plates or skelp cut smooth, and all the rough scaly surface removed, before submitting them to the operation of the revolving circular toothed cutters, as aforesaid. In some cases the edges of the plates or skelps are clipped with shears or otherwise, in order to render the width uniform, as already mentioned; in which case the rough scaly edges of the metal will have been removed, and if they are cut tolerably straight the edges will be in a proper state for being cut with vee groove and double bevils by two revolving circular toothed cutters, in manner aforesaid.

Figure 7, Sheet II., represents a pair of shears, such as have been used for so clipping the edges, and Figure 8 shews how a broad plate of metal is marked with lines in order to be cut along the middle of its breadth with the said shears, for dividing it into two narrow plates or skelps, and other lines for clipping the edges to render them straight and produce uniformity of breadth. A more complete mode of proceeding would be to plane the edges of a number of plates or skelps at once, by placing them 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, if great truth is desired, all the same plates or skelps might be turned over on the surface of the table with the other edges upwards, and those other edges could be all planed in turn to a flat surface. By this means both edges of each plate or skelp would be rendered truly straight and parallel, and the whole number of plates or skelps could be made exactly alike in width, and of the true intended width. After such preparation, by planing both edges straight, parallel, and square to the flat surfaces of the plates, the vee grooving and double bevelling of the same edges by a pair of circular revolving toothed cutters, would be easily effected, as there would be but little metal to remove by those cutters. And note, if preferred, two pair of such revolving cutters may be applied in the same machine, so as to employ two cutters for operating, one closely after the other, on the same edge of the plate; that pair of cutters which precedes and operates first on the two edges having coarse teeth, and cutting away more than half the metal which is to be removed, and the other pair of cutters, which follows after the said first pair, having finer teeth and cutting deeper for furnishing the vee grooving and double bevelling of the

edges to their intended state. The axes of both pairs of such cutters could be mounted and sustained by the same sledge, and the cutting would be more rapidly performed than by one pair. Or three pair of such cutters might be used, to follow one after another, in the same manner as above described respecting two pairs, and the cutting would be still more rapidly performed, the two pair which precede having coarse teeth, and each cutting away rather more than one third of the metal that is to be removed; the third or last pair would finish the vee grooving and double bevelling. And note, in case of tubes being required of a tapering form, that is, larger in diameter at one end than at the other end, like frustrums of cones, the flat plates or skelps therefore (which will be broader at one end than at the other end) may be prepared, according to this part of my improvements, with vee-grooved and double-bevelled edges, which may be cut in a planing machine either with the ordinary cutting tools of such machines, or with revolving circular cutters, in manner already explained, except that the two edges of such plates or skelps not being parrallel they could not both be cut at once, in the manner already explained; but the plate or skelp may be first fastened on the bed or table of the machine in a suitable manner for cutting one of its edges, and afterwards refastened thereon in a suitable manner for cutting the other edge. Or both edges of such tapering plates or skelps could be cut at once in a planing machine (or a machine similar thereto) operating with revolving circular cutters, as already explained, provided that the frames wherein the vertical axes of the cutter are mounted are rendered capable of motion in a transverse direction, or crosswise to the endway motion of the plate or skelp, so as to qualify the said circular cutter for acting upon the edges of the tapering plates or skelps, in order to cut out a vee groove in one of those edges, and to double bevil the other edge at the same time, notwithstanding the variability of the breadth of the tapering plate or skelp; because by the aforesaid motion in a transverse direction the circular cutters which are at the opposite edges of the tapering plates or skelps can be made to approach towards or recede from each other as the tapering form of the edges of the plate or skelp may require. And in like manner, in case of tubes being required larger in diameter at the middle part of their lengths, and smaller at each end, the flat plates or skelps therefore, which will be broader at the middle part of their lengths and narrower at each end, may have their edges prepared with vee grooves and double bevils, according to this first part of my improvement, in manner last explained, even although those edges should be curved lines instead of being straight lines.

Sheet III. represents another machine for preparing the edges of plates or skelps with vee grooves and double bevilled edges, according to this first

part of my improvements. It operates by revolving circular toothed cutters. Figure 9 is a side elevation, Figure 10 an end elevation, and Figure Eleven a horizontal plan. A, A, in all the Figures are two fixed standards forming the framing; B, D, a pair of cylindrical rollers, whereof the horizontal axes are sustained in the frames A, A, one roller B being above, and the other roller D beneath the plate or skelp F, and they hold the same between them so as to guide it to a proper level when it is moving onward endways. G and H are two revolving circular tooth'd cutters, mounted on two vertical axes *m* and *n*, which are sustained in bearings affixed to the frames A, A; and on the upper end of those axes *m* and *n* are pulley wheels *o*, *p*, for endless bands, by which a revolving motion is given to the circular cutter G and H; or cog wheels may be used in place of the pulley wheels *o* and *p*. The teeth around the circumference of the revolving circular cutter G are adapted for cutting a vee groove in one edge of the plate F, and the teeth of the other circular cutter G for cutting double bevils on the other edge of the same plate F at the same time. In passing through between the pair of rollers B, D, the plate F is retained at a proper level for the teeth of the revolving circular cutter G and H to cut the vee groove and the double bevil in the true middle of the thickness of each edge of the plate respectively. The plate F may be moved endways through between the rollers B, D, and the cutters G, H, by action of a draw-bench, at the end of which the machine is fixed, in the same manner as already explained respecting the machine in Sheet II. The dotted circles *e*, *f*, in Figure 9 indicate the places of two pairs of circular wheels mounted on horizontal axes *a*, *b*, one above the other, in the same manner as those already described in reference to Sheet II., and for the same purpose of paring the two edges of the plate F, when it is passing through between the said two pairs of circular wheels, which operate in the manner of circular shears, as already explained. G is that part of the frame by which the pivots at the end of the axes *a* and *b* are sustained, and *k* one of the setting screws by which the position of the upper axes *a* can be adjusted. The said wheels *e*, *f*, frame G, and setting screw *k*, are similar to the like parts in Figure 2, Sheet II., and the further representations of those parts in Figures 3 and 4, Sheet II., with the description thereof, will serve for the more complete explanation of the said parts in Figure 9, Sheet III. And note, the plates or skelps of metal in the state in which they are left by the rolling operations whereby such plates or skelps are manufactured, may have their edges cut smooth and straight and parallel by passing the plates endways through between two pairs of wheels, which are mounted on two horizontal axes, one over the other, in the same manner as the wheels *e*, *f*, and *g*, *h*, and their axes *a* and *b*, and frame G, G, Figures 2,

3, and 4, Sheet II., as herein-before described; except that both the said axes, with their said wheels, are to be turned round by the power of millwork for effecting the cutting of the two edges of the plate between the overlapping circumferences of the two pairs of wheels *e*, *f*, and *g*, *h*, in the manner of two pairs of revolving circular shears, as already explained; but the plate may be presented to the said pairs of wheels by a man, and assisted, if requisite, in moving endway forwards as fast as the two edges thereof are cut by the action of the said two pairs of wheels, which will in that way cut off a narrow strip from each of the edges, so as to cut both at once, and forming two smooth cut edges for the same purpose as is usually done by clipping along one edge at a time with shears, such as represented at Figure 7, Sheet II., and already mentioned. The two edges being cut at the same time will be straight and parallel, so as to reduce the breadth to uniformity, and both edges will be cut at once in less time than one edge could be clipped with shears. And note, it is not new to employ one pair of circular wheels, such as *e*, *f*, Figure 3, Sheet II., to cut along one edge at a time, in the manner of revolving circular shears, but it is new to combine two such pairs as *e*, *f*, and *g*, *h*, together, for the purpose of cutting off the two edges of a plate or skelp at the same time, and with certainty of rendering the breadth uniform; and the plate may be drawn endways through between such combined pairs *e*, *f*, and *g*, *h*, by power of a draw-bench, or other similar machinery, as already described in reference to Figures 2, 3, and 4, Sheet II.; in which case the two axes *a* and *b*, with the two combined pairs of wheels *e*, *f*, and *g*, *h*, are left freely at liberty to turn round as fast as the endway motion of the plate requires them to do in passing through between them. Or the two axes *a* and *b*, with the two combined pairs of wheels *e*, *f*, and *g*, *h*, thereon, may be turned round by the power of millwork applied to those two axes and the plate presented to the cutting action of the two combined pairs of wheels *e*, *f*, and *g*, *h*, by hand. And note, in cases when it is required to cut a broad plate along the middle of its breath, in order to divide it into two narrow plates or skelps, in the manner already mentioned in reference to Figure 8, Sheet II., then three pairs of wheels such as *e*, *f*, and *g*, *h*, and another third pair not represented, may be combined for cutting along the middle, and at the same time cutting along each edge of such broad plate along the lines represented dotted in Figure 8. In such case the two horizontal axes *a* and *b*, Figure 3, Sheet II., must be supposed to be so much prolonged at the ends which are beyond the wheels *g*, *h*, as to admit of having another third pair of wheels of the same kind as the wheels *g*, *h*, fastened on the prolonged ends of the axes *a*, *b*, the cutting edges of said third pair being at such distance from the cutting edges of the pair *g*, *h*, as will suit

for the intended breadth of one of the plates or skelps into which the broad plate is to be divided; the distance from the cutting edges of the pair *g*, *h*, to those of the pair *e*, *f*, being suitable for the intended breadth of the other of the plates or skelps into which the same broad plate is to be divided. Each of the axes *a* and *b* will therefore have three circular wheels fastened upon it, instead of the two which appear in Figures 3 and 4, Sheet II.; and when the two axes are mounted in due place, one over the other in their frame G, G, and their positions adjusted by their setting screws *k*, *k*, the said wheels will constitute three pairs suitably combined for the purpose of cutting along the middle and along the two edges of a broad plate at one operation, in order to cut two plates or skelps at once, with straight and smooth edges, and uniformity of breadth. The two axes *a* and *b* may be turned round by the power of millwork, in order to produce the said cutting action of the three combined pairs of wheels, or the broad plate may be drawn endways, by power of a draw-bench or other similar machinery, through between the said combined pairs of wheels. And note, the reference to Figure 3, Sheet II., in respect to three combined pairs of rollers, as herein-before last described, is only by way of illustration; but the strength of the axes *a*, *b*, and of the frame G, G, must be increased beyond the representation in those Figures suitably to the greater length that those axes must be, and to the greater strain they will have to endure with three combined pairs of wheels instead of two pairs. And instead of preparing the edges of flat plates or skelps with vee grooves and double-bevilled edges in the manner herein-before described, the said edges may be rabbeted in the manner shewn at Figure 2, Sheet I.; that is to say, a rabbet is to be formed along one edge by cutting away at one side or surface of the flat plate or skelp, and another corresponding rabbet along the other edge by cutting away at the contrary side or surface. The bottoms of the rabbets so cut may either be parallel to the said flat surfaces, or else may be bevilled, as is sufficiently explained by the Figures. The said rabbeted edges, when they are brought together by the turning up of the plate or skelp to a tubular form, must correspond and fit one rabbet to the other, so as to form a close longitudinal joint or seam along the length of the tube, as is represented in Figure 2; and such joints (which I term a rabbeted joint) partakes of the properties of a common butt joint and a lapped joint combined. The edges of the flat plates or skelps may be cut with such rabbets by any of the means herein-before explained for forming vee-grooved and double-bevilled edges, with such alterations of the cutting edges of the tools which are used as may be requisite. For instance, the rabbets may be cut by drawing the plates endways by power of a draw-bench between the cutting

edges of fixed tools, or they may be cut in a planing machine; or they may be cut with revolving circular toothed cutters applied in any of the modes herein-before described, or in any other suitable mode. And note, in case it should be required to accumulate a somewhat greater thickness of metal at the longitudinal joint or seam of a tube, by which the two edges of the plate or skelp are to be united, the thickness of that edge in which a vee groove has been cut may be increased by drawing the plate or skelp which has been prepared (in manner herein-before described) with a vee groove at one edge, and double bevil at the other edge, by power of a draw-bench, through between a pair of rollers, whereof one roller is formed with a double-bevilled edge around its circumference, for acting in the vee groove that has been previously cut along one edge of the plate or skelp, and the other roller is formed with a vee groove around its circumference, for receiving the double bevil that has been previously formed along the other edge of the plate or skelp. And in the passage between such pair of rollers the pressure which will be exerted by that roller which acts in the vee groove against one or both of the borders of that vee groove may be caused to act so as to spread out one or both of those borders to a wider angle, in order to increase the thickness of that edge of the plate or skelp along which the vee groove is formed beyond the original and proper thickness of other parts of the same plate or skelp. In such case it is obvious that the vee groove as originally cut out in the edge of the metal must be a deeper and narrower or more acute angle than will be ultimately required for the vee groove; also that the double-bevelled edge around the circumference of the roller must be formed with a wider or more obtuse angle than the vee groove as originally cut, in order that the pressure by such roller may be able to produce the spreading effect above mentioned, and thereby bring the vee groove to the proper obtuseness of angle which is required for fitting correctly to the double bevel at the other edge of the same plate or skelp. In short, the circumferences of the said two rollers must be so formed that by the pressure which they exert on the two two edges of the plate or skelp when it is drawn through between the pair, those edges will be left with a vee groove and double-bevelled edge properly adapted one to the other for fitting closely together when they are brought in contact by the turning up. Or, instead of such rollers fixed steel tools with blunt edges adapted for rubbing with a burnishing (and not a cutting) action may be substituted, and the plate or skelp being drawn through between two such fixed tools by power of a draw-bench, they will operate on the vee-grooved and double-bevelled edges in the same manner as the pair of rollers above described. And according to the form that may be given to

the double-bevelled circumference of the said roller (or to the blunt edge of the fixed rubbing or burnishing tool which may be substituted for the said roller) so the increased thickness that is given to the edge of the plate or skelp may be spread either at that side or surface thereof which will ultimately become the interior of the tube, or else at the other side or surface which will ultimately become the interior of the tube, or the said increased thickness may be spread at both sides. This will be fully understood by inspection of Figure *x*, Sheet 5. And the same may be said respecting the preparing of plates or skelps with rabbeted edges, as represented at Figure 2, Sheet I., and herein-before described, for accordingly as those edges may be cut during such preparation, so they may be made to produce an increased thickness along the joint or seam, when the said edges are brought in contact by the turning up of the prepared plate or skelp to a tubular form. And such increased thickness may either form a prominence beyond the proper outline for the external circumference of that tubular form, or else a prominence within the interior circumference thereof, or otherwise may form a slight prominence beyond the external circumference, and another within the internal circumference. This will be fully understood by inspection of Figure *y*, Sheet V. And note, in case of soldering or brazing the joints of tubes, the plates or skelps for which have been prepared with vee-grooved and double-bevilled edges accordingly to the first part of my improvements, and then turned up to a tubular form according to this second part of my improvements, the joint may be slightly forced open (by drawing a plug through the interior of the tube) whilst solder or spelter or brass wire with flur is put into the vee groove, and then the edges allowed to spring together and enclose the solder or spelter or brass wire in the joint in preparation for subjecting the tube to heat for melting the solder or spelter or brass wire, and brazing the joint. The tube should be kept in a proper position during the heating with the hollow of the vee groove downwards, so that melted solder will not escape. In case of soldering or brazing tubes with rabbetted joints the mode of proceeding will be nearly the same.

The second part of my said improvements relates to the operation of turning up flat plates or skelps of metal to a tubular form. The said flat plates are to be laid horizontally one at a time over the hollow of a long and somewhat broad gutter or trough of metal which serves for a mould, see a section thereof at A, A, Figure 1, Sheet IV., and the plate, whereof *a*, *b*, is a section, is forcibly pressed down by a suitably formed solid tool of metal B, B, into the said hollow of the mould A, A, so that the two extreme margins of the flat plate *a*, *b*, (being those portions of the breadth thereof which are most

immediately adjacent to the two edges *a*, *b*, of the flat plate) become bended up to the form of the two sides *d*, *d*, of the said hollow mould, and the middle part of the breadth of the plate becomes bended to the curvature of the lower part of the solid tool B, B, for a first stage of the operation of turning up. The form into which the plate is by that means bended for such first stage is indicated by the dotted lines *e*, *f*, *g*, *h*, *i*, being like a hollow gutter or trough with a concave bottom *g*, and the two sides *f* and *h*, ascending therefrom with a curvature which, at the extreme edges *e* and *i*, begins to be vertical, and the two margins *e*, *f*, and *h*, *i*, which are adjacent to the said edges *e*, *i*, being bended to the curvature of any suitable small portions (for instance, the Drawing represents twelfth parts) of a circular circumference of the same size as the tubular form that the whole breadth of the plate will be ultimately made to assume by the final completion of the turning up; but the middle part *f*, *g*, *h*, of the breadth of the plate, for an extent of five sixths of that breadth, is only bended with an easy curvature *f*, *g*, *h*, (dotted) during the said first stage; and as to the two margins *e*, *f*, and *h*, *i*, of that breadth (each of which margins is an extent of one twelfth of the whole breadth), the bending of those two margins during the said first stage being completed to the curvature of the intended tubular form, as already mentioned, the said first stage, as in fact a completion of the bending or turning up of two twelfths (or equal to one sixth) of the whole circumference of the tubular form that the whole of the plate will be ultimately made to assume by the final completion of the operation of turning up, the remaining five sixths of the breadth of the plate from *f* to *h* being bended to an easy curvature at that first stage in part of the bending that it must ultimately undergo. And then for the second stage of that operation the middle part of the concave bottom *f*, *g*, of the said gutter, which has been formed at the first stage, as aforesaid, is forcibly pressed by a suitable solid tool D, Figure 2, into the hollow of a long and narrow semi-cylindrical groove or trough E, which serves for a mould, and which groove E may, if convenient, be at the bottom of the hollow of the same mould A, A, as already described, Figure 1, or may be a distinct mould, so that the said concave bottom *f*, *g*, will be bended down by pressure of the tool D, and made to assume nearly the curvature of the hollow groove E, and exactly the curvature of the under part of the tool D. And during such bending the two extreme edges *e* and *i* of the plate will be turned up and brought one towards the other, as shewn by the dotted lines, in approximation towards the intended tubular form, until the said edges *e* and *i* have in that manner approached so near to the tool D as almost but not quite to touch the sides thereof. The bending of the plate is therefore brought

by the second stage to an incomplete oval curvature, as is shewn by the dotted lines in Figure 2. And then for the third and last stage of the said operation, the ovally-bended plate aforesaid is compressed between two long and narrow semi-cylindrical grooves, with the angles along each side of each such groove rounded off, see E and F, Figure 3, Sheet V., the said grooves corresponding one to the other like the two halves of a mould which, when they come together, will form a hollow cylindrical mould, of the proper size for the exterior of the tubular from which the metal is intended to assume when the turning up is completed, and by compression between the said two halves E and F, Figure 3, of such mould, the aforesaid extreme edges *e* and *i*, which had (as already mentioned) been brought one towards the other during the second stage, are brought into close contact one with the other at this third stage, and by giving a very forcible compression with the two halves E and F of the said mould after such contact has taken place, the turning up is finally completed to the intended tubular form, which is represented by the dotted circle k^*, Figure 3. And note, although the aforesaid description implies (and the Figures represent) that such tubular form is a cylindrical form of tube, and although a cylindrical form will most commonly be required, nevertheless if any other tubular form, such as elliptical or egg shaped, or polygonal or other form, should be required, my mode of turning up will be the same as aforesaid, but with the several hollow moulds suitably hollowed, and the solid tool suitably curved for producing the intended tubular form. And in like manner respecting tapering forms of tubes which are larger in diameter at one end than at the other end, or larger in diameter at the middle of the length than at the ends, the extreme edges of the flat plates or skelps being suitably shaped for such forms of tubes, and the several hollow moulds suitably hollowed, and the solid tool suitably curved, the turning up of such plates may be performed in the manner above described. And respecting the aforesaid first stage of the operation of turning up, according to this second part of my improvements, which stage is performed, as already described, by pressing the flat plate or skelp into a broad hollow mould by pressure, exerted with a corresponding solid tool, as shewn in Figure 1, the bending action during that first stage turns up the two marginal portions of the breadth of the flat plate or skelp which are most immediately adjacent to those two extreme edges of the plate or skelp which are ultimately to be brought together by the completion of the turning up. And the degree of bending to be given at that first stage to the said two marginal portions should be a completion (or very nearly a completion) of all the bending that those two marginal portions will require when they are ulti-

mately brought to assume their respective places in the circumference of the intended tubular form by the final completion of the turning up. The middle portion of the breadth of the flat plate or skelp between the said two marginal portions is only bended to an easy curvature at the said first stage. And respecting the aforesaid second stage of the said operation, which stage is performed by pressing the aforesaid concave middle portion of the breadth of the plate or skelp into a narrow hollow mould by presure, exerted with a nearly (but not truly) corresponding solid tool, as shewn in Figure 2, the bending action during the second stage should be solely operative on the said middle portion of the breadth, and the degree of bending to be given at that second stage to the said middle portion should be somewhat more than will be required when that middle portion is ultimately brought to assume its proper place in the circumference of the intended tubular form. This is represented in the Figure 2, where the curvature of the under part of solid tool D is shewn to be more rapid than the curvature of the hollow groove E beneath it, and the plate is bended down to the said more rapid curvature of the under part of the tool D at the second stage. And respecting the aforesaid third and last stage of the said operation, which stage is performed by forcibly pressing the partly turned up plate or skelp between the two corresponding halves of a hollow mould, as shewn in Figure 3, the bending action during that third stage should be chiefly operative on those portions of the breadth of the plate or skelp which intervene between the aforesaid middle portion and the two aforesaid marginal portions of the said breadth, and which intervening portions will not have been sufficiently bended at the two first stages. The final compression at this third stage, which, as already stated, completes the turning up, after the two extreme edges of the plate or skelp have come into close contact, tends to compress all parts of the metal of the plate or skelp to the exact form of the interior circumference of the hollow moulds. And as to the middle portion of the breadth, which, as before mentioned, was bended at the second stage somewhat more than would be ultimately required, that middle portion (during the said final compressure at the conclusion of the third stage) becomes rebended to its proper intended form as ultimately required; and in consequence of such over bending of the said middle portion at the second stage beyond what will be required, and the subsequent rebending thereof at the third stage to what is required, the two extreme edges of the plate or skelp which have been brought into contact will be kept securely in contact owing to the metal having been set on a strain by the rebending, with a tendency to close the said two extreme edges nearer together than their contact will allow, and therefore they will not separate or quit contact of

themselves after being released from the pressure, and removed from the hollow mould, but considerable force would be required for separating them from their contact. And the degree of such overbending during the second stage should be such as by the rebending thereof at the conclusion of the third stage will cause the two extreme edges to spring together with as much force of contact as may be required. And note, in case it should be required to turn up flat plates or skelps of metal to a tubular form, with the two extreme edges brought opposite one to the other, but not in contact, so as leave an open crevice of any required width between the said two edges, such turning up may be performed by this second part of my improvements if a metal ruler of the same width as the said open crevice is required to be, is fastened along within the summit of the hollow of the upper half of the mould which is used in the aforesaid third stage of the operation, in order that the two extreme edges of the plate or skelp may come in contact with the two edges of the said ruler at the summit of the mould at the same time and in the same manner as the said two extreme edges of the plate or skelp would (according to the foregoing description) come in mutual contact one edge with the other, and the said ruler keeping the said two extreme edges apart to a proper distance for the width of the open crevice which is intended to be left between them as aforesaid, the metal of the plate or skelp will be then qualified for receiving that final compression at the conclusion of the third stage of the operation, by which compression, as already explained, the turning up is completed, and the metal made to assume the form of the hollow left between the two half moulds. And in this way, by employing a ruler of suitable width within the mould, flat plates or skelps may be turned up to any required portion of the circumference of a tube, exceeding half; for instance, if the width of such ruler is equal to one fourth of the circumference of the interior of the mould then the plate or skelp which is turned up will be three fourths of the circumference of a complete tube, and so on of any other portion. The breadth of the plates or skelps which are prepared for such incomplete tubes must in all cases be as much less than the width that would be required for making a complete tube in the same moulds as the width of the ruler which is to be fixed within the mould, so that the breadth of the plate and the breadth of the said ruler will together make up the proper breadth for a plate or skelp which would be turned up to a complete tubular form in the same mould. And the flat plates or skelps of metal which are to be turned up in manner aforesaid may be prepared in any of the modes now in use for such purpose, that is to say, the extreme edges may be such as will be left by the rolling operation, whereby the plates or skelps have been manufactured, and brought to their

intended thickness, and as nearly as can be done to their intended breadth; or the edges so left may be afterwards dressed or clipped with shears or otherwise, to render them smooth and more correct in breadth, and may also be cut more truly parallel by drawing the plates or skelps by power of a draw-bench through between the cutting edges of fixed tools, as herein-before mentioned; and the said extreme edges may be square, that is, at right angles to the flat surfaces of the plates or skelps, suitably for becoming edge-to-edge or butt joints in the tubular form which will be given by the turning up, see Figure A. Or the said edges may be feather-edged suitably for becoming lapped joints in the tubular form which will be given by the turning up, see Figure B. Or the said edges may be rabited or may be vee grooved and double bevelled according to the first part of my improvements, as herein-before described, suitably for becoming rabited or vee-grooved joints in the tubular form which will be given by the turning up, see Figures 1 and 2, Sheet I. But what I prefer is, that the extreme edges of the plates or skelps should be prepared with vee-groove and double-bevilled edges according to the first part of my improvements, as herein-before described. And then the turning up of the plates or skelps, so prepared, being performed according to the second part of my improvements, as herein-before described, the said edges will form a very close and firm longitudinal joint or seam for the tube which is produced by such turning up, see the section thereof, Figure 1, Sheet I. And as to the means of producing the requisite pressure for bending the plates or skelps of metal into hollow moulds, according to this third part of my improvements, as herein-before described, in reference to Figures 1, 2, and 3, Sheet IV. Any kind of mechanical powers commonly used in machinery for pressing or bending metals may be employed, choosing such as will be capable of exerting sufficient force of pressure for the purpose. The force that will be required will vary according to the thickness of the plate, and the kind of metal, and the size of the tubular form which is to be produced, and according to the length of such tubular form or to the length thereof which is intended to be bended up at once. For the several hollow moulds and the solid tool, herein-before described, in reference to Figures 1, 2, and 3, Sheet IV., may be somewhat longer than the whole length of the plates or skelps of metal which are to be turned up in those moulds, in which case very great pressure and great strength of pressing machinery will be required for bending the plate or skelp, in manner herein-before described, throughout the whole length from end to end thereof at the same time. Or the said moulds and tool may be short suitably for bending only a portion of the whole length of the plate or skelp at once, in which case less pressure and strength

may be requisite. And after the bending of one such portion of the length has been carried as far as one of the three stages herein-before described, (but no farther,) then by a repetition of the pressing in the same short mould and tool, another adjoining portion of the length of the plate or skelp is to be similarly bended in continuation, and so on, portion after portion is to be subjected to the bending action in the same short mould and tool, until the whole length is bended and brought to the same state as would have been done at once if the long moulds and tool had been used, as above mentioned. But note, with short moulds and tool, and for bending only portions of the whole length at once, the hollows of the several moulds must be enlarged at the ends of their lengths with easy curves, in the manner of what are termed bell-mouthed or trumpet-mouthed hollows, in order that the plate or skelp of metal may not be forced to change its state too suddenly from that portion of its length which is beyond the length of the mould, and remains unbended thereby, to that neighbouring portion of the length of the plate or skelp which is bended in the mould to a more advanced stage of the bending. And of the transition from the bended to the unbended part of the length of the same plate or skelp takes place with an easy curvature from once such part to the other, the bending by repetitions, as aforesaid, will effect the turning up of a long plate or skelp in a proper manner with less expensive moulds and tools, and with less force of pressure, and less expensive machinery for giving the pressure; but the work of turning up must go on slowly in so bending by repetitions, and therefore, in manufacturing tubes in a large way, it will be better to use long moulds and tools, as already stated, for bending the whole length of the plates or skelps at once, and to employ machinery of sufficient strength and power for exerting the great pressure which will in that case be required. And by way of shewing an example of one kind of pressing machinery, which will be suitable amongst other kinds which may be used for the purpose, I will explain how the well-known mechanical power of hydro-mechanical or hydrostatic press may be applied, and two, three, or more hydrostatic cylinders combined into one press for acting in concert to produce like pressure along every part of the length of the long hollow moulds and tool before mentioned, see Sheet VI., wherein Figure 4 is a longitudinal elevation, and Figure 5 a transverse section of a compound hydrostatic press with three cylinders N, O, P, which are lodged in a very strong horizontal frame Q, Q, to which upright pillars *v*, *v*, are firmly fastened at their lower 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 piston or plunger fitted into it, commonly called the ram of the press,

see *r* in the section Figure 5, with a collar of leather applied around within the upper end of the cylinder N, for close fitting around the ram *r*, and on the upper end of each of the three rams is a strong plate called a follower, as at S, T, V, and upon those three followers the lower hollow mould A, A, is lodged and fastened by suitable screws, the upper mould or solid tool B, B, being fastened to the under side of the head R, R, by screws which suspend its weight. The relative positions of the hollow mould A, A, and the solid tool B, B, above it, appears in the section Figure 5, which is the same as Figure 1, Sheet IV., already explained, but on a smaller scale. The action of the press is the same as that of ordinary hydrostatic presses, and which action is well known. Water is injected into the hollow of each cylinder N, O, P, by means of a forcing pump and a conveyance pipe therefrom to the said hollow, and the water acting beneath the lower end of the same by the hydrostatic pressure forces the ram to move up out of the cylinder through its collar of leathers above mentioned with a very great force, all which being as usual in hydrostatic presses requires no further description; but in the present case, the said conveyance pipe from the injecting pump must communicate equally by branches with all the three cylinders N, O, P, in order that any quantity of water which is injected by the pump may distribute itself equally amongst the three cylinders, and then the three rams thereof will be forced up with equal force and motion, because they are all precisely of the same diameter, and they act by their followers S, T, V, beneath the lower hollow mould A, A, at equal distances apart along the length thereof; and the force required for bending the plate or skelp of metal will be required to act at all parts of the length of the long mould A, A, and upper mould or solid tool B, B. The injecting pump may be worked by power of a steam engine or other power, and a loaded safety valve must be applied to some convenient part of the pump, communicating freely with the interior of the said conveyance pipe, in order to permit the water to escape by lifting that loaded valve whenever, by continuance of the injection of water by the pump into the interior of the three cylinders has been continued until the hydrostatic pressure on the valve, and consequently the hydro-mechanical force exerted by the three rams to press the lower hollow mould A, A, upwards towards the upper tool B, B, has become as great as it is intended to be, and if the injecting pump continues to be worked after that pressure has been attained, then the said loaded safety valve will allow all the water which may be afterwards forced by the pump into the conveyance pipe to escape therefrom into the open air without entering into either of the cylinders, or causing any increase of the force exerted by the rams Wherefore, by loading the said safety valve more or less, the force of

pressure that will be exerted to force the lower hollow mould A, A, upwards towards the upper tool B, B, and consequently to compress the plate or skelp of metal between the two, can be limited to what is required without risk of exceeding the intended limit, all which is as usual in hydrostatic presses, and therefore requires no farther explanation; but the facility wherewith the pressure can be thereby limited, and the great force which can, as is well known, be exerted by hydrostatic cylinders, renders them a very suitable mechanical power to be applied for this purpose. The manner of performing the operation of turning up by the said press is as follows:—For the first stage of the operation, the long hollow tool A, A, being lodged and fastened in its place on the three followers S, T, V, and the upper solid tool B, B, being fastened beneath the head R, R, of the press, as they appear in the section Figure 5, the said hollow mould and solid tool will be in the same relative positions as they are represented in the section Figure 1, Sheet IV., which has been already explained. The flat plate or skelp of metal must be introduced horizontally endway into the press between the pillars V, V, thereof, and when laid horizontally over the broad hollow of the said mould A, A, as already explained, it is guided so as to lay correctly over the hollow by means of studs, which are fastened at each edge of the hollow of the mould A, A, and project upwards suitably for receiving the two edges of the plate or skelp of metal between them; and if the plate should be too wide, it will not go in between those stops, and will be detected as being unfit for turning up; but the plate should be of a proper width, which will be shewn by being wide enough to fill the space between the said studs without being loose between them. The plate being properly laid, then the injecting pump is set to work, and by forcing water into all the three cylinders at once, will raise up the three rams and their followers S, T, V, and the hollow tool A, A, together with the plate or skelp thereon, until the said plate in so rising upwards is brought with its upper surface in contact with the under part of the solid upper tool B, B, which is immoveable, and then what has been before described as a pressing of the plate begins, though in fact in the mode now describing it is rather a pressing up of the two margins of the plate by the ascending motion of the lower hollow tool A, A, whilst the middle part of the breadth of the plate is prevented from rising by the upper fixed tool B, B, but the effect is the same as already described in reference to the aforesaid Figure 1, and need not be repeated, except to state that the motion of the press is to be continued until the plate is completely bended, and a great force of pressure should be ultimately exerted in order to ensure that the bending is completely performed. Then the water is let out from any convenient part of the conveyance pipe by

opening a cock in the usual manner by hydrostatic presses, and the rams *r*, with the followers S, T, V; and the long hollow tool A, A, will descend by their own weight, and the bended plate or skelp may be removed from the hollow of the mould by passing it endways out of the press between the pillars *v*, *v*, thereof, and it will be one plate or skelp bended to the first stage of the operation of turning up. After a number of such plates or skelps have been treated in the same manner as aforesaid, then the press may be prepared for performing the second stage of the operation of turning up, by removing the upper solid tool B, B, from beneath the head R, R, of the press, by withdrawing the screws by which it was suspended and fastened in place beneath the same; and the other solid tool D, Figure 2, is to be substituted and suspended beneath the head R, R, by the said screws. After this preparation the further bending of the plates or skelps which have been previously bended to the first stage is to be performed by introducing those plates or skelps, one at a time, endways into the press between the pillars *v*, *v*, thereof, and the press put in operation in the manner above described, for the purpose of bending the middle part of the breadth, so as to turn up the edges to the second stage, as shewn in Figure 2, and already explained. And after a number of the plates or skelps have been so treated, then the press may be prepared for performing the third stage, by removing the upper solid tool D, and substituting an upper hollow tool, such as appears at X, in Figure 6, and herein-before described as hollowed, with a semi-cylindrical groove for forming the upper half of a hollow mould; the corresponding semi-cylindrical groove E, Figure 3, for the lower half thereof being formed at the bottom of the hollow of the mould A, A, and the press is worked as before, in order to compress the partly turned-up plates or skelps between the said two halves E and X, as already explained in reference to Figure 3, for completing the turning up of the plates or skelps to their intended tubular form. And note, instead of a semi-cylindrical groove E being formed, as aforesaid, at the bottom of the hollow of the mould A, A, a distinct mould with such a groove may be used for the lower half, as shewn at Y, Figure 6, and a like mould Z, with a corresponding groove for the upper half, so as that such two halves Y, Z, when they come together will form a complete hollow mould, which will be the same as to its interior form and size, and will operate in the same manner as the mould formed by the groove E at the bottom of the mould A, A, and the groove in the mould X, in Figure 6. But in case of so using the pair of half moulds Y, Z, the mould A, A, must be removed from its place on the three followers S, T, V, of the press, and the lower half mould Y substituted, when the press is to be prepared for performing the third stage of the operation, the

upper half mould Z being at the same time suspended from the head R, R, of the press, instead of the half mould. And note, in case of an extensive manufacture of tubes there may be three such presses as represented in Sheet V., whereof one press may perform turning up of the plates or skelp to the first stage with the hollow mould A, A, and solid tool B. Another press may continue the turning up of the same tubes or skelps to the second stage, with the hollow mould A, E, and solid tool D; and the other press may be employed for completing the turning up of the intended tubular form, either with the hollow half moulds A, E, and X, or else the half moulds Y and Z; and in that way the loss of time and trouble of changing the moulds and tools will be avoided, and a great quantity of work performed. And note, when plates or skelps of shorter length than the full length of the hollow moulds are required to be turned up therein, short pieces of one of the same plates or skelps should be laid in the hollow of the mould at the two ends of the hollow, beyond the two ends of the short plate or skelp, so as to serve for prolonging the short plate or skelp to the full length of the hollow, in order that all the length thereof may be filled up when the great pressure is given, and therefore the said pressure will be operative in a uniform manner along all the length of the moulds in the same manner as if plates or skelps of the full length were to be operated upon. Such short pieces, when they have been once pressed into the form of the hollow, may be retained and fastened therein for continual use, so long as short plates or skelps are to be turned up. The plates or skelps of metal which are to be turned up, according to this second part of my improvements, in the manner herein-before described, must be correctly prepared in their width and their thickness to suit the exact size of the tube, which the hollow moulds and tools are adapted to form by their operation as aforesaid; and for so turning up for tubes of different sizes, different hollow moulds and tools must be provided. The hollow moulds and tools may be made of wrought iron or of cast iron, with their hollows and acting surfaces accurately formed by planing, so as to be straight and true and parallel, and also their exterior surfaces, which are to apply beneath the head of the press R, R, and above the followers S, T, V, should be planed true, flat, and parallel. The surface of those followers, and of the head of the press to which the said exterior surfaces of the moulds and tools are to apply, being also planed true, the parts will fit correctly together to perform the turning up with accuracy. Care must be taken to keep the hollow of the moulds well cleaned out from dirt and scales, which will be liable to separate from the surfaces of the plates or skelps when they are in the act of being bended. And the plates or skelps of metal which are to be turned up, according to this second part of my

improvements, may be operated upon in a cold state, the metal having been previously annealed in order that it may bend more easily; or the metal may be slightly heated and operated upon whilst in the heated state if preferred, although it will not be advisable to heat the metal so strongly as to occasion scales to be formed on its surfaces by the heating. The said mode of turning up, according to this second part of my improvements, is most applicable to tubes whereof the metal is thin in comparison to the interior diameter of the tubes, such as the tubes which are used in the interiors of steam boilers for locomotive steam engines and steam engines for steam navigation, particularly the latter. Such tubes require to be very truly formed, and the edges well united, and owing to the thinness of the metal whereof they are usually made, the bending can be performed for turning up in manner already explained when that metal is cold. And respecting the turning up of plates or skelps which have been prepared with vee-grooved and double-bevilled edges, according to the first part of my improvements herein-before described, and with an increased thickness of metal along that edge which is vee grooved, or the turning of skelps which have been prepared according to the said first part of my improvements, by rabbeting the edges, and so that the overlapping of the rabbeted edges will cause an increased thickness at the joint, and in case of such increased thickness being intended to be at that side or surface of the plate or skelp which will ultimately become the exterior surface of the tube, all which has been herein-before described in reference to Figures *x* and *y*, Sheet V. When the turning up of such plates or skelps to a tubular form is to be preformed by pressure within hollow moulds, according to this second part of my improvements, as herein-before described, then the internal surfaces of the hollows of such moulds should be suitably cut away at those parts where such increased thickness will apply to, and be pressed against the said interior surfaces, in order that after the turning up the said thickened edge may be left slightly prominent beyond the correct outline that is proper for the exterior circumference of the tubular form which is produced by the turning up. And such prominent part continuing along the longitudinal seam or joint all the length of the tube will allow for any loss of metal which may take place in the subsequent operation of heating and welding the edges together, and the prominence being hammered or pressed down in that operation, or subsequently, well render the joint very close. Or in case of soldering or brazing it may be thought desirable to have such a prominent part along the joint, which may be subsequently hammered or pressed down, if preferred. And respecting the turning up of plates or skelps of metal which have been prepared with bevilled or feather edges, suitably for forming lapped or scarf

joints, such as Figure B, Sheet I., and which mode of preparing skelps with bevilled or feather edges is commonly practised, and forms no part of my improvements, the turning up of such bevelled or feather-edged plates or skelps to a tubular form may be performed by pressure within hollow moulds, according to this second part of my improvements, in the same manner as herein-before described, except that the bending of the middle part of the breadth of the plate during the second stage of the operation by pressure with the upper solid tool D, Figure 2, Sheet IV. should be no more than will be ultimately required, without any of the overbending herein-before mentioned. This will be effected by making the under part of the tool D of the same curvature as the interior of the intended tubular form to which the plate is to be turned up. But in that case the bevelled edges of the plate will not remain in close contact one with the other after the turning up, for when the metal is released from the pressure that is given at the conclusion of the third stage of the operation, and withdrawn from the hollow moulds used in that third stage, the metal will spring so as to separate the bevelled edges from the contact and open the joint. In such case the said edges may be afterwards brought into contact again, and secured from separating by application of the third part of my improvement, herein-after next to be described.

The third part of my said improvements consists in a mode of fastening together the two edges of plates or skelps of metal which have been turned up to tubular forms. For this purpose double-dovetail pieces of metal called cramps are to be inserted or inlaid into corresponding double-dovetail notches cut out in the two edges, which are to be fastened together, one such cramp being so inserted at every place along the length of the tube where such fastening is required. See Figure 1, Sheet VII., where *a* is one of the double-dovetail pieces called cramps, which is wider at each end and narrower at the middle. It may be cut out by suitable tools in a fly press from a flat plate of metal, which is somewhat thicker than the thickness of the turned up plate or skelp into which the cramp is to be inlaid. A great number of such cramps may be made by that mode with ease and rapidity, and the cramps so cut out will all be exactly of the same form and size. C, Figure 2, represent two of the dovetail notches in the edges of the turned up plate or skelp; they are exactly opposite one to the other, so as to form a pair of dovetail notches which are adapted for receiving one of the cramps *a*. The two notches which constitute the pair of notches C may be cut out in both edges of the turned-up plate or skelp at once, by suitable tools in a fly press after the turning up to the intended tubular form has been performed, the pair of notches so cut out being exactly of a proper form and size to admit of

inserting one of the cramps *a* into the pair of notches, but so as that the cramps so inserted will fill the pair of dovetail notches, leaving no sensible vacancy, and then by hammering or pressing on the flat surface of the cramp as it lays in its place in the notches, and is supported on a suitable mandril within the turned-up tube, the cramp can be spread laterally so much as to fast itself into the notches, and also its thickness will become reduced to the same thickness as the metal of the turned-up tube, and the two surfaces of the cramp brought into exact conformity with the internal and external surfaces of the turned-up tube; and such double-dovetail cramps may be applied to plates or skelps which have been prepared for turning up, and which have then been turned up to a tubular form, by any of the modes heretofore commonly known or practised for preparing and turning up of plates or skelps of metal, without the adoption of either of the first or second parts of my improvements, because such cramps are equally applicable whether the edges of the turned-up plate or skelp form an edge-to-edge or butt joint along the length of the tube, as shewn at Figure A, Sheet I., or whether those edges form a lapped or scarfed joint, as shewn at Figure B, Sheet I., and whether the two edges are in close contact, or whether an open cleft is required to be left between the edges, the said cramps will in either case have the effect of securing the edges in their intended relative positions, either in close contact or at their intended distance asunder, as the case may be. And the edges which are so secured by the insertion of such cramps in manner aforesaid may be left without other means of union than the said cramps afford, or the said edges may be united together by any of the usual modes of soldering or brazing or welding, which latter, in the case of the metal being wrought iron, is to be preferred, and the said cramps will in either of those cases be very useful for retaining the two edges in their intended relative positions whilst the operation of soldering, brazing, or welding is performed. And particularly so in the latter case, because of the welding heat to which the iron must be subjected, whereby it becomes softened and renders the edges of the turned-up plate or skelp (without such cramps liable to become separated; also in the case of welding the action of the hammering or of the pressure between revolving groove rollers, or of the drawing through conical or bell-mouthed apertures, to one or other of which operations the heated and softened iron is subjected for effecting the welding, renders the said edges in either case very liable to be displaced from their intended relative positions during the operation of welding. But such displacement will be prevented by the said cramps, which will hold the two edges securely together in close contact during the heating and during the welding. And the said cramps

being themselves of wrought iron they will become welded into the iron of the welded tube, so as to form one solid mass therewith to render such welding the more complete, and the cramps should be cut out of plates of iron of the same quality as that of the plates or skelps into the edges of which they are to be inlaid, and should be inlaid with the lengthway of the fibres of the iron disposed in the same direction in the cramp, as is the case in the plate into which the cramp is inlaid. And in like manner in soldering or brazing the edges together the cramps become securely soldered or brazed into their places. And what I prefer is to use such cramps in the manufacture of metal tubes, whereof the flat plates or skelps have been prepared with vee-grooves and double-bevilled edges, or with rabbeted edges accurately cut, according to the first part of my improvement, already described, and which plates or skelps have then been turned up to a tubular form by pressure in moulds, according to the second part of my improvements, as herein-before described, with the said edges fitting accurately one to the other with very close contact; and in conformity with the other parts of the circumference of the tubular form, and then by inserting cramps, according to this third part of my said improvements, the said edges will be effectually secured in the true intended relative positions which have been previously given to them. And note, in case of plates or skelps which have been prepared with bevilled or feather edges in the usual manner for making lapped joints, as shewn at Figure B, Sheet I., without any part of my improvements, and which have then been turned up to a tubular form, according to the second part of my improvements, such turned-up tubes are liable, as already explained, to spring open at the joint, and separate the bevilled edges from close contact. In such case, if this third part of my improvements is to be adopted, the bevilled edges of the turned-up tube must be brought into proper contact by any adequate means of compressing the exterior of the turned-up tube previous to the inlaying, and during the inlaying and fastening of the cramps into the said edges, and the cramps so inlaid will secure the edges from separation. And note, according to the degree of the said compression which is so given to the exterior of the turned-up tube, the bevilled or feather edges may be forced together beyond their places of contact, and thereby the joint or seam of the turned-up tube will acquire an extra thickness, with a prominence along the joint beyond the regular outline of the circumference of the turned-up tube. This will be understood by inspection of Figure *z*, Sheet V., where it is shewn how such prominence may be at the exterior surface of the turned-up tube, or at the interior surface thereof, or at both exterior or interior surfaces, or how the joint may be rendered even without any prominence, as may be desired. And

whichever of those states the joint may be brought into previous to and during the inlaying of cramps into the edges of the turned up skelp, according to this third part of my improvements, those cramps will retain the edges securely in that state. And this third part of my improvement is particularly applicable in cases of plates or skelps which have been prepared with square edges suitably for butt or edge-to-edge joints, as shewn at Figure A, Sheet I., and which plates have then been turned up to a tubular form, according to the second part of my improvements; cramps inlaid into the edges of a turned-up skelp of that kind will be very useful for fastening the edges together. The manner of cutting out the dovetailed notches in the edges of turned-up tubes by tools in fly presses, as herein-before mentioned, for the reception of cramps, according to this third part of my improvements, is explained by Figure 3, Sheet VII., which is a front elevation of a long work-bench A, A, whereon two, three, or more ordinary screw or fly presses (whereof one is shewn at B) are fixed in a row, and at such distances apart as the cramps are intended to be inlaid into the edges of the tube, and which will most commonly be one cramp near to each end and one cramp at the mid-length of each tube, unless the tube is very long or large, and then more cramps may be inserted, but the said fly presses can be moved along the bench A, and again fixed at the places required, but all in a straight row, and as many of them as may be required. One of the presses is shewn at B, and the dotted lines C, D, denote the places for two other like presses. The upper moveable tool in each press (marked *a*) is a punch of the proper size and shape for cutting out a double dovetailed notch in the usual manner of fly-press punches; but as to the bolster or lower hollow tool into which the said punch is to descend when it is forced down by turning the handle *d* of the screw *e* of the press, in order to cut through the metal of the tube that is to be operated upon, the said hollow tool cannot be fixed in its usual and proper place on the base R of the press, because it must go withinside of the tube. Therefore the said lower hollow tools for all the presses that are uses are formed or are fixed in a long cylindrical iron bar E, F, that is of a size to admit the tube which is to be operated upon to press easily over the bar. The said bar E, F, is kept truly to its intended place by an upright cylindrical bolt G, which is sustained at its lower and upper ends by fitting truly through holes in a bracket H, fitted to the bench A, near to one end thereof, and the middle part of the bolt G passes through the enlargement or cross socket at the end F of the bar with exact fitting. The other end E of the bar is mounted in the same manner, but with a smaller cylindrical bolt *g*, which will not require any enlargement of the bar E, F, beyond its cylindrical form. The latter small bolt *g* is withdrawn when

the tube which is to be operated upon is to be put into its place, which is done by putting it endways over the bar E, F, as represented in section at *i*, *i*, with the seam or longitudinal joint of the tube uppermost. Then the said small bolt *g* being inserted again, the bar E, F, becomes secured in its proper place, so that the several bolsters or hollow tools will be exactly beneath their respective punches *a*, in a proper manner for cutting out the double dovetailed notches in the edges of the tube *i*, *i*. But as the bar E, F, would spring downwards by the force of such cutting out, it is necessary to support it firmly beneath each hollow tool; for which purpose the under side of the cylindrical bar E, F, is notched or cut away to obtain a broad flat surface beneath each hollow tool, in which surface is inclined from the horizontal, and a wedge piece is fitted beneath the said inclined surface, so as to be capable of sliding endways along beneath that surface in the direction of the length of the bar E, F. Part of the said wedge piece is formed to suit the curve of the interior of the tube *i*, *i*; and if the wedge piece is sliding along beneath the inclined surface of the bar E, F, towards the highest end of that surface, then the wedge piece and the bar together will allow the tube to pass easily over them both, for putting the tube into its place in the manner already explained. But after that is done, the said wedge piece being slided along in a contrary direction, or towards the lowest end of the said inclined surface, then the wedge piece will quite fill the space beneath it within the tube *i*, *i*, and thereby enable the bar to receive a solid support within the tube when the lower side of the bar is lodged, as shewn in Figure 3, in a suitable hollow at the base R of the press. Each of the said hollow tools is provided with such a wedge piece; and in order to move the several wedge pieces in manner aforesaid, whilst they are inclosed within the tube, each one has a stem extending from it alongside of the bar E, F, or in groove cut therein to near one or other of the ends thereof, beyond the limits to which the ends of the tube extend towards the ends of the bar E, F, so that by pushing or pulling the said stems endways, the several wedge pieces to which they belong respectively can be made fast within the interior of the tube, as is requisite for enabling the hollow tools in the bar E, F, to resist the force of cutting out the double dovetailed notches in the tube by the forcing down of the punches *a* of the several presses through the metal of the tube, and into the said hollow tools which are beneath that metal within the interior of the tube. Or the several wedge pieces can by means of their said stems be set loose within the tube *i*, *i*, so as to allow the same to be removed from off the bar E, F. The hollow tools in the bar E, F, must be of steel, welded or otherwise fastened to the upper side of the bar E, F; the upper surfaces of the steel being formed to

suit the curve of the interior of the tube, and the hollow in each tool (which hollow is of the exact size and shape of the punch *a*, or upper tool of the press) must be continued down into the substance of the bar E, F, in order to form a hollow space for the reception of the fragments of the metal of the tube which will be cut out therefrom in making the double dovetailed notches. The wedge piece will form a bottom to the said hollow space, and prevent those fragments from falling through into the interior of the tube, but after so many have been cut as to nearly fill up the said hollows with such fragments, they must be removed. And after the double dovetailed notches have been cut out in a tube in manner aforesaid by action of the several presses, then a cramp is to be inserted into each of those notches to fill the same up. But previously the bar E, F, is moved endways for a short distance within the tube *i*, *i*, (but without allowing any motion of the tube *i*, *i*,) whereby the hollows in the several hollow tools in the bar E, F, are carried away from beneath the upper tools or punches *a* of the several presses, and solid parts of the steel surfaces of the hollow tools are brought beneath the said punches or upper tools *a*, suitably for bearing up beneath the several cramps, which are then to be inserted into the notches, and then the flat lower ends of the upper tools *a* being forced down by action of the several presses upon the upper surfaces of the cramps, so as to compress and expand the same laterally, in order that they may become fastened into the notches wherein they have been inserted, and in fact become inlaid into the substance of the metal of the tube. Note, in order to allow the aforesaid endway motion of the bar E, F, to take place, the base part of the bracket H should be fitted into a metal groove, which is fastened to the bench A, A, so as to render the bracket H capable of sliding horizontally the requisite short distance for the aforesaid endway motion of the bar E, F. And note, in cases when from any cause the edges of the turned-up plate or skelp are not in proper contact one with the other, they ought to be then after the said turned-up skelp has been put into its place (as at *i*, *i*, Figure 3, and as already described), some suitable force of compression should be applied to the exterior circumference of the turned-up skelp, so as to bring the two edges thereof into their proper intended state of contact, and then (but not before) the double-dovetailed notches should be cut out by action of the several presses in the manner already explained, and then the cramps inserted and fastened as already explained, so as to retain the edges in their said intended state of contact before the force of compression is relaxed; the requisite force of compression aforesaid may be given by thumb-screws tapped through small puppets in the base R of each press, and pointing in a horizontal direction towards the

centre line of the tube; and when a plate or skelp of metal has been accurately prepared with vee grooves and doubled-bevilled edges, or else with rabbeted edges, according to the first part of my improvements, and then turned up by pressure in hollow moulds into a correct tubular form, with those edges in close contact and in exact coincidence one with the other, according to the second part of my improvements; and then the said edges being secured from separating by means of double-dovetailed cramps inlaid and fastened into corresponding notches in the said edges at suitable distances apart along the length of the tube, according to third part of my improvements, the result will be very complete, whether a tube so formed is to be left without any further uniting of its said edges than by means of the said cramps, or whether those edges are to be further united by soldering, brazing, or welding; and particularly so in the latter case, because the said clamps will effectually retain the edges in their close contact, and prevent them from separating whilst the iron is in progress of being heated, as well as after the iron is become heated to its welding heat, and consequently become much softened, and whilst it is undergoing the operation of welding, however that operation may be performed. And those edges of the iron plate or skelp which are to be united together by the welding, and also those edges of the iron cramps which are inlaid into the iron of the plate or skelp, being all clean cut surfaces of iron, and being in close contact whilst the heating is going on, no dirt or scale can gain admission between the said surface, so as to hinder or impair the perfect welding thereof together, and consequently the said welding will be very completely formed, with much less force of hammering, or of pressure by rolling between revolving grooved rollers, or by drawing through bell-mouthed apertures, than is usually required for effecting the welding of similar tubes which have been prepared in any of the modes heretofore known or practised for manufacturing tubes. And respecting turned-up plates or skelps of wrought iron, the edges of which are to be welded together to form the longitudinal seam or joint of the tube, when such a skelp has been brought to a welding heat throughout all its length in a furnace, and is to be withdrawn therefrom, the iron will be in a softened state; and as to that end of the said skelp which is formost when the skelp is withdrawn from the furnace (by a man taking hold of that end with tongs in the usual manner of proceeding), the said end being at a welding heat is liable to be bended, and the edges of the plate or skelp displaced from their proper intended contact by the force to which the said foremost end is then subjected. In order therefore to prevent such displacement of the edges at the said foremost end, the said edges should be secured by one of the said double-

dovetailed cramps inlaid into the two edges near to the said end, or two such cramps may be so inlaid near together, in order to render the said foremost end very secure from separation or displacement of the edges when the said end is at a welding heat, and is to be withdrawn from the furnace. Or both ends of the skelp may be treated alike in manner aforesaid, and a cramp being also laid into the edges at the midlength of the tube will in most cases be sufficient for securing the edges together, unless the length of tube or its size may render more security advisable, and in such case more cramps may be inlaid. And respecting the preparing of the two edges of the turned-up plate or skelp at that end of the tube which will be foremost when the tube is in the act of being withdrawn from the furnace, in order to secure those edges from displacement or separation when such end is afterwards heated to a welding heat, instead of inlaying cramps into those edges at the said end in manner aforesaid, those edges may be prepared by previously welding them together at the said end by hand hammering on the groove of a swage block, with a plug or mandril inserted into the interior hollow of the tube in the usual and well-known manner of welding iron tubes by hand labour. The said welding of the edges may extend along as much of the length of the tube from the said foremost end thereof as can be conveniently welded at one time of heating the end of the tube in a forge fire to a welding heat. And by such preparatory welding the said foremost end will be prepared for resisting the force to which it will be afterwards subjected, when the whole or the greater part of the length of the tube (including the said foremost end) has been heated in the furnace to a welding heat, and is in that state to be withdrawn from the furnace by taking hold of the said foremost end with tongs.

And whereas it has been the practice to weld together the edges of turned-up plates or skelps of wrought iron for short portions of the length at the two ends of each such skelp, in cases when the remainder of the said edges are to be united together along all the rest of the said length by brazing, therefore I make no claim to any such welding at the ends, except when the same is done by substitution for the inlaying of double-dovetailed cramps into the edges at the ends, as herein-before described, by way of a previous preparation, for the whole or the greater part of length of the turned-up plate or skelp of iron being afterwards heated to a welding heat in a furnace, the end which is so prepared by welding partaking of such welding heat, and being that end which will be the foremost end of the skelp when the same is to be withdrawn from the furnace after having been heated to a welding heat therein. For hitherto in the manufacture of iron tubes by welding the edges together no

means whatever have been used for securing those edges in their intended relative positions during the operation of heating the iron to a welding heat in a furnace, and of afterwards withdrawing the iron from the furnace in that state. This third part of my improvement in preparing plates or skelps of iron (which have been turned up to a tubular form), by inlaying double-dove-tail cramps into the edges of such plates or skelps, has the effect of securing those edges in their intended relative positions whilst they are undergoing the operation of heating to a welding heat in a furnace, as well as afterwards, whilst the iron is in the act of being withdrawn from the furnace in that state, and likewise during the remainder of the operation of welding, however that operation may be performed. And the said securing of the edges being most wanted at that end of the turned-up skelp or tube which will be the foremost, and when it is in the act of being withdrawn from the furnace with that end at a welding heat, the securing of the edges at the said foremost end may be performed either by inlaying of a cramp or cramps into the said edges, in manner herein-before explained, or otherwise by preparatory welding of the said edges in manner herein before explained; and the same result will be obtained in either case of securing the said edges whilst heating, and after being heated in a furnace to a welding heat, and no such result has been hitherto obtained by any means hitherto known or in use in the manufacture of welded iron tubes, whereof the whole of the length of the tubes, including the foremost end thereof, is heated to a welding heat. And respecting the welding of the edges at the ends of iron tubes, whereof the remaining length of the same edges are afterwards to be brazed together (and which welding has been commonly practised as herein-before mentioned), the object of such welding has been to obtain greater strength at the ends of the tubes than can be obtained by brazing the edges together, because such tubes have been made for the boilers of locomotive steam engines, and require to be fastened by their ends into their places in such boilers, and the longitudinal seam or joint of the edges of such tubes when finished is a welded joint at each extreme end, and a brazed joint along all the length intervening between those two extreme ends. And such tubes are not heated throughout the whole or the greater part of their length to a welding heat in a furnace, but the heat to which the iron is subjected for brazing the joint is not such as to render the iron very soft, as is the case in a welding heat, nor are those ends which are welded subjected to any action during the heating and brazing which requires the edges at those ends to be secured, or which renders the ends liable to injury, and the brazing of the edges from end to end of such tubes could be performed as well without any welding at the ends as with such welding, if it were not

required for the particular use for which such tubes have been manufactured as aforesaid, that the ends should be more strongly united than can be done by brazing.

And another fourth part of my said improvements is a new mode of introducing turned-up plates or skelps or tubes into the furnace wherein they are to be heated for the purpose of soldering, brazing, or welding those edges of the metal which are to be united together by one or other of those means. Hitherto the turned-up skelps for manufacturing welded iron tubes have been merely thrown into the furnace through the open doorway thereof by the strength of a man's arms, and allowed to fall heavily with an endways motion by their whole weight on the heated bottom or bed of the furnace. And in case the whole length of a long skelp cannot be so thrown in at once, then the end of it is seized with a pair of tongs, and it is pushed further into the furnace by sliding it endways along the said bed thereof, until its whole length is introduced. In that way of introducing the tubes, the foremost end thereof is liable to cut up the surface of the heated bed, and get scoria or dirt into the open end of the tube. Most commonly the skelps have been thus thrown into the furnace at the same door through which the iron is afterwards to be withdrawn after it has acquired its welding heat. But in some cases the turned-up skelps have been so thrown into the furnace at another doorway at the opposite end or side of the furnace to that end thereof where the door at which the heated iron is to be withdrawn is situated. I prefer the latter mode, and my new mode of introducing the turned-up skelp into the furnace is to mount the same upon a strong iron bar which is longer than the tube, and one end of the bar extends into the interior of the tube more than half way through the length thereof, in order that the tube may rest securely with its whole weight suspended upon the upper edge of the said iron bar, which is so much smaller in its dimensions than the interior of the tube as not to touch the tube at any other place than along the highest part or summit of the circumference of that interior. The said iron bar having the tube thus suspended upon one end of it, is kept in a horizontal position, or nearly so, whilst it is moved with an endway motion through the open doorway of the furnace, in order to convey the tube into the interior of the furnace without touching the bed, or sides, or any part thereof; and when the whole length of the tube is so introduced through the doorway, the said bar is lowered down so much as to allow the tube to descend easily, in order to deposit it horizontally without violence on the flat heated bed of the furnace, so that it may rest with its weight thereon, and be supported throughout all its length, and then the iron bar is withdrawn with an endway motion from the interior of the tube without disturbing the tube,

but leaving the same deposited on the heated bed of the furnace, in the precise position it is intended to occupy therein for becoming heated. The weight of the said iron bar and of the tube may be sustained during the above operation in a very simple manner by means of a pendulous rod or chain, suspended from some fixed point as high up in the roof of the building as can be obtained, the lower end of that rod or chain terminating in a ring large enough for the said iron bar to pass easily through, and a notch may be made in the under side of the said bar for lodgment thereof in the said ring, at such place in the length of bar as will cause the weight of the two ends thereof to be nearly balanced. The said pendulous rod or chain should hang vertically when the iron bar is at the midway of the whole extent of endway motion that must be given to the bar for withdrawing the end of it from the interior of the tube, in order to leave the same deposited on the heated bed of the furnace, in the manner already explained. And there should be some kind of screw link in the rod or chain, or other means of adjusting its length, so that the ring will sustain the iron bar in a horizontal position whilst the end of it is withdrawn in manner aforesaid from the interior of the tube. A workman holding the extreme end of the said long bar in his hands, when the whole weight thereof is suspended by the rod or chain (with the weight of the two ends of the bar nearly balanced), he can very easily withdraw the end of the bar from the interior of the tube without disturbing the tube as it lays horizontally on the bed of the furnace. And after the end of the bar has been so withdrawn from the interior of the tube, and from the door of the furnace; the workmen can then turn the direction of the long bar sufficiently aside for enabling him to insert the end of the bar into the interior of another tube, which may be one of a heap laid in a convenient position near to the furnace for such insertion. Then he may move the ring at the lower end of the pendulous rod or chain along the bar (towards the said tube) to another notch in the under side of the bar, at a proper place therein for causing the weight of the two ends of the bar to be nearly balanced when the tube is mounted in place upon one of those ends. After this preparation he can with ease take up the tube upon the end of the bar without feeling the weight thereof, and after restoring the lengthway of the bar and the tube thereon to the proper direction of the doorway of the furnace, he is ready for introducing the tube with promptitude into the interior of the furnace the instant after the door is opened. And after having quietly deposited the tube horizontally on the heated bed of the furnace, as before explained, he may then remove the ring of the pendilous chain back again along the bar to the first-mentioned notch in the under side thereof, where the

weight of the two ends of the rod itself without any tube will be nearly balanced, and then he can withdraw the end of the iron bar from the interior of the tube without disturbing the tube, as already explained; and the instant that the extreme end of the bar is withdrawn from the doorway of the furnace, the door thereof may be closed to avoid unnecessary cooling of the interior of the furnace. For welding iron tubes (in which case it is important to avoid such cooling) the door may have a notch in it of sufficient size to allow the said bar to be withdrawn, but no larger, and then the door may be shut down the instant that the tube has been deposited on the heated bed of the furnace, and the bar can be withdrawn at leisure through the said notch, so as only to require the doorway to be kept open during the very short time that is requisite for introducing and depositing the tube on the bed of the furnace in manner aforesaid, and after the bar has been withdrawn the said notch is to be closed. By the adoption of this fourth part of my improvements the bed of the furnace will not be disturbed or cut up from its proper flatness, by the force of throwing the cold iron tubes down upon it, and by afterwards pushing them endways further in with tongs, and getting them to lay straight in the proper place whilst resting with their weight on the said floor, and the tubes will not be liable to get any scoria or dirt of the floor into their open ends by moving them along the floor, as is the case in the ordinary mode, as already mentioned. And the bed of the furnace, whilst the same is heating, may be prepared to a true straight bed at the part where the tubes are to lay upon it by batting and smoothing down the surface of the bed with a long heavy bar of iron, which is suspended by the pendulous rod or chain before mentioned, and the weight so much balanced as to be easily handled by men holding the extreme end of the bar which is out of the furnace, and thereby raising and letting fall the heavy end that is within the furnace in a suitable manner for beating flat on the bed of the furnace with heavy blows of the said heavy end of the iron bar, which must be straight and broad, and rubbing along the bed with a horizontal endway motion thereof till the bed, when strongly heated and the materials softened, is made very straight and true and smooth, and with a proper surface for the iron tubes to lay upon, in order that they may be properly supported along the whole of their length, so that they cannot bend down or become crooked when they become softened by the heat. Or, instead of the simple pendulous rod or chain for suspending the long bar upon which the tubes are to be introduced into the furnace, as above described, a carriage with four wheels to run upon a railway may be used for holding a similar (but shorter) bar horizontally, and at the same time moving it endways with the tube upon it, in order to convey the same into the

furnace through the open doorway thereof, and with means of then lowering the said bar just so much as is requisite for depositing of the tube gently upon the flat bed of the furnace, but still keeping the said bar horizontal, and afterwards withdrawing it with an endway motion horizontally from the interior of the tube without touching that interior, but leaving the tube deposited on the flat bed of the furnace. See Sheet VIII., wherein Figure 1 is a longitudinal elevation, Figure 2 an end elevation, and Figure 3 a horizontal plan. A, A, Figures 1 and 2, are two railway bars, laid horizontally on the ground opposite to the door of the furnace, and conformably to the direction in which the tubes are to be laid in the furnace, on the flat bed thereof. B, B, B, B, are the four wheels of the carriage to run upon the rails A, A, and D, D, is the carriage which rests with four bearings upon the two axles of the said four wheels. E, E, are four upright pillars which stand up from the carriage D, being firmly fastened thereto at their lower ends, and having screw threads around their upper ends for nuts *a*, *a*, to screw upon, and thereby enabling the pillars E, E, to sustain a horizontal platform F, F, which by turning the nuts *a*, *a*, can be set higher or lower as may be required, and with the surface of the platform F horizontal, and it can then be made fast by screwing down other nuts *e*, *e*, on the pillar above the platform F, F. G is a broad bar or trough which is moveable, and is sustained above the platform F, F, by means of four inclining parallel levers *g*, *g*, *g*, *g*, which are fastened at their lower ends upon two horizontal axes *w*, *w*, which extend across the width of the platform F, F, and the upper ends of the said levers *g*, *g*, sustain four joint pins which project out horizontally from the sides of the moveable trough G; all those four parallel levers *g* being of equal length and inclining alike, they can be made to act with motion similar to that of a parallel ruler (as is apparent in Figure 1) for raising or lowering the trough G a small quantity, but it will preserve its horizontal position in so rising or lowering. H is one end of the bar of iron whereon the tube is to be mounted, as already mentioned. The said end H is fastened upon the trough G in a horizontal position, and projects forwards over the end thereof in a direction parallel to that of the rails A, A; but the Drawing only shews a portion of that end of the bar H whereon the tube is to be mounted for introducing it into the furnace. J is a balance weight at the lower end of a lever I, which descends from one of the axes W, W, of the parallel levers *g*, *g*. It balances a portion though not the whole of the weight of the trough G with the bar H, but without the weight of the tube upon it, so that those parts have a decided tendency to descend by their own weight by motion of the four parallel levers *g*, *g*, *g*, *g*, about their horizontal cross axes W, W, and joint pins before

mentioned, until such descent is limited by a stop K, which is fastened to the trough G, and strikes against the end of a stop screw *h*, which screws horizontally through a part of the platform F, and therefore by turning the handle at the end of the screw *h*, the height can be regulated at which the trough G and the bar H will rest, when their further descent is stopped by the stop screw *h*, but they will continue horizontal. When the parallel levers *g*, *g*, are in a vertical position the trough G and the bar H, with the tube thereon, will be at their highest position, but still horizontal. And when the lever I, with its balance weight J, is in a vertical position, the parallel levers *g*, *g*, will have passed a little way beyond the vertical, as is shewn by the dotted lines *z*, *z*, and then the trough G and bar H, with the tube which is mounted on the end of it, will remain at their highest position which is suitable for introducing the tube into the furnace, which being done then by the parallel levers *g*, *g*, being moved from the direction *z*, *z*, to the directions *g*, *g*, Figure 1, the trough G, with the bar H and the tube thereon, will be lowered down as much as is requisite for depositing the tube upon the flat bed of the furnace; and the stop screw K, which limits the further descent of the parts, retains the bar H at the proper height for being withdrawn from the interior of the tube after the same has been deposited on the flat bed of the furnace. And the said stop screw K must be regulated according to the height of the flat bed of the furnace, so as that when the stop *h* comes in contact with the end of the screw K, the bar H will not then touch the interior of the deposited tube during the withdrawing of the bar H with an endway motion from that interior. The manner of using this apparatus is as follows:—The whole carriage is run back along the rails A, A, so as to remove it from the furnace to any convenient place where prepared plates or skelps turned up into a tubular form are laid up in readiness. And the trough G and bar H being raised to their highest position by the workman pushing the trough G endways until the parallel levers *g*, *g*, pass beyond the vertical to the direction *z*, *z*, the bar H will remain in that highest position as already explained, then a tube is put horizontally over the projecting end of the bar H, the extreme end of which bar must reach more than half way through the length of the tube, in order that the latter may by its weight hang steadily on the bar H, and there should be some stop on the bar H to determine the proper place to which the tube is to be brought along the bar from the extreme end thereof. Then the carriage with the tube on the bar H is to be run forwards along the rails A towards the furnace until the end of the tube approaches close to the door, which being opened the tube is without any delay introduced with a horizontal endway motion into the furnace, through the opened doorway, by running the carriage

steadily forwards along its rails A, A, until the further endway motion of the tube in that direction is stopped by the end of the trough G coming in contact with a fixed stop *m*, Figure 1, and thereby the parallel levers *g*, *g*, are removed from their said direction *z*, *z*, and forced beyond the vertical position on the other side thereof, whereupon the weight of the trough G and the bar H, with that of the tube thereon, causes those parts to descend in opposition to the balance weight J, but in an easy manner, by motion of the parallel levers *g*, *g*, *g*, *g*, which keep the trough G and the bar H and the tube horizontal in so descending, and thereby the tube is gently deposited in its intended position on the flat bed of the furnace; but the descent of the trough G and bar H continues a little further, until the stop screw *h* prevents any more descent, and leaves the end of the bar H, which is within the interior of the tube, quite free from all contact with that interior. Then the said end of the bar H is withdrawn from the interior of the tube by motion of the whole carriage backwards along the rails A away from the furnace, leaving the tube properly deposited within the furnace, and the door thereof may be closed the instant after the end of the bar H has been so withdrawn. And note, the horizontal endway motion, whereby the tube is introduced into the furnace, will be so correctly performed with the said carriage that it will not be requisite to open the usual large door of the furnace for introducing the tube therein, but only a notch or small arch at the lower part of that door, which arch may be only as much larger than the tube as to just admit the same to be introduced without touching, but leaving only very little open space at which cold air can gain admission, so as to cool the furnace; and the opening of the said small arch may be closed the instant after the extreme end of the bar H is withdrawn. And in order that the motion of the carriage along its rails A may be performed with regularity when introducing the tube into the furnace, and when withdrawing the bar H from the interior of the deposited tube, an endless rope or chain W, Figure 1, whereof one part is attached to the carriage, may be extended over two pulley wheels V, V; and one of those pullies being turned round either by hand or by connection with millwork, the carriage will be moved with a very steady motion, avoiding jerks. And this fourth part of my improvements also includes the following mode of facilitating the withdrawing of the heated tubes from the furnace. After a tube has acquired a welding heat within the furnace, and requires to be withdrawn therefrom, it is usually seized at one end with a pair of tongs, and dragged all its length along the bed of the furnace through the open door thereof; but the iron being in a softened state by the heat, the tube is liable to become bended in being so drawn out at the door, and is also liable to carry out scoria and dirt with it

from the bed of the furnace. In order to facilitate the withdrawing of the tube, when at a welding heat, I apply a grooved roller on a horizontal axis beneath that doorway of the furnace through which the heated tube is to be withdrawn, so that the tube will rest on the groove of the said roller whilst the tube is in the act of being drawn out; and a revolving motion may be given to the roller, in order to assist in withdrawing the tube when it is resting in the said groove; and the said revolving motion, if sufficient rapid, will cause the surface of the roller with which the heated tube is in contact to rub beneath the surface of the tube with a tendency to remove loose scoria and dirt, which the tube may carry out with it from the bed of the furnace. The groove in the said roller being in conformity with the direction in which the tube lays on the bed of the furnace, the tube will be kept straight in coming out. The horizontal axis of the said roller may be turned round by any suitable means which will give it a revolving motion; and the roller should be situated as near to the furnace as it can be, and part of the wall of the furnace beneath the fire-door may be cut away to leave room for the roller. And in order to facilitate the moving of the heated tube endways along the bed of the furnace when it is first pulled at the foremost end by a man with a pair of tongs in the usual manner, the hinder end of the heated tube may at the same time be gently pushed onwards by a man with an iron rod introduced through the other door of the furnace, so as to assist the endway motion of the tube. And in cases where my improvement is adopted for introducing the tubes into the furnace, as herein-before described, the same long iron bar which is provided for so introducing the tubes may be used for pushing gently at the hinder end of the heated tube as it lays on the bed of the furnace; a cap, with a flat end, being first fastened on the extreme end of that bar, suitable for applying to the end of the heated tube. But note, the force wherewith the end of the heated tube is so pushed onwards must be moderate, or the iron of the tube in its softened state might be bended from its proper form. The principal force must be given by the man at the foremost end, dragging forward that end of the tube with his tongs in the usual manner, but a gentle pushing behind at the other end will afford some assistance in first moving the tube endway along the bed of the furnace, until the foremost end of the tube is advanced sufficiently forward through the doorway to begin to bear in the groove of the revolving roller before mentioned, and then the action thereof will begin to assist in the further endway motion of the tube for withdrawing it from the furnace. And whereas it will be the foremost end of the heated tube which will have to endure the principal part of the force which the man must exert with tongs for dragging the tube endway along the

bed of the furnace; and the said foremost end is liable to be bended, and the two edges of the plate or skelp disjointed, from their proper contact by that force, the double-dovetail cramps which are to be inlaid into the said edges, according to the third part of my improvement, as herein-before described, will be extremely useful for securing the said edges against such separation; and accordingly one or more of the said cramps should be inlaid into the said edges near to each end of the tube, in order to enable those ends, when they become softened by the heat, to sustain the force to which they must be subjected in the act of withdrawing the tube from the furnace by dragging it endways at the foremost end with tongs in the usual manner, and pushing it endways at the hindmost end. On, instead of inlaying such a cramp into the said edges at the foremost end, those edges may be firmly welded together by hand hammering or otherwise, before the tube is introduced into the furnace, so as to complete the foremost end of the pipe for a short portion of its length, in the manner herein-before described; and when the tube so prepared is heated to a welding heat in the furnace, the foremost end will be better qualified for resisting the force to which it will be subjected for withdrawing it from the furnace. After a tube has acquired a welding heat within the furnace, and requires to be withdrawn therefrom, it is usually seized at one end with a pair of tongs, and dragged all its length along the bed of the furnace, through the open door thereof; but the iron being in a softened state by the heat, the tube is liable to become bended in being so drawn out at the door, and is also liable to carry out scoria and dirt with it from the bed of the furnace. In order to facilitate the withdrawing of the tube when at a welding heat, I apply a grooved roller on a horizontal axis beneath that doorway of the furnace through which the heated tube is to be withdrawn, so that the tube will rest on the groove of the said roller whilst the tube is in the act of being drawn out. And a revolving motion may be given to the roller, in order to assist in withdrawing the tube when it is resting in the said groove; and the said revolving motion, if sufficiently rapid, will cause the surface of the roller, with which the heated tube is in contact, to rub beneath the surface of the tube with a tendency to remove loose scoria and dirt which the tube may carry out with it from the bed of the furnace. The groove in the said roller being in conformity with the direction in which the tube lays on the bed of the furnace, the tube will be kept straight in coming out. The horizontal axis of the said roller may be turned round by any suitable means which will give it a revolving motion; and the roller should be situated as near to the furnace as it can be, and part of the wall of the furnace beneath the fire-door may be cut away to leave room for the roller. And in order to facilitate the

moving of the heated tube endways along the bed of the furnace, when it is first pulled at the foremost end by a man with a pair of tongs in the usual manner, the hinder end of the heated tube may, at the same time, be gently pushed onwards by a man, with an iron rod introduced through the other door of the furnace, so as to assist the endway motion of the tube. And in cases where my improvement is adopted for introducing the tubes into the furnace, as herein-before described, the same long iron bar which is provided for so introducing the tubes may be used for pushing gently at the hinder end of the heated tube as it lays on the bed of the furnace, a cap with a flat end being first fastened on the extreme end of that bar suitable for applying to the end of the heated tube; but note, the force wherewith the end of the heated tube is so pushed onwards must be moderate, or the iron of the tube in its softened state might be bended from its proper form. The principal force must be given by the man at the foremost end dragging forward that end of the tube with his tongs in the usual manner, but a gentle pushing behind at the other end will afford some assistance in first moving the tube endway along the bed of the furnace, until the foremost end of the tube is advanced sufficiently forward through the doorway to begin to bear in the groove of the revolving roller before mentioned, and then the action thereof will begin to assist in the further endway motion of the tube for withdrawing it from the furnace. And whereas it will be the foremost end of the heated tube which will have to endure the principal part of the force which the man must exert with tongs for dragging the tube endway along the bed of the furnace, and the said foremost end is liable to be bended, and the two edges of the plate or skelp disjointed from their proper contact by that force, the double-dovetail cramps which are to be inlaid into the said edges according to the third part of my improvement, as herein-before described, will be extremely useful for securing the said edges against such separation. And accordingly one or more of the said cramps should be inlaid into the said edges near to each end of the tube, in order to enable those ends when they become softened by the heat to sustain the force to which they must be subjected in the act of withdrawing the tube from the furnace, by dragging it endways at the foremost end with tongs in the usual manner, and pushing it endways at the hindmost end. Or, instead of inlaying such a cramp into the said edges at the foremost end, those edges may be firmly welded together by hand hammering or otherwise, before the tube is introduced into the furnace, so as to complete the foremost end of the pipe for a short portion of its length, in the manner herein-before described; and when the tube so prepared is heated to a welding heat in the furnace, the foremost end will be better qualified for resisting the

force to which it will be subjected for withdrawing it from the furnace. And other parts of my improvements in the manufacture of metal tubes relates to the welding together of the edges of plates or skelps of wrought iron which have been turned up to a tubular form.

The fifth part of my said improvements is for welding the edges of plates or skelps of wrought iron which have been turned up to a cylindrical tubular form by passing such skelps, when heated to a welding heat throughout the whole of their length, between a pair of revolving grooved rollers, whereof the grooves are formed to operate upon one fourth part of the circumference of the said tubular form by each roller, one at the highest and the other at the lowest part of such circumference, and with a pair of grooved guiding cheeks applied between the said rollers, to operate laterally against the other fourth parts of the circumference of the said tubular form at each side of that circumference. See Sheet IX., wherein Figure 1 is a front elevation, and Figure 2 a horizontal plan, of a machine for the above purpose. *b*, *b*, are the standards of the frame for sustaining the bearings for the two horizontal axes A, A, and B, B, whereon the revolving grooved rollers E and F are fastened, and are turned round with a continuous revolving motion by the power of millwork applied to the said axes A, B, in the usual manner of a pair of revolving rollers for operating upon metal, but the circumferences of the two rollers E and F do not touch one another, in order that space may be left for a pair of grooved guiding cheeks R and S, to be fixed to the frame *b*, *b*, so as to be interposed between those circumferences at the places where those circumferences are nearest one to the other, as is shewn in Figure 1, which also shews that the grooves around the circumferences of the two revolving rollers E and F, and the grooves in the two fixed guiding cheeks R and S, conform one groove with the other, so as to leave between the four a circular aperture *a*, of a proper size for the heated skelps to be passed through and receives as much compression in so passing as will effect the welding of the edges of the iron together. The propulsion by which the heated iron is carried onwards through between the rollers will be only operated at the upper end and lower parts of the circumference of the heated iron, to which parts of the grooves of the revolving rollers apply, as must necessarily be the case when only one pair of rollers is used; but in respect to compression of the heated iron by the rollers in so passing through between them, the guiding cheeks R, S, will operate at each side, to prevent the iron from spreading laterally beyond the intended cylindrical form by the compression which the rollers do exert upon the upper and lower parts of the circumference of the said cylindrical form, and by such operation of the said

cheeks the compression will be sufficient to effect the welding, provided that the edges of the iron of the plates or skelps have been previously prepared and turned up with care, so that the said edges will fit correctly together with close contact, and then carefully treated in the furnace for heating the iron to an uniform welding heat throughout all its length, and for withdrawing it from the furnace when at a welding heat without displacement of the edges from their said contact. All which may be done by skilful and attentive management of the usual and well-known modes of preparing the edges, turning up and heating the iron, without adopting any of the parts of my improvements for those purposes. But if the edges of the plates or skelps of iron are prepared with vee grooves and double bevils, or with rabeted edges, according to the first part of my improvements, and then turned up to a correctly cylindrical tubular form according to the second part, and the edges fastened together according to the third part, and the turned-up skelps so prepared are introduced into the furnace and withdrawn therefrom when at a welding heat according to the fourth part of my improvements, as herein-before described, the edges will be kept so correctly and closely in contact when at a welding heat that a slight degree of compressing force will be sufficient for effecting the welding; and by aid of the pair of grooved guiding cheeks R and S, fixed and applied between the pair of revolving grooved rollers E and F, the requisite compression may be given for effecting the welding. Each of the guiding cheeks R and S is affixed to the middle part of a flat plate of steel *r* and *s*, which is disposed in a vertical plane parallel to the adjacent standard *b*, and firmly fastened thereto at the upper and at the lower ends by supporting bolts *t*, *t*, *u*, *u*, by which means the guiding pieces R and S are firmly held in their proper places between the circumference of the rollers E and F, as is shewn in the Figures. The upper and lower surfaces of the guiding pieces R and S, which apply to the circumferences of the rollers, may be curved to suit those circumferences with close contact thereto. The grooves in the guiding cheeks R and S may be curved in the direction in which the heated iron is to pass endways through between them, as is shewn in Figure 2. The plates of steel *r* and *s* will bend and yield to allow the guiding cheeks R and S to recede a little laterally in case of necessity. And from each guiding cheek R and S a strong screw bolt *w* or *x* passes horizontally through the plate of steel *r* or *s*, and through the standard *b*, with a nut *y* or *z* screwed on the end of the screw, and acting to draw the guiding piece R or S away from its place as part of the circular aperture *a*. And the steel plate *r* or *s* is set on a spring, so as to urge the guiding piece towards the said aperture with considerable force, which is resisted by the bolt *w* or *x*, but the bolt will not prevent the aforesaid

receeding of the guiding piece in case of necessity. A stationary mandril may be applied in the aperture *a*, between the rollers E, F, and guiding cheek R and S, with a long stem for sustaining such mandril, in the usual and well-known manner of using a mandril in the manufacture of welded tubes by revolving grooved rollers, or the tubes may be welded by passing them through the said aperture *a* without any such mandril therein, as may be preferred. And note, the edges of the turned-up skelp which are to form the joint or seam along the tube should be uppermost when the foremost end of the heated skelp is presented to the aperture *a*, and it will continue to be uppermost whilst the whole length of the heated skelp is passing through between the revolving grooved rollers E, F, and grooved guiding cheeks R, S, and if the turned-up skelp has been introduced into the furnace on the end of a bar moved horizontally endways, and the same skelp has been withdrawn therefrom when at a welding heat by aid of a grooved bearing roller under the doorway of the furnace, according to the fourth part of my improvements, the edges or seam may be kept uppermost when it is presented to and passed through between the revolving grooved rollers E, F, and grooved grinding cheeks R, S. And after the grooved rollers E, F, have passed nearly all but not quite the whole length of the heated skelp through between them, by their revolution in a forwards direction, they may then be turned round in a backward direction in order to repass the heated skelp through between them again for repetition of their compressing and welding action whilst the iron retains its welding heat, and whilst the skelp is so repassing it may return with part of its length into the furnace to assist in keeping up its welding heat; and after nearly but not quite the whole length of the heated skelp has been so repassed, then the motion of the revolving rollers is reversed, and they are again turned round in a forward direction to pass the tube through again; and such passing and repassing alternately in contrary directions may be repeated as often as may be requisite for completing the welding of the edges of the iron together with a proper seam or joint. In so turning the rollers alternately backwards and forwards, their motion in each direction must not be continued so far before it is reversed as would cause the extreme end of the heated iron to be passed quite through the aperture *a*, but the end of the heated iron continuing between the rollers when their motion is reversed, the iron cannot fail to be carried backwards and forwards in a proper manner. The revolving rollers may be thus turned round, first in one direction and then in the contrary direction, by the same kind of wheelwork, or pulley and endless strapwork, as is commonly used in planing machines for the like purpose of turning the wheels or pinions thereof

alternately backwards and forwards (as herein-after more particularly explained), and with the same means of reversing the direction of the motion, when some exact extent of motion as may be required has been performed; or, if preferred, the revolving grooved rollers E, F, may be turned round in a forward direction for performing the welding, by motion in one direction, without reversing or repassing as aforesaid.

And the sixth part of my improvements is a new mode of welding the edges of turned-up plates or skelps of iron, whereof only one end or half (or other portion) of the length of each skelp is heated to a welding heat at the same time, the said welding being performed by passing such heated portion through between the circumferences of revolving grooved rollers. That end or portion of the skelp which is not heated is used for handling the whole skelp when required, in order, in the first instance, to introduce the other end or portion which is to be heated into a proper furnace for that purpose, and afterwards to withdraw the said portion from the furnace as soon as that portion has acquired its proper welding heat therein, and to present the said heated portion to the revolving grooved rollers for being passed through between them so as to perform the welding by their agency. And note, it has been the usual practice to heat only one end or half of the length of such skelps at a time in manner aforesaid, in case of the welding thereof being performed by drawing the heated portion of the skelp by power of a draw-bench with an endway motion, through bell-mouthed or conical apertures in tongs or dies for welding by the compression so caused. But in all cases of the welding of such skelps being performed between revolving grooved rollers, the whole length of the skelp has been heated to a welding heat at the same time; and the extremity of the foremost end, which is first entered between the said revolving grooved rollers, being at a welding heat and in a soft state, is liable to become bended or deformed from its proper tubular form, and the edges which are to be welded to become separated from their proper contact, by the force to which such foremost end must be subjected by the tongs wherewith it is withdrawn from the furnace and presented to the revolving grooved rollers for being caught and taken in between them, all which has been herein-before mentioned; and it has been explained how such separation of the edges at the said foremost end may be prevented by previous fastening of those edges together, either by inlaying of cramps or by preparatory welding of the edges at the extremity of the said foremost end of the skelp, according to the third part of my improvements. But according to the sixth part of my improvements, now about to be described, the action of the revolving grooved rollers to begin to compress the

iron between them does not commence at either extremity of the skelp, but commences at some middle part of the length thereof, and in such manner as that the said commencement of the welding action of the rollers will take place with greater certainty of being correctly commenced that can be the case when an extremity which is in a heated and softened state is presented to the rollers for being caught and taken in between them in order to commence their welding action, as has been hitherto the case in the manufacture of welded iron tubes by revolving grooved rollers. Each of the revolving grooved rollers which is to be used according to this sixth part of my improvements, has a portion of its circular grooved circumference cut away at one place in that circumference so as to render the same deficient at one place in that circumference, in order that when the deficient places in the circumferences of all the several rollers are opposite one to the other, see Figure 1, Sheet XII., and the rollers are standing motionless, that a sufficient large aperture may then be left open between the rollers for allowing the turned-up skelp to be pushed freely endways through the said large aperture, in order to introduce one end or half (or other portion) of the length of the skelp into a suitable furnace, which is situated as near to the revolving rollers as can conveniently be done; and after the said end or portion has been heated to a welding heat it is withdrawn from the furnace by taking hold of the end which has not been heated, and drawing the same by hand through between the said large aperture between the rollers until the commencement of that part of the skelp which is heated is brought within that large aperture, and then the rollers are put in motion by the power of the millwork, and as they turn round the deficient places in their circumferences pass immediately away, and then the grooves around those circumferences come into action to form, by their concurrence, an aperture of a proper size for compressing the heated iron and passing it through between the revolving rollers in a suitable manner for effecting the welding of the edges of the skelp. The length of groove around circumferences of the several rollers (without reckoning their deficient part) must exceed the length of the portion of the skelp which is heated at once in manner aforesaid. When the rollers have completed one revolution they must then stop of themselves, and then their said deficient parts will have come round again, leaving the iron at liberty within the large aperture aforesaid either to be put back again into the furnace, if it is intended to repeat the welding, or else after the iron is turned end for end and cooled, the other end or half is to be treated in the same manner (above described) as the first half was treated. In this way rather more than half of the whole length must be heated at each time. No mandril is required to be used in this part of my improvements, and for

greater facility of repeating the welding operation, the revolving motion of the rollers may be reversed in its direction as soon as the iron has been carried through between the rollers, in manner above described, in a direction away from the furnace, and nearly all, but not the whole, of the length of the heated portion of the iron has been passed through between the rollers, and the extreme end of that portion has very nearly, but not quite, passed through. And on such reversal of the motion the iron will be repassed through between the rollers in a direction towards the furnace, so as to be again subjected to their compressing action, and the heated end or portion of the iron will re-enter into the furnace during such repassing, and will acquire fresh heat in preparation for being again drawn out, and passed a third time through between the rollers by a repetition of the operation above first described. The reversing of the motion of the revolving rollers may be performed in several ways, which are well known, being in common use in other machinery, particularly in planing machines, where a very suitable mode of reversing is commonly used; videlicet, the machine may be put in motion by two endless straps acting around a large horizontal cylindrical drum, which is continually turned rapidly round by power of millwork, the same two endless straps also acting around three pullies on a horizontal axis, which, by a suitable connection of toothed wheelwork gives the required motion to the revolving rollers. The said three pullies are disposed close together side by side on the said axis, all three being of the same size. The middlemost of the said three pullies is fastened upon the axis so as to give motion thereto, when it is turned round by either of the straps; the other two outside pullies are fitted loosely upon the axis so as to revolve freely thereon. One of the two endless straps aforesaid is crossed, but the other strap is not crossed; consequently, whichever of the pullies the two endless straps may operate upon, those two pullies will always be turned round in contrary directions. When the crossed strap is acting upon one of the side loose pullies, and the other or open strap is acting upon the middlemost pulley, then their axis will be turned round by the latter strap and pulley in one direction, and by means of the wheelwork aforesaid the revolving rollers will be turned round in a direction to carry the heated iron through between them in a direction away from the furnace. And when the rollers have in that manner been turned round so far in that direction as that nearly, but not quite, the whole length of the heated portion of the iron will have been passed through between them, and their motion requires to be reversed, as already mentioned, then both the endless straps are removed laterally on their drum and on their pullies at once, so that the crossed strap will pass from off the middlemost pulley to the adjacent side pulley, which being loose

will give no motion to their axis, but the open strap being at the same time removed from that side loose pulley on which it had before acted, and brought to act upon the middlemost pulley (as soon as the crossed strap quitted the same), the open strap will turn the middlemost pulley and the axis and wheel-work, and consequently the rollers, round in a contrary direction to that in which they were before turned, so as to repass the heated iron through between them towards (and into) the furnace, as already explained. When both straps are removed to the two side loose pullies respectively, so that neither will act on the middlemost pully, then no motion will be given to the axis, and the rollers will be left standing still. The requisite removing of the two endless straps on the three pullies for the above purpose is well known, and may be performed by moving suitable strap guides by hand, or such guides may be moved by the machinery itself, in the same manner as is done in planing machines, and is generally known. Note, the revolving grooved rollers which are most suitable to be used in this sixth part of my improvements are such as are combined to act three or four in concert for compressing the heated iron which is passing through between them at as many sides at once, the grooves around their circumferences concurring together to form a truly circular aperture between the three or the four grooves for the heated iron to be passed through, and such combined revolving grooved rollers were formerly invented by me, and Letters Patent were granted to me therefor by Her present Majesty on or about the Twenty-seventh day of March, One thousand eight hundred and forty, and the same are fully described in my Specification thereof which stands inrolled in Chancery. The machine represented on Sheet XII., although intended for a different purpose, as herein-after explained, will serve for a representation of one which is proper to be used in this sixth part of my improvements, and Figure 1 thereon is a section to explain the deficient part of the circumferences of the rollers herein-before mentioned; the section representing the rollers when they are standing still.

The seventh part of my said improvements is a new mode of preparing the extreme ends of metal tubes which are to be united together end to end in prolongation of the length of one tube or piece or length of tube by another such tube or piece or length; for this purpose the end of one piece is to be cut out with a vee groove in the edge of the thickness of metal of the tube all around the circumference of the said end; and the edge of the thickness of metal at the end of the other piece is to be cut to a double bevilled edge all around the circumference of the said end. The said double bevil must fit accurately into the said vee groove when the two pieces of tube are put together end to end, as is shewn in section by Figure 4, Sheet VII., and requires

very little further explanation. The said vee groove and double-bevelled ends are easily formed at the ends of the pieces by turning in a lathe with slide rest in the usual manner practised by workmen in like cases; and after the said ends have been so fitted one to the other, and put together in close contact, then double-dovetail cramps are to be inserted into corresponding double-dovetail notches cut out in the metal of the tube, as is represented at *w*, Figure 4, which is a longitudinal section, and the said cramps being inlaid into the notches will hold the two ends together until they can be permanently united by soldering, brazing, or welding, which operations are to be performed in the usual manner, as commonly practised for uniting the ends of metal tubes together bye one or other of those means respectively, and requires no further explanation, this seventh part of my improvement being the aforesaid means of preparation of the end for being so united. The cramps *w* are to be the same in every respect as already described in the third part of my improvements, and the manner of cutting out the double-dovetailed notches, and inlaying the cramps into them, is the same as already described in reference to Figure 3, Sheet VII. By means of this seventh part of my improvements the ends of pieces of welded iron tubes may be very correctly and firmly welded one to another, in order to obtain longer lengths of welded tubes than can be conveniently manufactured; and in case of welded iron tubes which are required to be made very truly circular and of uniform thickness at their ends, such would easily be done by turning the said ends in a lathe, if metal could be spared for so turning without rendering the metal too thin at the ends; but according to this part of my improvements short pieces cut from a tube which has been made with suitable thickness of metal for the purpose can be fitted in manner above described, according to this seventh part of my improvements, to join to the ends of the intended tube, so as when welded thereto to afford sufficient metal for afterwards turning the ends true in a lathe, and yet after such turning that the ends shall be of the same thickness as the rest of the tube; or if the ends are required to be permanently thicker after such turning, the thickness of the ends which are welded must be provided accordingly.

The eighth part of my improvements is for cleaning and smoothing the surfaces of metal tubes by putting a number of them into a hollow cylinder, which is mounted with its length horizontal on pivots at its two ends, and is turned round by power of millwork in the manner of a barrel-churn, in order that the tubes within it may roll round and rub one against another, so as to clean and smooth their exterior surfaces, see Sheet XI., wherein Figure 1. is a horizontal plan, and Figure 2 an end elevation of five such cylinders A, A, A, A,

mounted side by side in one frame B, B, and turned round by bevel wheels *a*, on the end of the axis of each cylinder, and other smaller bevel wheels *b*, *b*, on a horizontal cross axis D. The tubes are introduced into the cylinders through two holes in the ends, and when finished are taken out at doors in the said ends, as is shewn in Figure 2. In case of welded iron tubes each tube may be put to the cylinder immediately after the welding, whilst the tube continue red hot, and the action of the other tubes therein will tend to straighten the tube and to keep it straight whilst it is cooling; and in case it is required to clean the interior surfaces of the tubes then a solid cylindrical rod of iron may be inserted loosely into each tube, and the weight of such rod rolling round within the interior of the tube, by the rolling motion given thereto in the hollow revolving cylinder, will operate to render the interior surface of the tube clean and smooth.

The ninth part of my improvements is for finishing welded iron tubes and rendering them straight and truly cylindrical, which is done by heating them to redness within cast-iron retorts, which are set in a furnace somewhat in the manner of the retorts used in making gas. The said retorts are cylindrical within, see a section, Figure 1, Sheet XII., and open at the ends for inserting and withdrawing the tubes, which are to be finished according to this part of my improvements, and which are by that means heated uniformly at all parts of their length to a red heat, and are taken one at a time in that state and laid in a long angle groove along a straight bar or trough of iron of an angular form, which is horizontal, and which lodges the hot tube in the exact line of the aperture between a set of combined revolving grooved rollers, such as represented in Sheet XII., and the red-hot tube being pushed along endways in the said straight groove is thereby presented to the said rollers, and they pass it through between them, and as it goes through on the other side it passes along into another like angle groove, fixed there, in exact continuation of the one first mentioned. In thus passing, the tube is slightly compressed on all sides, so as to make it take the form of the circular aperture between the grooved rollers, and the tube is rendered straight by moving in the aforesaid angle grooves at each side of the rollers; and when the tube has passed all its length through between the rollers in manner aforesaid, then the revolving motion of the rollers is reversed, in order to repass the tube through between them in a contrary direction, but before the end of the tube is re-entered into the aperture between the rollers for so repassing, it is turned partly round, so as to bring a different side in contact with the angle grooves, in which the tube rests. When the tube has repassed all its length then motion of the rollers is again

reversed. And in this way the tube is passed and repassed several times backwards and forwards all its length through between the rollers until it is rendered straight and true to its intended cylindrical form and size, and until the iron is become so cool that it will preserve its said true form.

The tenth part of my improvements is for facilitating the using of machinery which is constructed according to my aforesaid Patent of the Twenty-seventh of March, One thousand eight hundred and forty, with three or four revolving grooved rollers combined, and consists in mounting the whole framework containing the combination of such rollers on wheels, which run upon the rails of a railway, as represented in Sheet XII., so that the whole machine is rendered moveable in order that it may be put into complete order in a suitable workshop, with the grooves around it rollers adjusted one to another, and then it can be wheeled along the railway to the place where it is to be worked, and at that place it is firmly fixed to a substantial base or foundation ready for work, and the horizontal axes *v* and *w* of one or more of the rollers connected with the axes of V and W of the millwork, by which the machine is to be put in motion. And in case of derangement, or when the machine requires repair, then it is unfastened from its foundation, disconnected from the millwork, and wheeled away along the railway to the workshop, and another machine which is in good order brought along the said railway to replace it. The said railway must be provided with such turn-plate and crossing places as the localities of the manufactory may require. And when different sizes of pipes are to be made, the grooved rollers can in this way be changed in the workshop, and the machine with the proper rollers wheeled along the railway to the proper place for working the machine.

The eleventh part of my improvement is for forming the grooves around the circumferences of rollers, which are combined according to my said Patent of the Twenty-seventh of March, One thousand eight hundred and forty. See Sheet XIII., wherein E, F, are the uppermost and lowermost of the combined rollers, and X, X, part of the frame of the machine in which those rollers are mounted. D, D, is a tube having a large circular flange L, by which it is fastened to the frame X, X, and a brass lining, which is fixed into the tube D, sustains a horizontal axis K, and which has a steel cutter *v*, projecting from that end of it which is in the aperture between the combined rollers, for cutting the grooves around the circumferences of of the rollers when they are turned slowly round, and at the same time the axis K is turned very much more slowly round by means of a worm wheel W on the end of it, and an endless screw V, which the workmen turns as required by a handle R. The steel cutter *v* is thereby carried round about with the axis K with a truly circular motion of its

own, so as to cut successively in the grooves of the rollers all around for rendering the aperture that is formed between the said grooves truly circular.

The twelfth part of my said improvements is for cutting off the ends of cylindrical metal tubes to an exact length by the machine represented in Sheet XIV., wherein the tube A is fixed fast in a horizontal position with its two ends passing through the hollows of two hollow axes, which are mounted in bearings B and B, and turned round by pullies *b*, *b*, and endless bands. On the end of each hollow axis a flat circular plate *d* is fastened and revolves with it; the circumference of the plate *d* has teeth around it like a spur cog wheel, as is shewn in the end view; and against the flat surface of the said plate *d* a slider *i* is applied to carry a tool *e*, the cutting edge of which is towards the centre, and is carried round about the fixed tube A with the said cutting edge in contact with the outside of the tube so as to cut the same, and by a slow motion of the slider *i*, the tool *e* is advanced towards the centre so as to cut into the metal of the tube until it is cut quite through. The slow advancing motion of the slider *i* and tool *e* is given thereto by an excentric circular groove *l*, formed in the flat surface of a circular cog wheel *k*, which is fitted loose on against the back of the wheel or plate *d*, so as to be carried round therewith; but the cog wheels *k* and *d* have a different number of teeth, as is shewn by the Figures, and the teeth of both wheels are geared into a pinion *m*, which revolves on a fixed stud pin; but owing to the different numbers of teeth in the two wheels, the wheel *k* acquires a very slow relative or differential motion around behind the wheel *d*, and that motion, by means of the excentric groove *l*, advances the slider *i* and the cutting tool *e* towards the tube for cutting the same, the slider *i* having a pin which enters into the said excentric groove *l*. A bearing piece *r* is also applied to the face of the wheel *d*, to sustain the tube at the opposite side thereof to that which is at the time of cutting by the tool *e*. Both ends of the tube are cut off at once, in manner aforesaid. The bearings B, B, can be set nearer together or farther apart, to suit for cutting tubes off to different lengths.

The thirteenth part of my said improvements is for a new kind of head for a mandril, to be used in the welding of iron tubes between revolving grooved rollers, the head of which mandril is to remain stationary within the interior of the tube, whilst the tube is passing through between the revolving rollers, over the stationary mandril, in the usual and well-known manner of using such a mandril. As such mandrils have been hitherto used, they are liable at times to stick to the tube which is passing over them.

Sheet XV. represent the new kind of head for a mandril, which is formed

Prosser's Improvements in the Manufacture of Metal Tubes.

of a circular steel plate A, Figure 1, cut with notches in its circumference, and then bended into the form of a hollow cup B, Figure 2, which is applied, as shewn in the section Figure 3, on the end of the stem E of the mandril, and fastened by screwing on the pointed end or extremity F of the mandril in the manner of a nut upon a screw formed at the end of the stem. The sides of the hollow cup B form the piston or bulb end of the mandrel which is to be within the tube that is welding, and opposite to the place of greatest compression by the revolving grooved rollers at the outside of the tube. And in case of the heated iron of the tube sticking fast, so as to clog up the aperture between the rollers, then the sides of the hollow cup B will yield and collapse towards the stem E, so as to avoid causing such a strain upon the axis or wheel-work of the revolving rollers as would break any of the parts, as is sometimes the case where that part of the mandrel (for which the hollow cup B is the substitute) is a solid piece of metal.

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 Letters Patent herein-before recited, consists in the following improvements:—

Firstly, in the improvement herein-before described, and represented in Figure 1, Sheet I. of the Drawings hereunto annexed, of preparing the edges of flat plates or skelps of metal, which are afterwards to be turned up into tubular forms, with a vee groove along one edge, and a double bevil along the other edge, of each such plate or skelp; which vee-grooved and double-bevelled edges will fit one to the other, when the prepared plate is afterwards turned up into a tubular form. Or otherwise preparing the said edges with rabbets, in the manner herein-before described and represented in Figure 2, Sheet I.; one such rabbet being formed at one side or surface of the flat plate, and the other rabbet at the contrary side or surface, and which rabbets will fit one to the other, when the prepared plate is afterwards turned up to a tubular form. Also the improvement herein-before described, and represented in Figures 2, 3, and 4, Sheet II., of combining two pairs of circular wheels *e*, *f*, and *g*, *h*, together, for the purpose of operating at the two edges of flat plates or skelps of metal at once, in the manner of circular shears, for paring or cutting off narrow strips from those two edges, leaving the same smooth, straight, and parallel. Likewise of combining three such pairs of circular wheels together, in manner herein-before explained, for the purpose of cutting along the middle, and at the same time cutting along the two edges of a broad plate, so as to divide the same into two flat plates or skelps, each having two smooth, straight, and parrallel edges. Note, no claim

is made to the application of one pair of such circular wheels for cutting along one edge at a time, but only to the aforesaid combination of two pairs for cutting along two edges at once, and of three pair for cutting along the middle as well as along the two edges of a broad plate at one operation. Nor is any claim made to the application of the aforesaid combinations of two pairs and of three pairs of circular wheels to any other purpose than that of cutting the edges of plates or skelps of metal, which are afterwards to be turned up into tubular forms.

Secondly, in the improvement herein-before described, and represented in Figures 1, 2, 3, and 4, 5, 6, Sheets IV., V., VI., of turning up flat plates or skelps of metal to tubular forms, by pressing the flat plates into the hollows of suitable moulds, so as to bend the plates by degrees to the required tubular forms.

Thirdly, in the improvement herein-before described, and represented in Figures 1, 2, and 3, Sheet VII., for fastening together the edges of plates or skelps of metal which have been turned up to tubular forms, by inlaying double-dovetailed cramps into corresponding double-dovetailed notches cut out in the two edges of the turned-up plate or skelp. Also for securing the edges of plates or skelps of iron which have been turned up to a tubular form, by preparatory welding of the edges together, in manner herein-before described, for a short portion of the length of each turned-up plate or skelp at that end thereof which will be foremost, when such turned-up plate or skelp is to be withdrawn from the furnace wherein it has been heated to a welding heat, the said foremost end which is so secured by preparatory welding partaking of that welding heat. But no claim is made to any preparatory welding together the edges at the end or ends of any turned-up plate or skelp, whereof the other parts of the edges which have not undergone such preparatory welding are to be afterwards united by brazing. The only preparatory welding together of the edges at the end which is claimed being for such turned-up plates or skelps of iron as are afterwards to be welded along all the other parts of the edges which have not undergone such preparatory welding.

Fourthly, in the improvements herein-before described, and represented in Sheet VIII., for introducing turned-up skelps of iron into a furnace, wherein they are to be heated to a welding heat; also for facilitating the withdrawing of such turned-up skelps from the furnace after they have been heated to a welding heat therein, by the application of a revolving groove bearing roller beneath the door of the furnace, as herein-before described, together with the application of a preparatory welding of the edges of the turned-up plate or skelp at that end thereof which goes foremost in so withdrawing, and which

end is at a welding heat, and must endure the force of pulling with tongs for withdrawing, as already mentioned.

Fifthly, in the improvement herein-before described, and represented in Sheet IX., for welding the edges of turned-up plates or skelps of wrought iron which have been heated throughout the whole length to a welding heat, by passing such heated skelp through between a pair of revolving grooved rollers, having a pair of grooved guiding cheeks fixed so as to enter between the circumferences of the two grooved rollers in such manner as that the grooves in the said two guiding cheeks and the grooves around the circumference of the two rollers will conform one groove to the other, in order to produce a circular aperture for the heated skelp to be passed through, the upper and lower portions of the circumference of the said aperture being formed by the grooves around the two rollers, and the two side portions of the same circumference being formed by the grooves in the two guiding cheeks R and S, and the said guiding cheeks being capable of yielding laterally in case of necessity. Also the aforesaid revolving grooved rollers being, if preferred, turned round first in a forward and then in a backward direction alternately, for the purpose of first passing and then repassing the heated skelp through between the grooved circumferences of the revolving roller, and between the aforesaid grooved guiding cheeks, in order to repeat the compressing action by which the welding is to be performed.

Sixthly, in the improvement herein-before described, and represented in part in Figure 1, Sheet XII., for welding the edges of turned-up plates or skelps of iron, whereof only one end or half (or other portion) of the length is heated to a welding heat at the same time, the said welding being performed between revolving grooved rollers, having deficient places in their circumferences for permitting the iron to be put through between the rollers whilst they are standing motionless, in order to introduce that end or portion which is to be heated into the furnace, and to withdraw the same after it has become heated. The said revolving grooved rollers being turned once round for passing the heated part of the iron through between them, and they may, if preferred, be so turned once round, first in a forward and then in a backward direction alternately, for passing and then repassing the heated iron through between them in alternate directions for repeating the compressing action by which the welding is to be performed.

Seventhly, in the improvement herein-before described, and represented in Figure 4, Sheet VII., for preparing the ends of welded iron tubes for being welded together end to end, in continuation of length, by forming a vee groove around one of the two ends which are to be welded together, and forming a

double bevil around the other of those ends, which vee groove and double bevil will fit true one into the other, and then fastening together the two ends which are so fitted by inlaying double-dovetailed cramps into corresponding notches cut out in the two ends; and after being so prepared, the joint to be heated and welded, by hammering or otherwise, as may be preferred. Also the application of such mode of joining tubes end to end, for adding and welding on ends of thicker metal to tubes which require to be turned true in a lathe at the ends, such thicker metal allowing for the waste occasioned by such turning.

Eighthly, in the improvement herein-before described, and represented in Sheet XI., for cleaning and smoothing the surfaces of metal tubes, by putting a number thereof into a hollow cylinder with the axis thereof horizontal, and which is turned round in the manner of a revolving churn, in order to cause the tubes which are within it to be rolled round, and rubbed one against another, so as to clean and smooth their surfaces; and a cylindrical metal rod may be inserted into the interior hollow of each tube when it is so put into the said hollow cylinder, for the purpose of cleaning and smoothing the interior surface of the tube by the rolling and rubbing action of the said rod therein.

Ninthly, in the improvement herein-before described, and represented in Sheet XII., for straightening tubes, and bringing them to a correct cylindrical form and true intended size, by heating them to a red heat within cylindrical retorts set in a furnace, and then passing and repassing each tube whilst hot alternately backwards and forwards endways through between combined grooved rollers, which are turned round alternately in one direction, and then in a reverse direction; the tube being supported at each side of such rollers by an angular trough fixed in a horizontal direction, so as to support the tube and keep it straight.

Tenthly, in the improvement herein-before described, and represented in Sheet XII., of mounting the whole framework of machines containing revolving grooved rollers, to be used in the manufacture of metal tubes, upon wheels adapted to run upon horizontal rails like those of a railway, in such manner as that such machinery may be put into complete order in a suitable workshop, and then wheeled along the rails to its proper place for working, and there fixed for working, or may be removed therefrom again when repair is required, and replaced by another complete machine which has been previously put into complete order; also for changing a machine containing grooved rollers suited for one size of tubes for another machine containing grooved rollers suited for a different size of tubes.

Eleventhly, in the improvement herein-before described; and represented in Sheet XIII., for cutting the grooves around the circumferences of combined revolving grooved rollers, so that the aperture formed between the several rollers by their said grooves will be a truly circular aperture.

Twelfthly, the improvements herein-before described; and represented in Sheet XIV., for cutting off the ends of cylindrical metal tubes to an exact length by cutting tools, which are carried circularly round about those ends of the tube which are to be cut off, whilst the same is held fast in a horizontal position for cutting both ends at once; the said tools cutting deeper and deeper into the metal of the tube at each revolution that they make around the tube, until they cut quite through the thickess of the metal.

Thirteenthly, in the improvement herein-before described, and represented in Figures 1, 2, 3, Sheet XV., for a mandril to be used in the manufacture of metal tubes, which will collapse in case of accident, so as to avoid breaking the machinery.

In witness whereof, I, the said Richard Prosser, have hereunto set my hand and seal, this First day of November, in the year of our Lord One thousand eight hundred and forty-five.

RICHARD PROSSER. (L.S.)

AND BE IT REMEMBERED, that on the First day of November, in the ninth year of the reign of Her Majesty Queen Victoria, the said Richard Prosser came before our said Lady the Queen in Her Chancery, and acknowledged the Instrument aforesaid, and all and every thing therein contained and specified, in form above written. And also the Instrument aforesaid was stamped according to the tenor of the Statute made in the fifty-fifth year of the reign of His late Majesty King George the Third.

Inrolled the First day of November, One thousand eight hundred and forty-five.

DREW.

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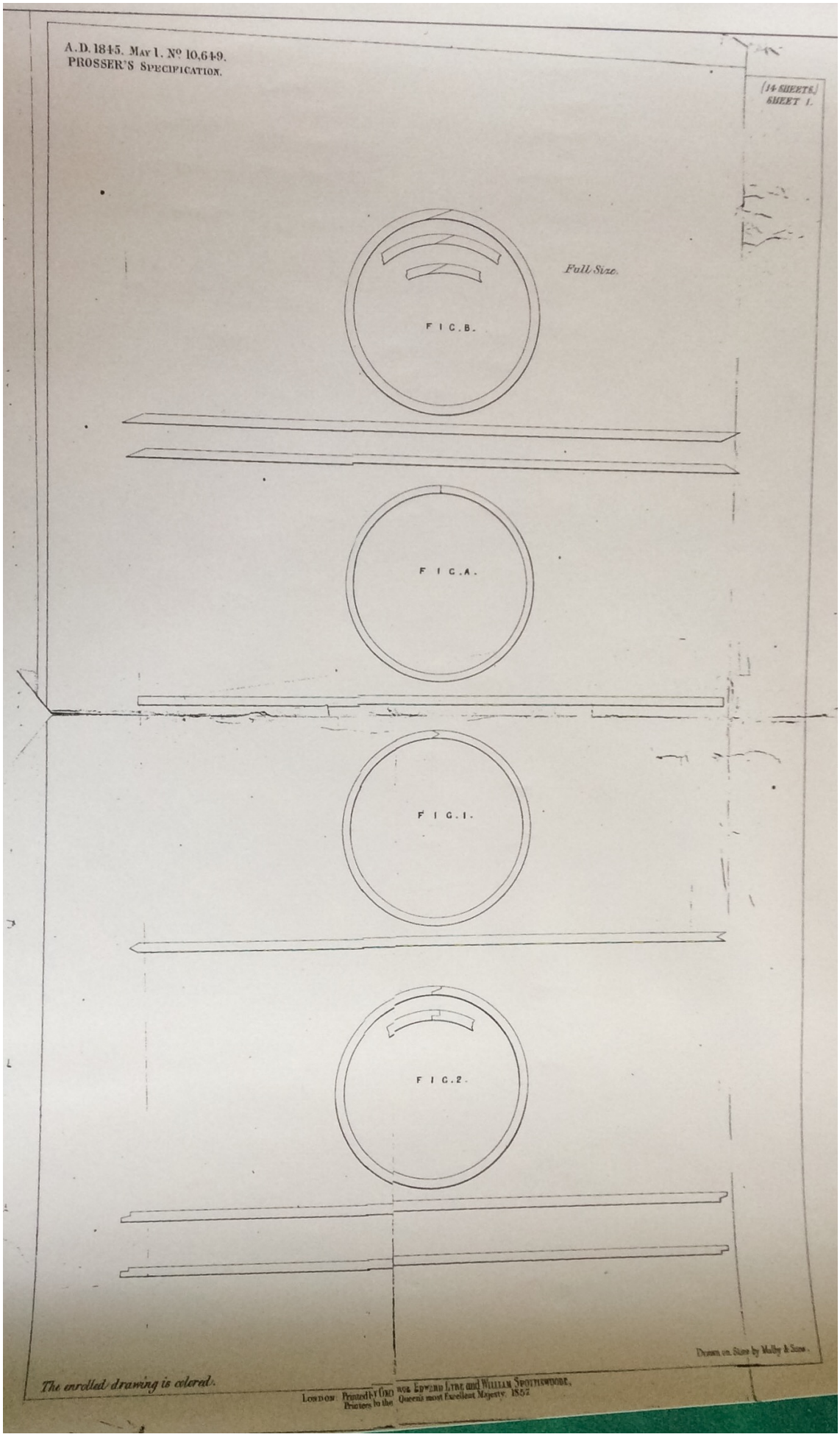
A.D. 1845. May 1. Nº 10,649.
PROSSER'S SPECIFICATION.
14 SHEETS.
SHEET 1.
Full Size.
FIG.B.
FIG.A.
FIG.1.
FIG.2.
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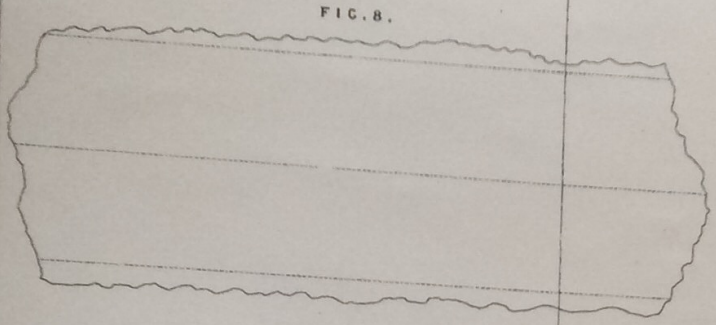
(1½ SHEETS.)
SHEET 2.

Scale 1½ Inches to the Foot.

FIG. 8.



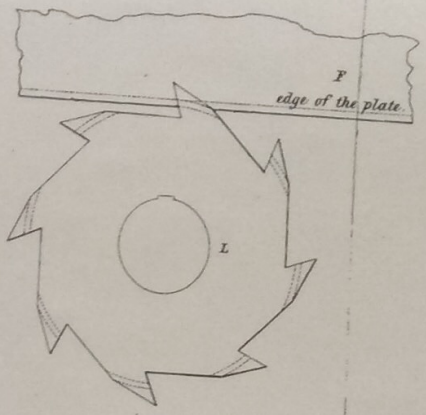
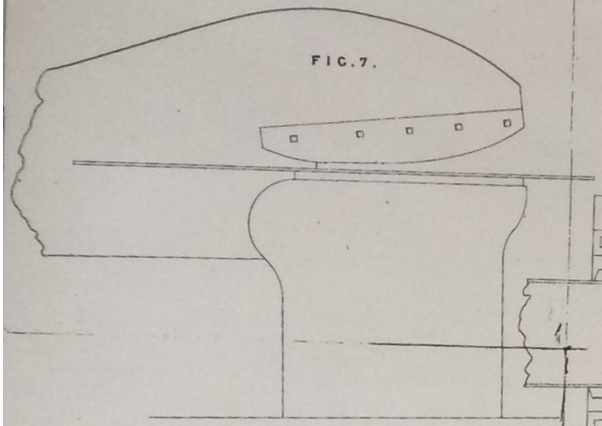


FIG. 7.



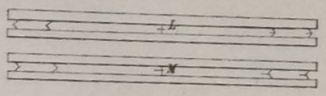


FIG. 6.

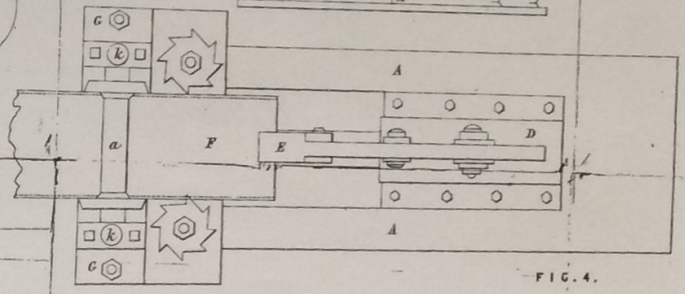


FIG. 4.

FIG. 3.

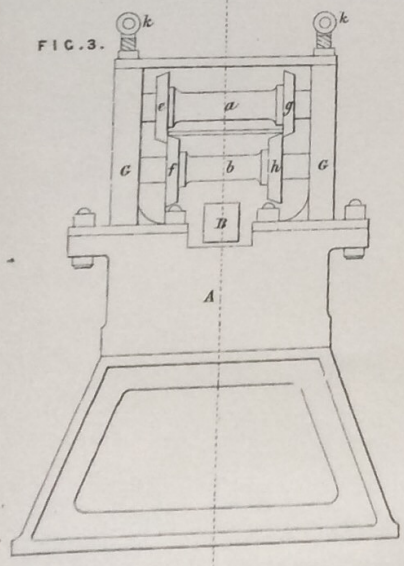
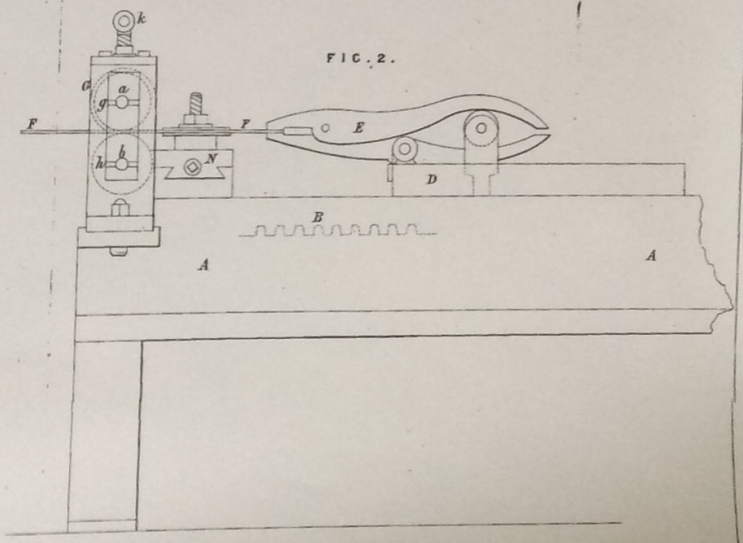


FIG. 2.



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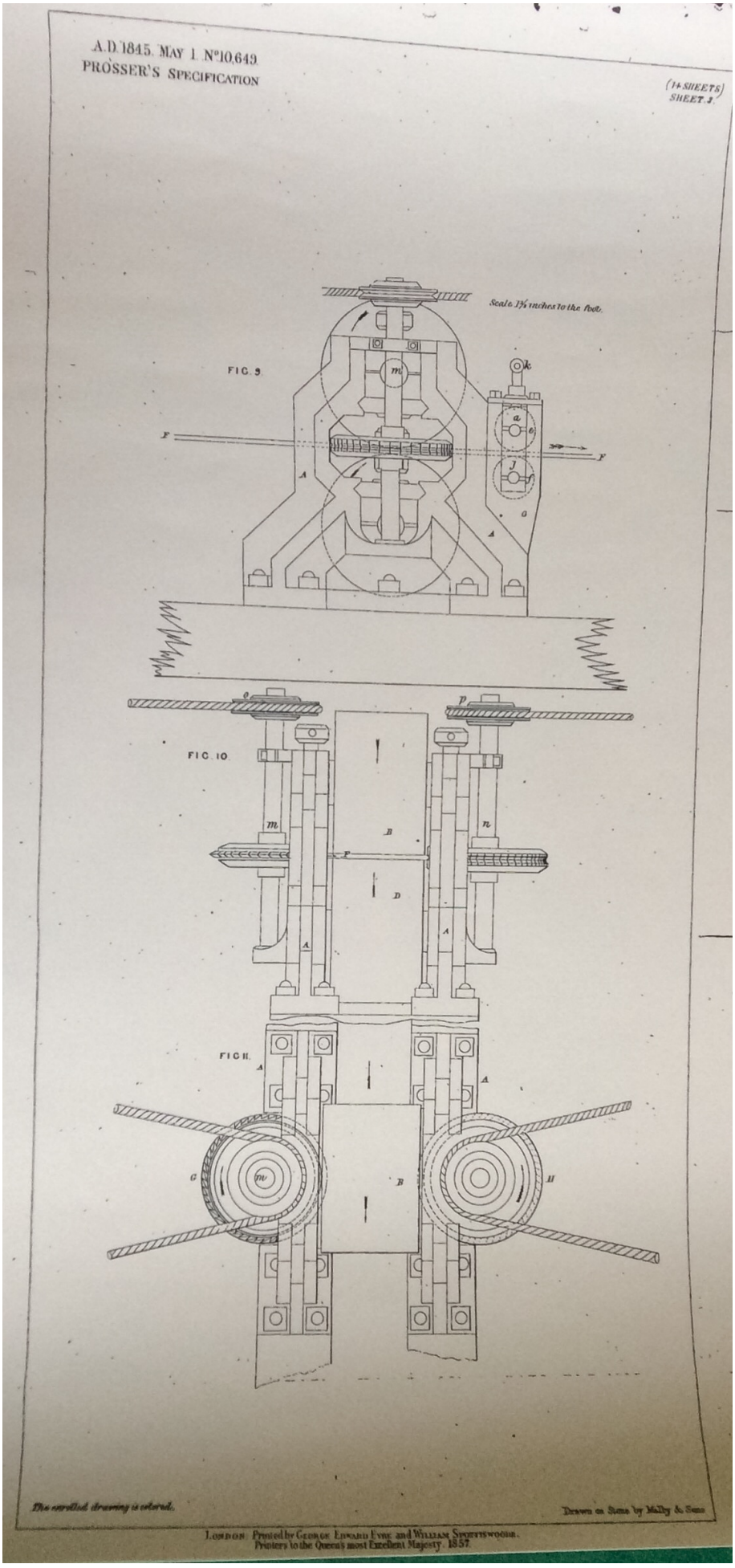
A.D. 1845. MAY 1. N°10,649.
PROSSER'S SPECIFICATION
(14 SHEETS)
SHEET 2.
Scale 1½ inches to the foot.
FIG. 9
FIG. 10
FIG. 11
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(14 SHEETS.)
SHEET 4.

FIG 1.

Full size.

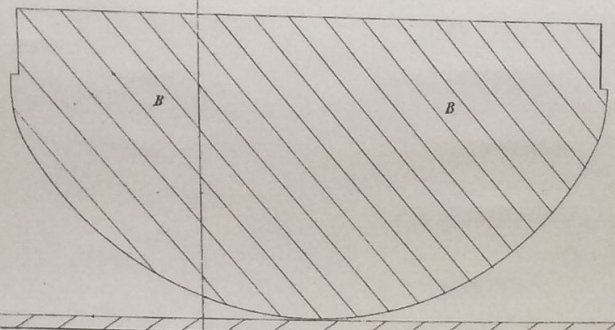


FIG. 3.

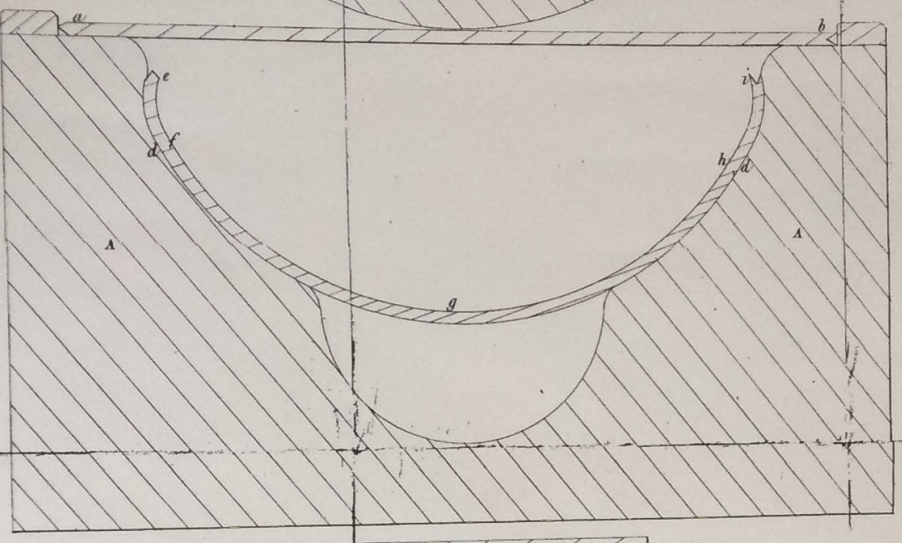
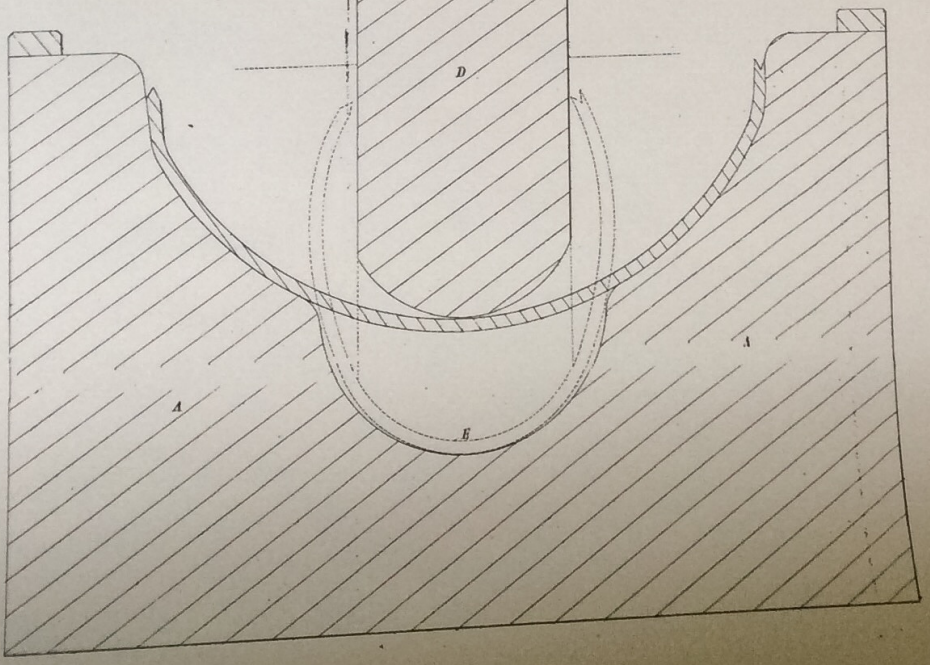


FIG. 2.



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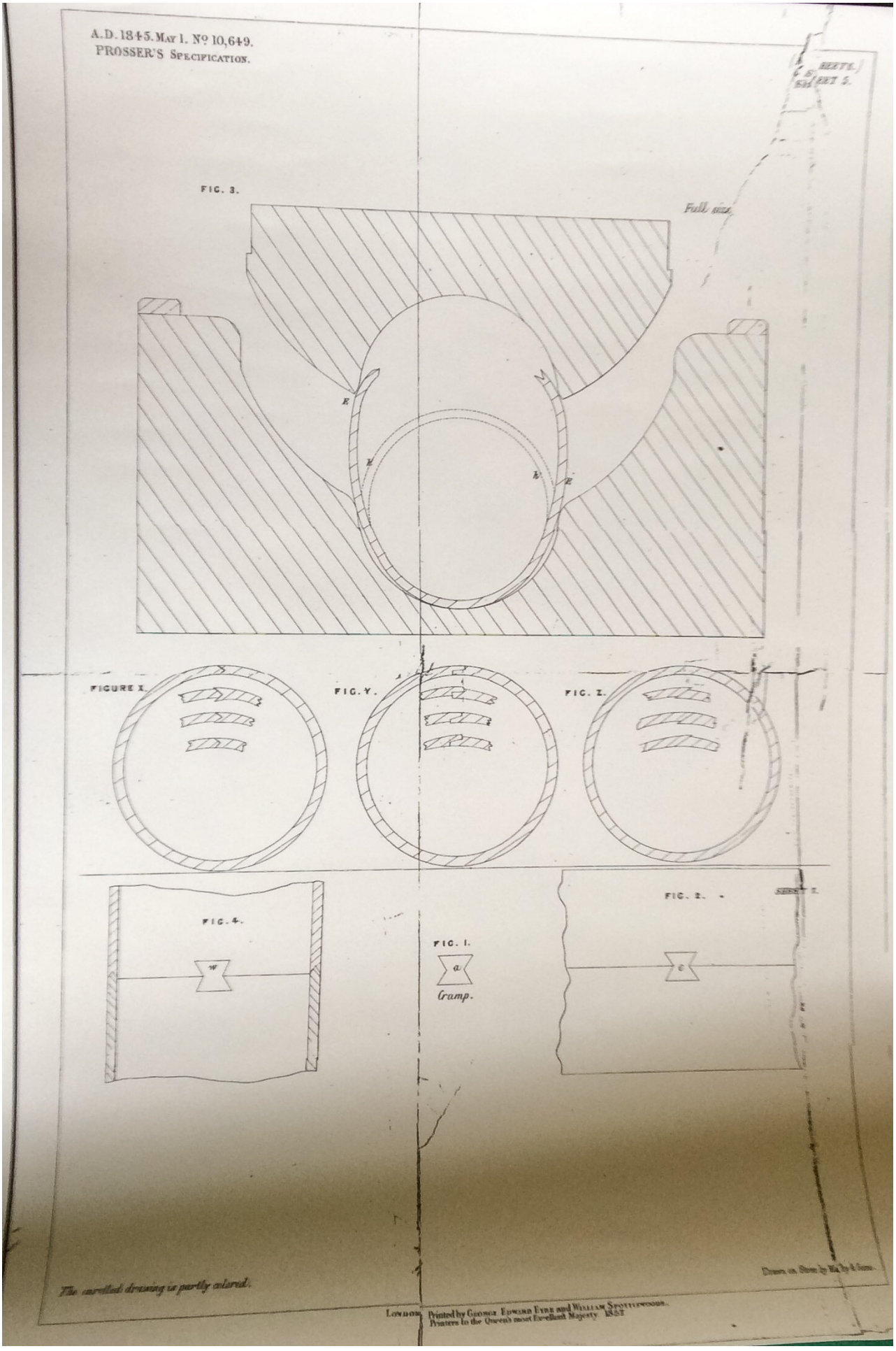
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PROSSER'S Specification.
SHEET 6.
SHEET 6.
FIG. 3.
Full size
E
E
E
E
FIGURE X.
FIG. Y.
FIG. Z.
FIG. 4.
W
FIG. 1.
a
Cramp.
FIG. 2.
SHEET 7.
c
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SHEET 6.

A.D. 1845. MAY 1. Nº 10,649.
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FIG. 4.

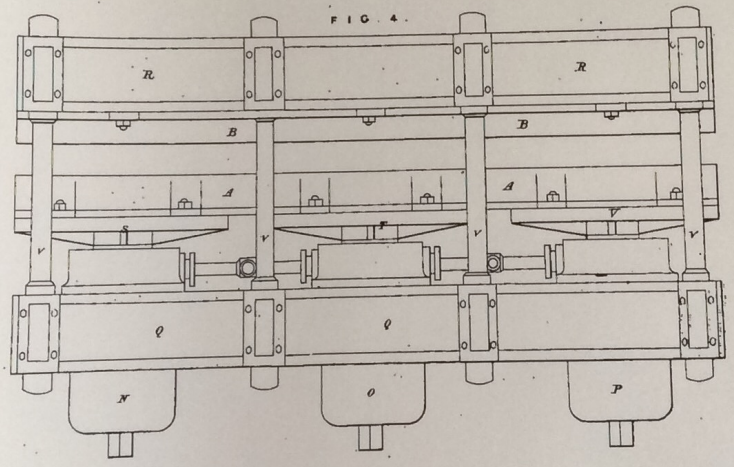
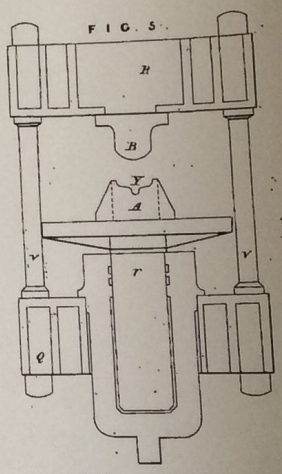


FIG. 5.



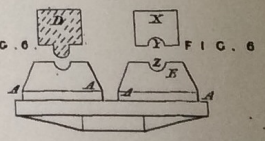


FIG. 6. FIG. 6

Scale 1½ inch to the foot.

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SHEET 7

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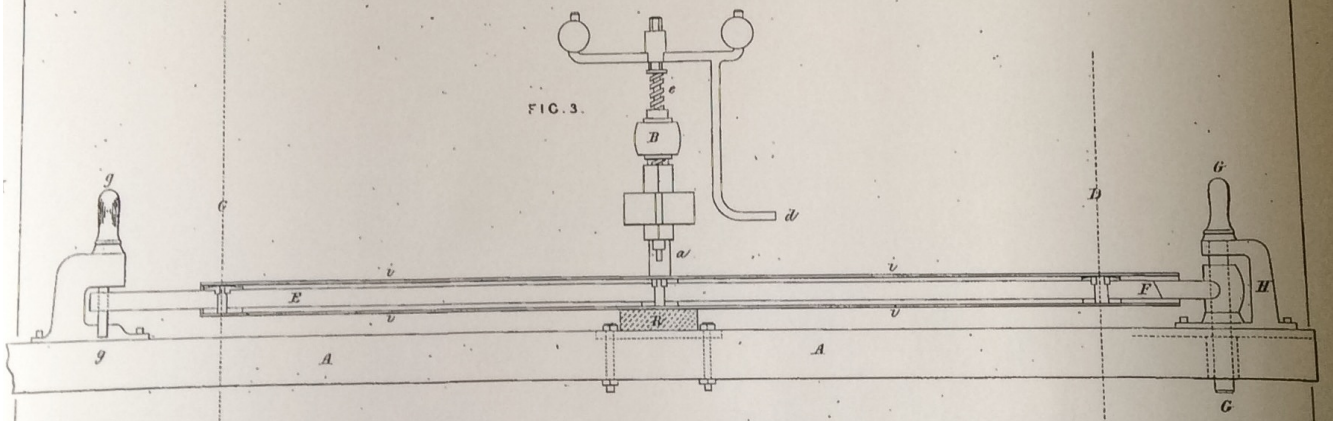
PROSSER'S SPECIFICATION.

FIG. 3.



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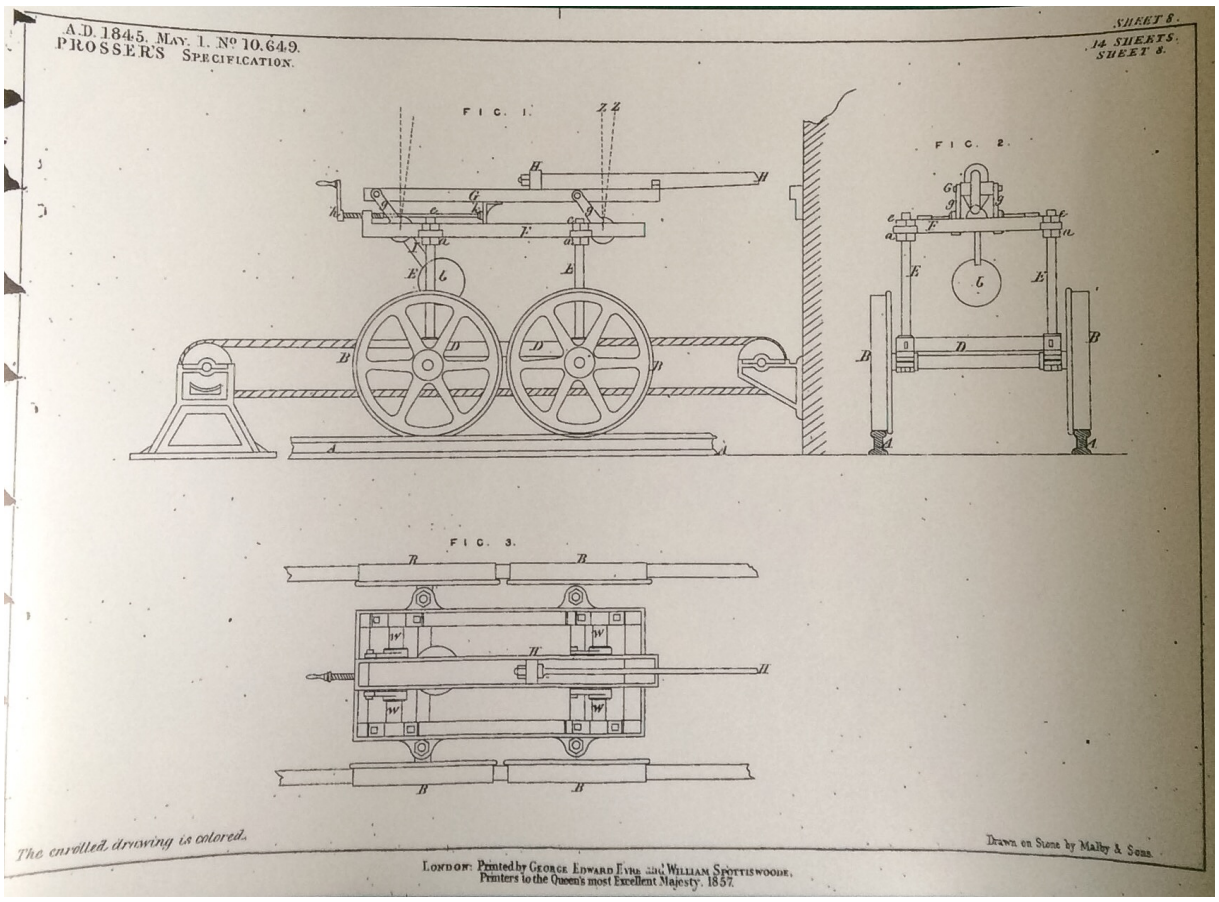
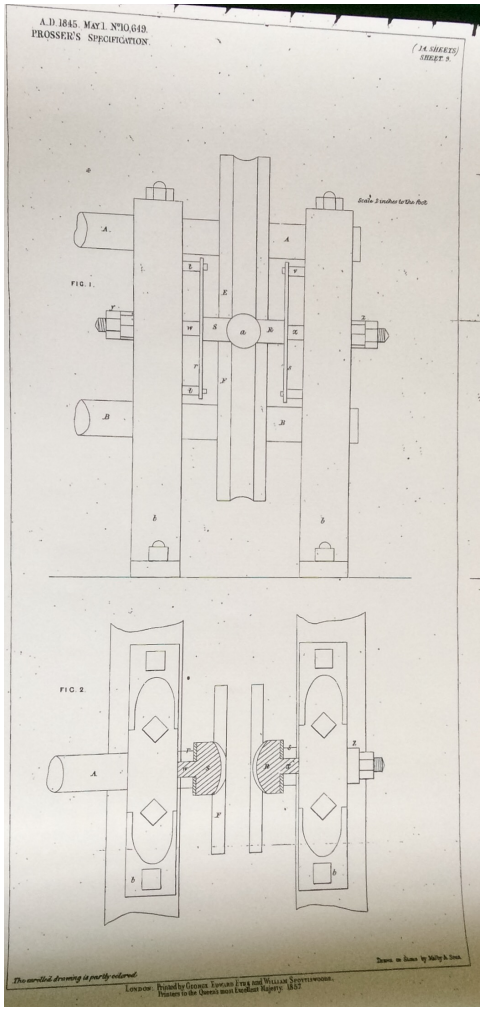
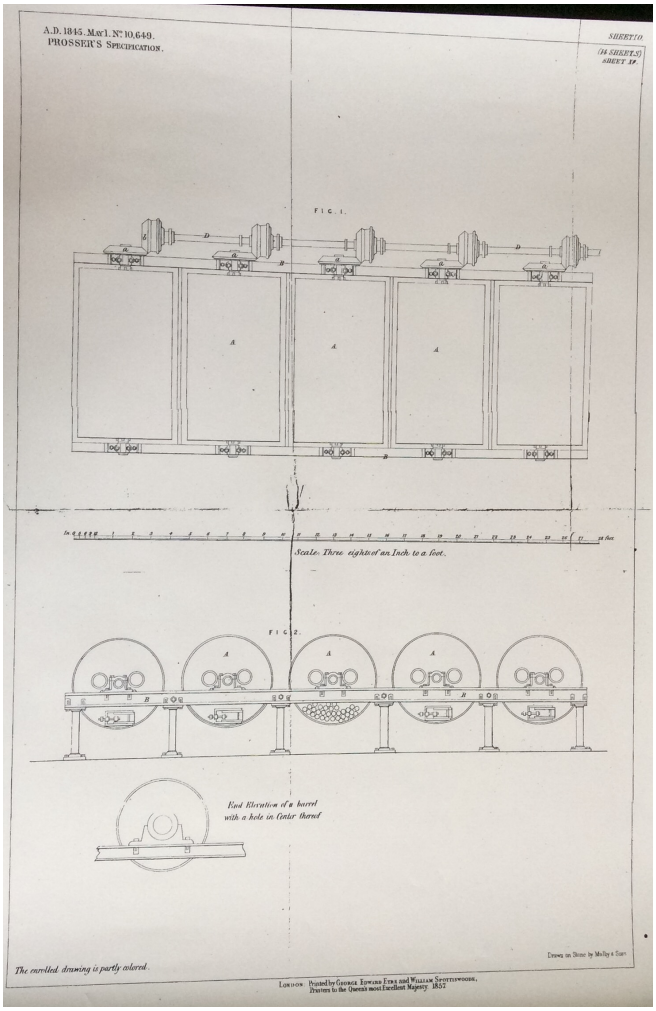

A.D. 1845. MAY. 1. Nº 10,649.
PROSSER'S SPECIFICATION.
SHEET 8.
14 SHEETS.
SHEET 8.
FIG. 1.
FIG. 2.
FIG. 3.
The enrolled drawing is colored.
Drawn on Stone by Malby & Sons.
LONDON: Printed by GEORGE EDWARD EYRE and WILLIAM SPOTTISWOODE,
Printers to the Queen's most Excellent Majesty. 1857.


A.D. 1845. May 1. Nº 10,649.
PROSSER'S SPECIFICATION.
(14 SHEETS) SHEET 9.
FIG. 1.
FIG. 2.
The enrolled drawing is partly colored.
Drawn on Stone by Malby & Sons.
LONDON: Printed by GEORGE EDWARD EYRE and WILLIAM SPOTTISWOODE,
Printers to the Queen's most Excellent Majesty. 1857.

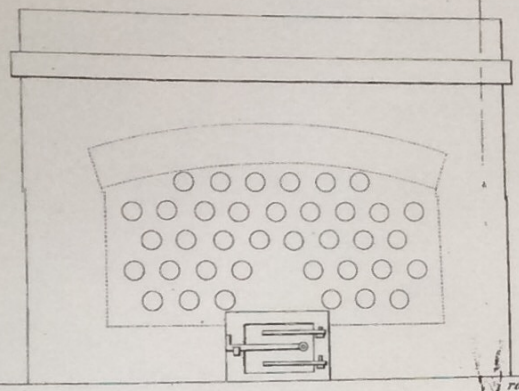

A.D. 1845. May 1. Nº 10,649.
PROSSER'S Specification.
SHEET 10
(14 SHEETS) SHEET 10
FIG. 1.
Scale. Three eighths of an Inch to a foot.
FIG. 2.
End Elevation of a barrel with a hole in Centre thereof
The enrolled drawing is partly colored.
Drawn on Stone by Malby & Sons.
LONDON: Printed by GEORGE EDWARD EYRE and WILLIAM SPOTTISWOODE,
Printers to the Queen's most Excellent Majesty. 1857.

A.D. 1845. May 1. Nº 10649.
PROSSER'S Specification.

SHEET II.
(14 SHEETS)
SHEET III.

Scale 1 inch to the foot.

FIG. I.



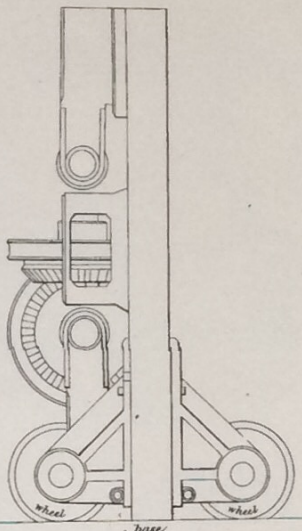
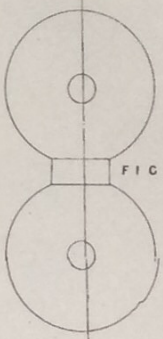
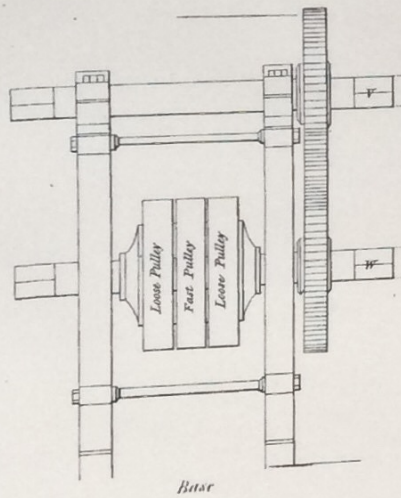
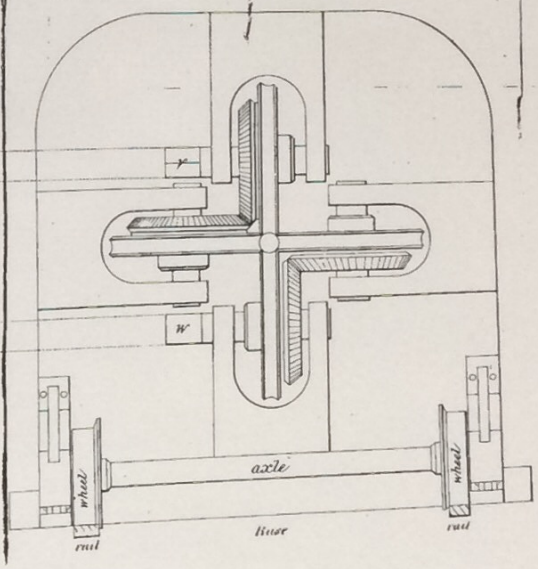


FIG. I.



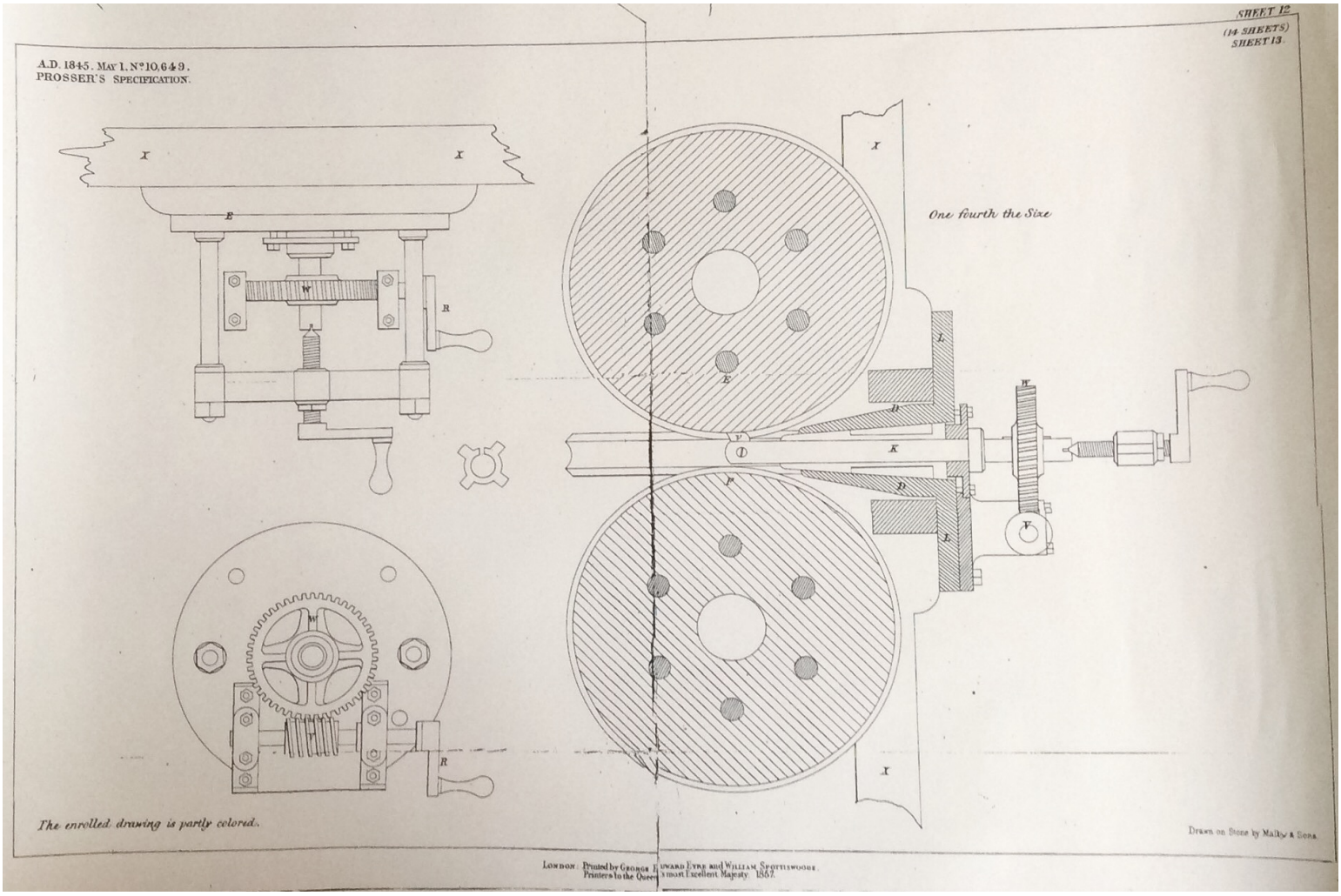




Drawn on Stone by Malby & Sons.

The enrolled drawing is colored.

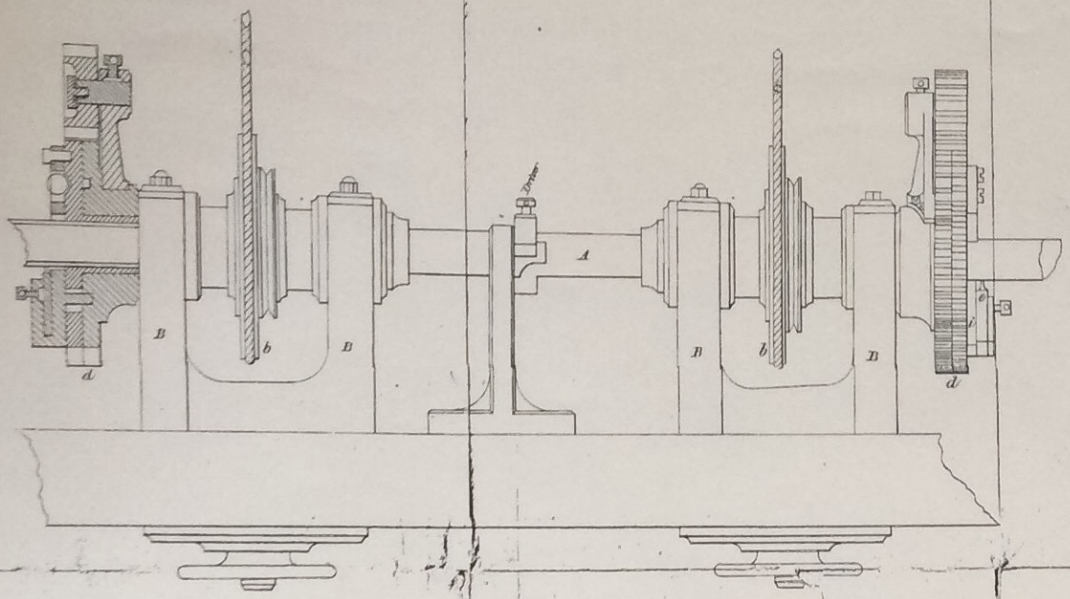
London: Printed by George Edward Eyre and William Spottiswoode,
Printers to the Queen's most Excellent Majesty. 1857.

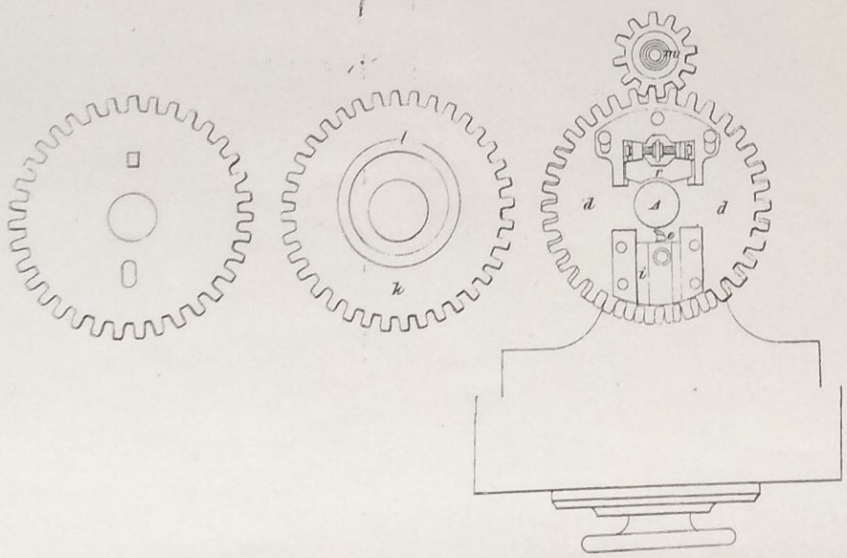

SHEET 12
(14 SHEETS)
SHEET 13.
A.D. 1845. May 1. N°10,649.
PROSSER'S SPECIFICATION.
One fourth the Size
The enrolled drawing is partly colored.
Drawn on Stone by Malby & Sons.
London: Printed by George Edward Eyre and William Spottiswoode
Printers to the Queen's most Excellent Majesty. 1857.

A.D. 1845. May 1. N° 10.649.
PROSSER'S SPECIFICATION.

SHEET 13.

14 SHEETS
SHEET 14.





Drawn on Stone by Melly & Son

The enrolled drawing is partly coloured.

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A.D. 1845, May 1. Nº 10,649.
PROSSER'S SPECIFICATION

SHEET 14.
(14 SHEETS.)
SHEET XV.

FIG. 3.

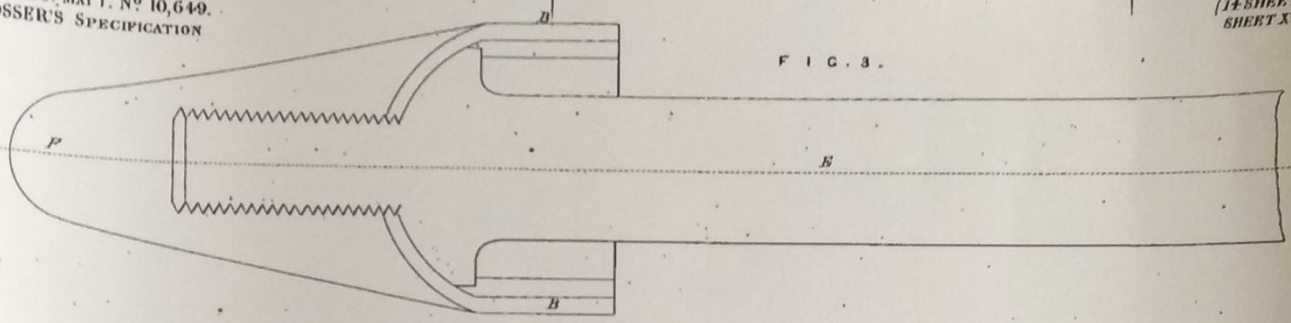


FIG. 1.

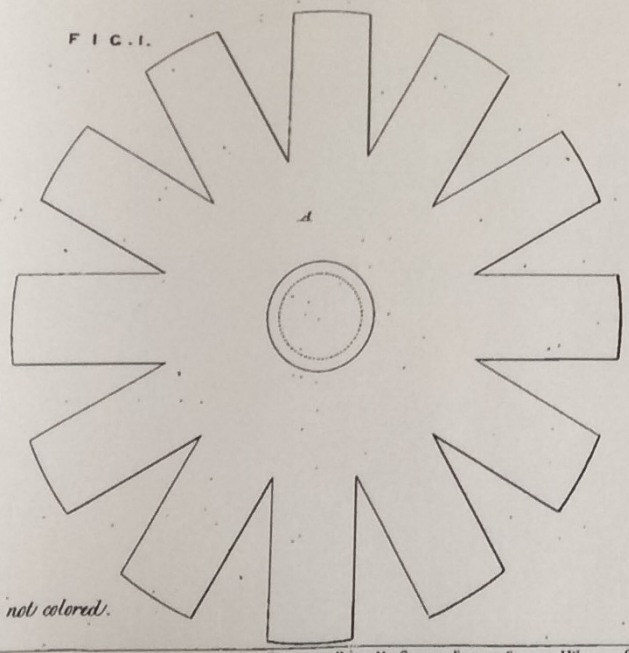
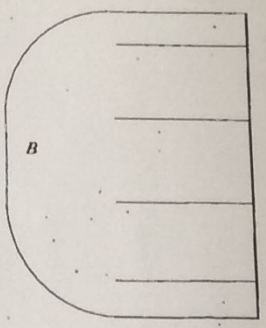


FIG. 2.



The enrolled drawing is not colored.

Drawn on Stone by Malby & Sons.

LONDON: Printed by GEORGE EDWARD EYRE and WILLIAM SPOTTISWOODE,
Printers to the Queen's most Excellent Majesty. 1857.