(No Model.) 4 Sheets—Sheet 1.

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ART OF ANNEALING STEEL CASTINGS AND STEEL FORGINGS.

No. 429,775. Patented June 10, 1890.

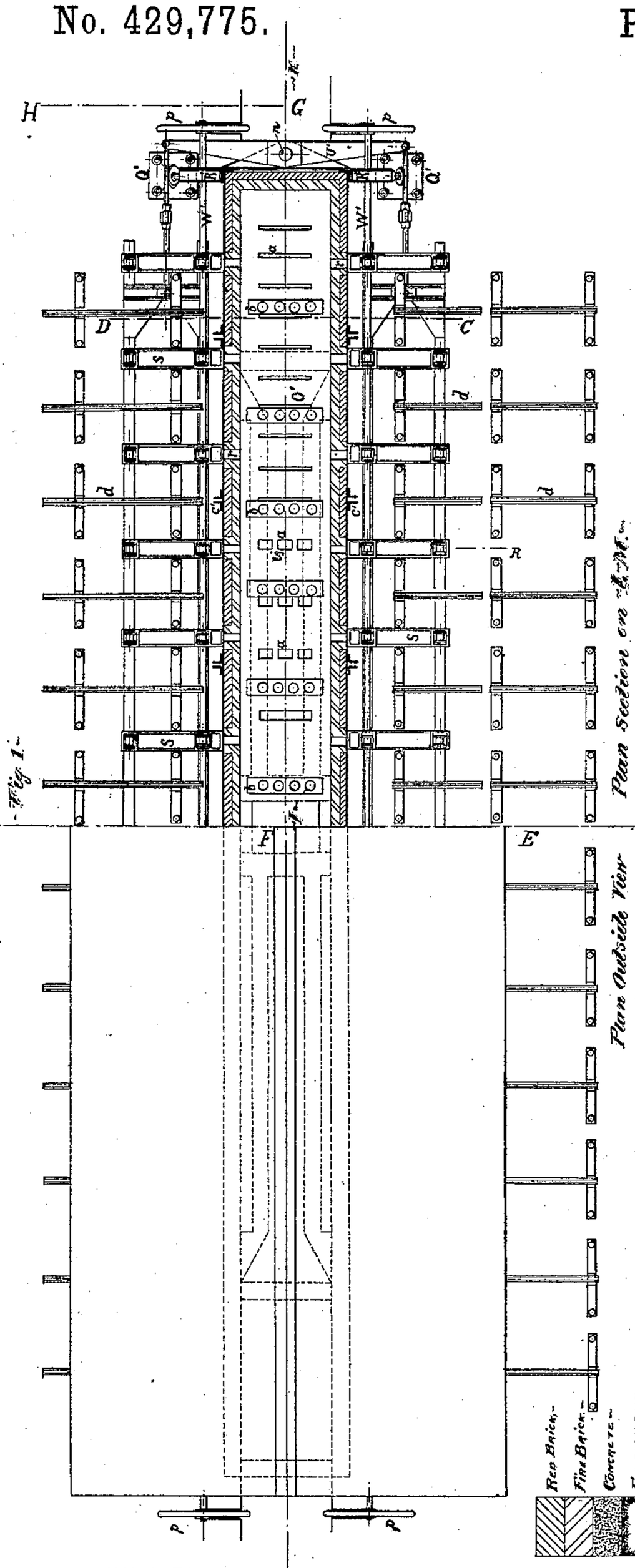
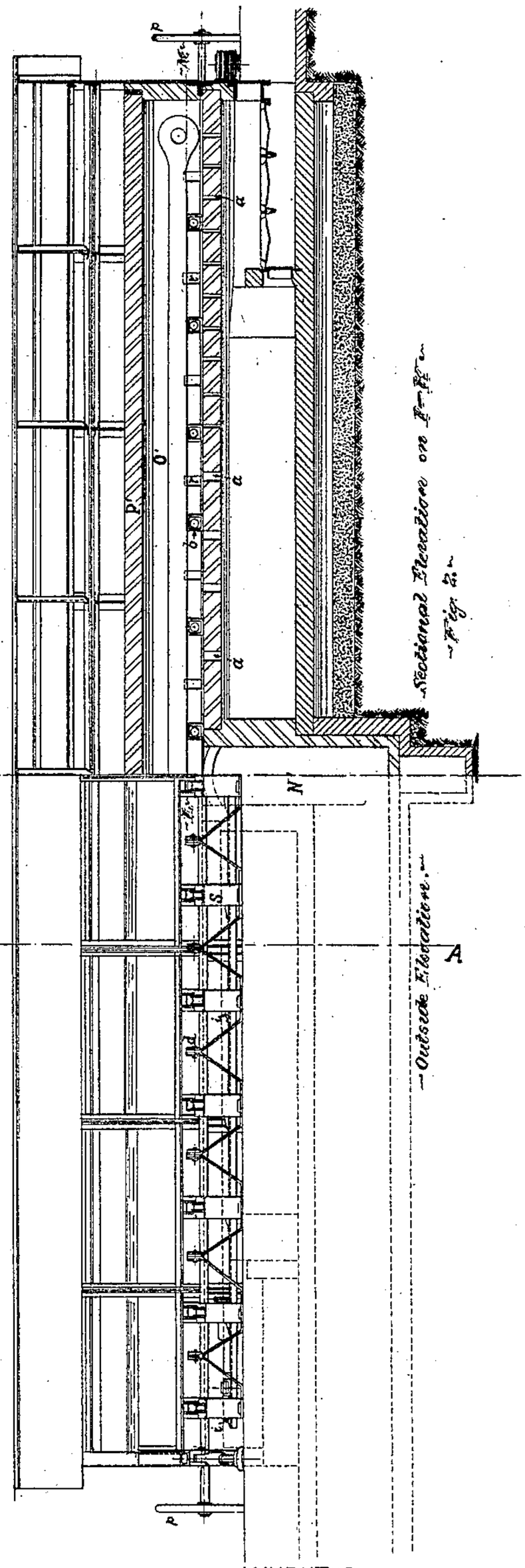


Fig. 1.



Sectional Elevation on E-F.

Fig. 2.

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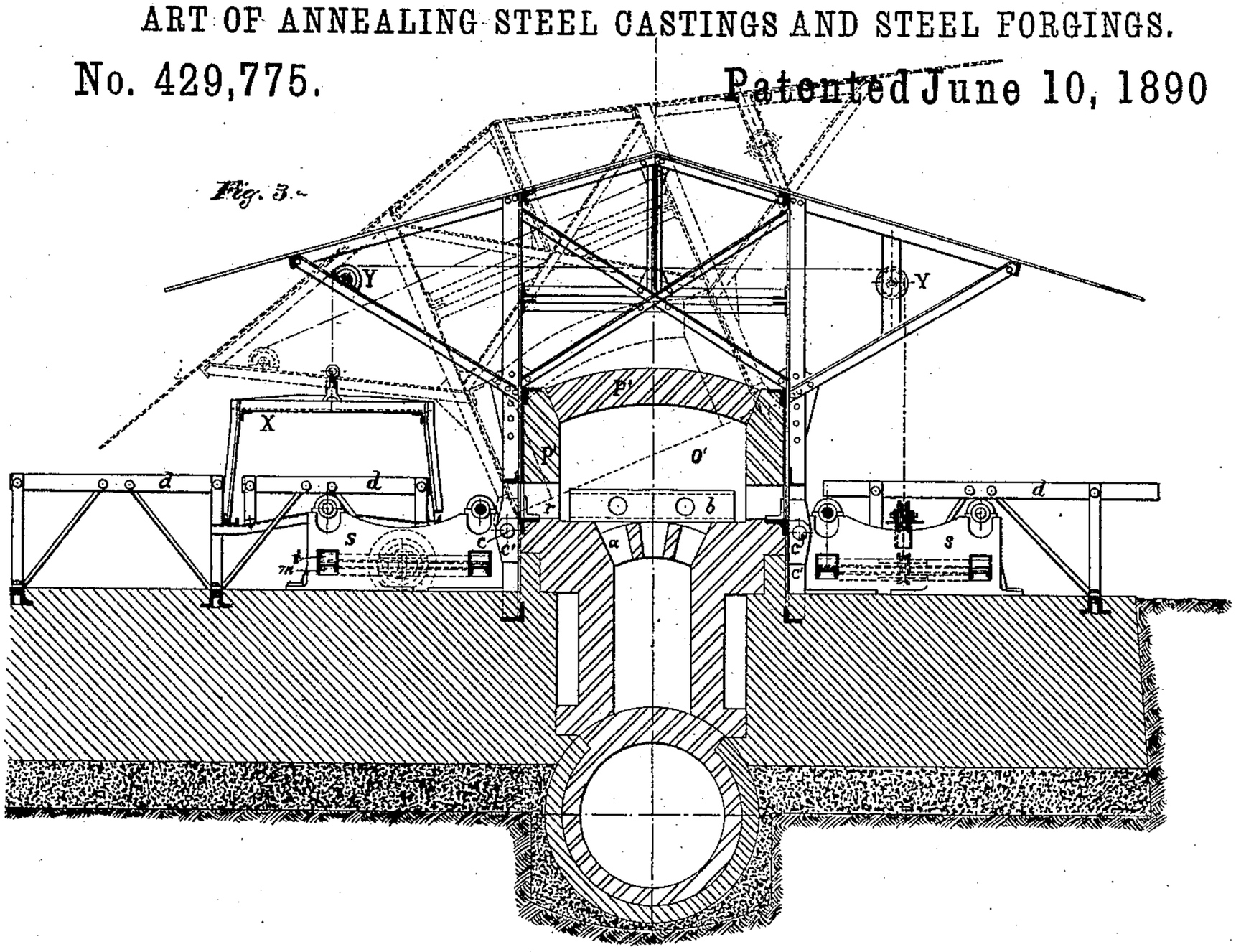
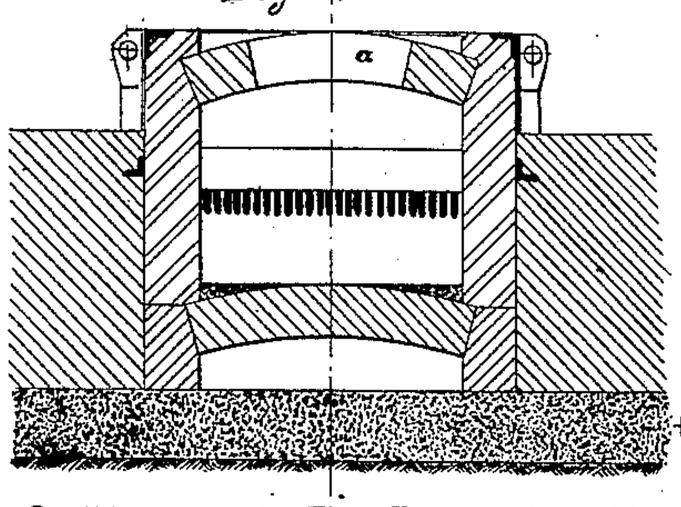
Fig. 3.



Section on A-B

Fig. 4.



Section on C-D

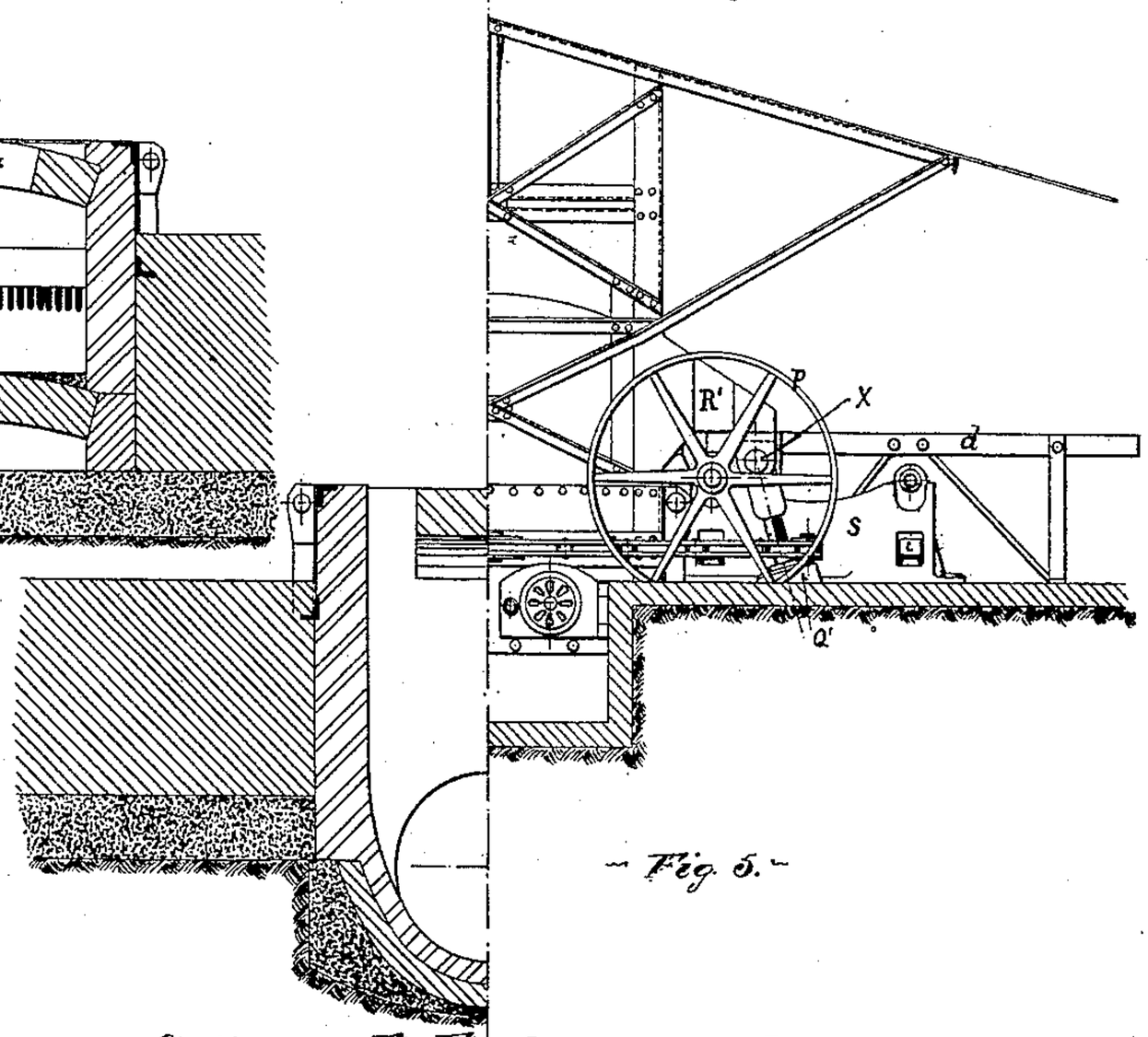


Fig. 5.

Section on E-F

Section on G-H

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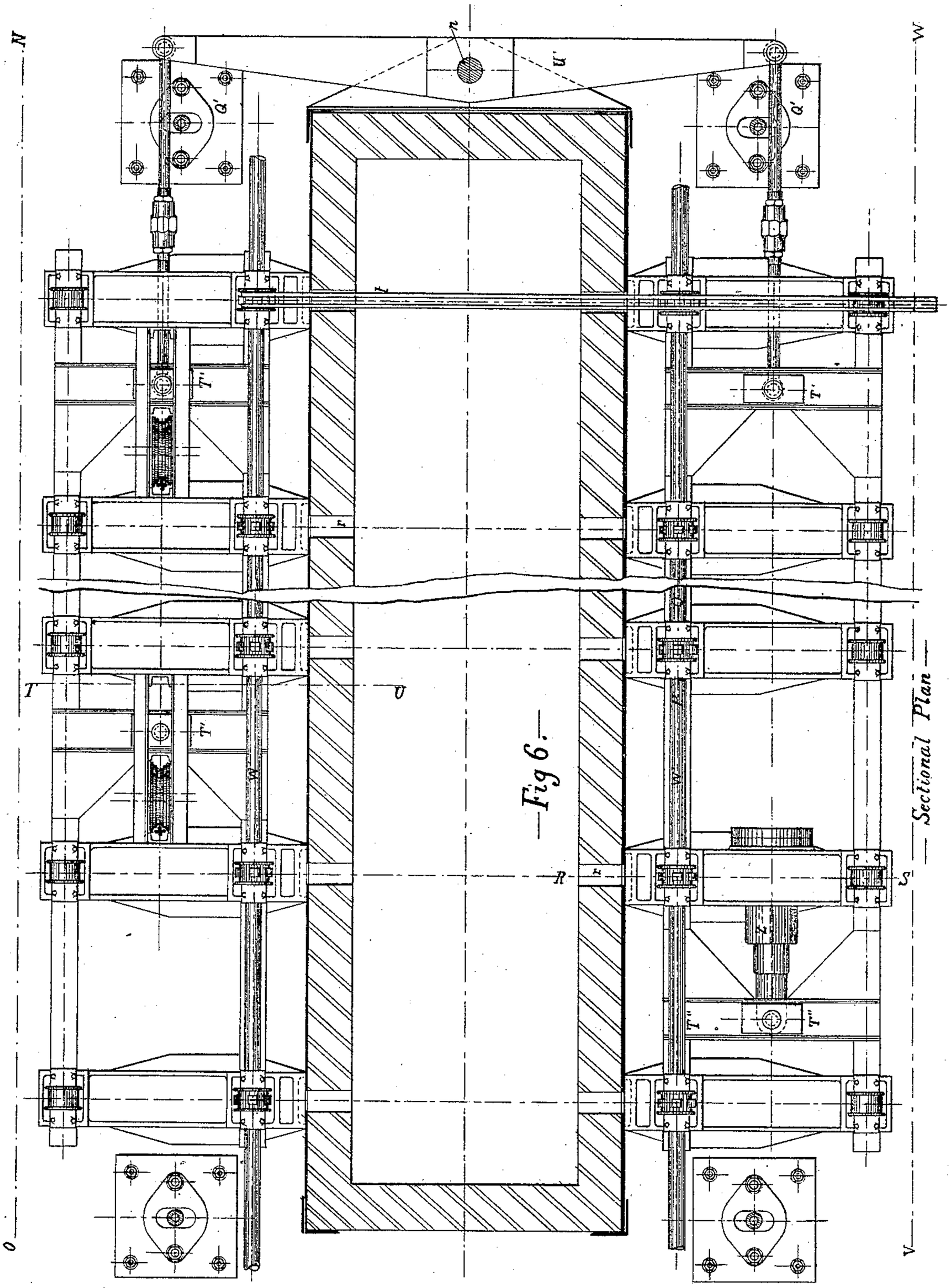

Fig 6.

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ART OF ANNEALING STEEL CASTINGS AND STEEL FORGINGS.

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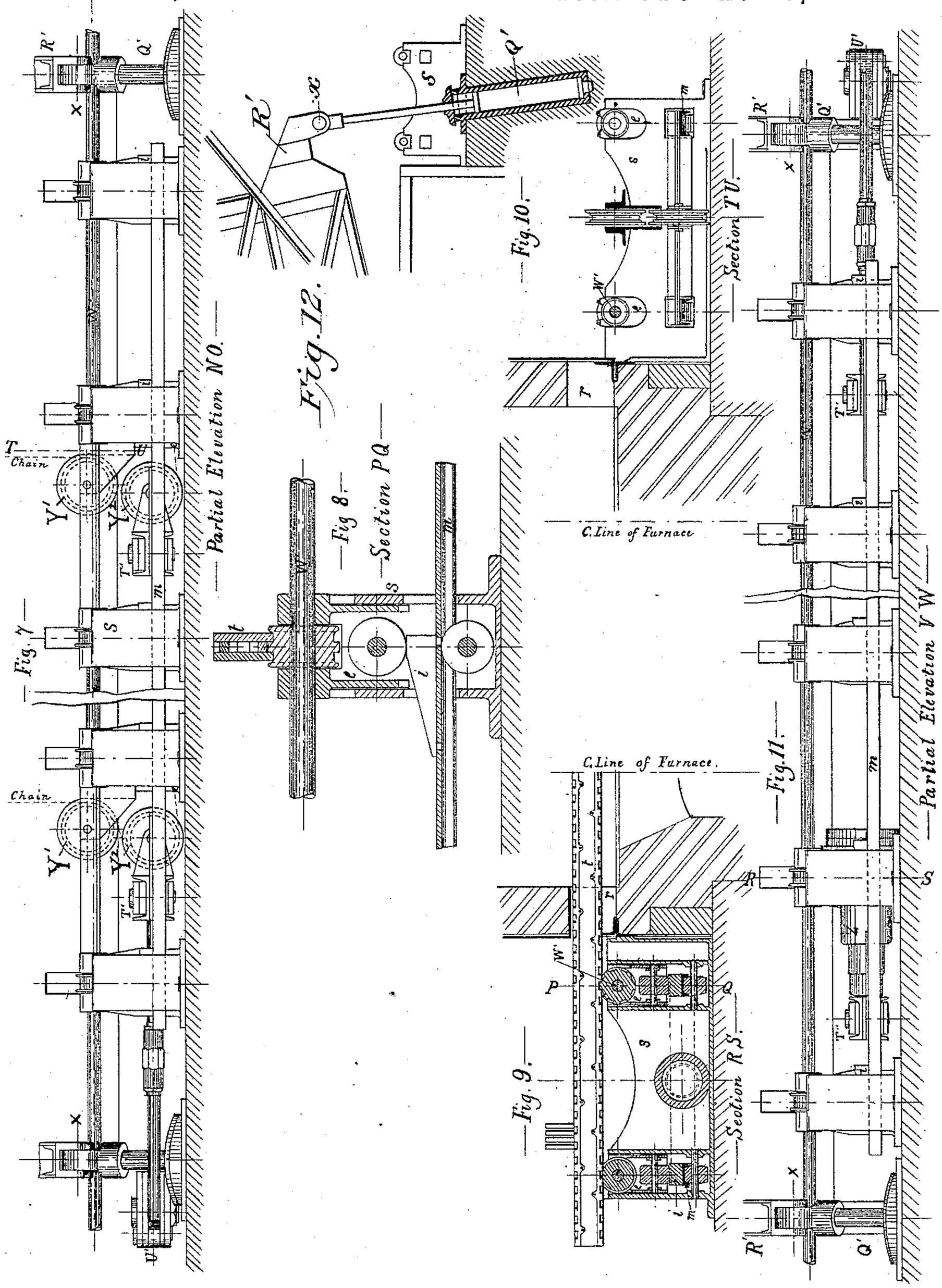

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UNITED STATES PATENT OFFICE.

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ART OF ANNEALING STEEL CASTINGS AND STEEL FORGINGS.

SPECIFICATION forming part of Letters Patent No. 429,775, dated June 10, 1890.

Application filed March 11, 1887. Serial No. 230,558. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM SELLERS, of the city and county of Philadelphia, in the State of Pennsylvania, have invented certain new and useful Improvements in the Art of Annealing Steel Castings and Steel Forgings; and I do hereby declare the following to be a full and exact description thereof, reference being had to the accompanying drawings, forming part of this specification, in which—

Figure 1, Sheet 1, is a plan with one-half in section on the line L M. Fig. 2, Sheet 1, is a side elevation with one-half in section on the line I K. Fig. 3, Sheet 2, is an end view in section on the line A B. Fig. 4, Sheet 2, is an end view of the furnace-chamber in section on the line C D. Fig. 5, Sheet 2, is an end elevation of one-half of the complete furnace, showing a section of the coaling area on the line G H and a section of the downtake and chimney-flue on the line E F. Fig. 6, Sheet 3, is a sectional plan showing the relative position of the several devices for opening and closing the heating-chamber and the annealing-chamber and charging and discharging both chambers. Fig. 7, Sheet 4, is a partial elevation on the lines N O of Fig. 6. Fig. 8, Sheet 4, is a section on the lines P Q of Fig. 9, showing the detail of apparatus for raising and lowering the charge preparatory to and subsequent to its transmission and the apparatus of transmission. Fig. 9, Sheet 4, is a section on the line R S of Fig. 6, showing details of the apparatus of transmission. Fig. 10, Sheet 4, is a section on the line T U of Fig. 6, showing the detail of apparatus for opening and closing the annealing-chamber; and Fig. 11 is a partial elevation on the line V W of Fig. 6, showing the details of apparatus for raising and lowering the charge and the position of the prime mover vertically. Fig. 12, Sheet 4, is an elevation of one end of the furnaces, showing in section one of the four hydraulic cylinders and pistons which raise and lower the cover and its connection therewith.

It is well known that in the manufacture of steel castings, particularly in those of considerable weight, an important molecular change is effected by subjecting such castings to an equable heating at a bright-red temperature and to a uniform cooling, and that this change results in important additions to the ultimate strength and ductility of the metal, while imparting to it greater uniformity in these particulars throughout the mass. It is also well known that all forgings of steel in which the whole mass is not finished at a uniform heat will be subject to internal strains, which are liable to result in fracture from trivial shocks, and as it is difficult in most cases and impossible in many to finish such forgings at a uniform heat it is the recognized rule to subject all to an annealing operation—that is, to heat them evenly in an open fire to a red heat and then embed them in hot ashes or other non-conducting material which will exclude the air or prevent its circulation, or to heat them in a furnace and allow them to cool off slowly with the furnace in which they were heated. The former is objectionable by reason of the difficulty in procuring a uniform heat, which is only possible with small objects, and the uniformity of the cooling is uncertain, while the latter, although it effects great uniformity in cooling, involves a great loss of heat, because both metal and furnace must cool off together and the heat of the furnace must be restored with the next charge. It involves a great loss of time, because the furnace cannot be used for heating a second charge until the first has been cooled off and withdrawn. It involves additional plant because additional furnaces are required to compensate for such intermittent heating, and these require larger space to contain them. It must be observed that there is a radical difference between the cooling operations in these two systems. In the first the air is excluded, or its circulation is impeded as far as possible. In the second the uniformity of temperature is maintained throughout the closed heating-chamber by a free circulation of the heated gases within this chamber after the furnace is closed to the external air, while the reduction of temperature is effected by conduction to the external air through the outer wall of the heating-chamber and by radiation from the outer surface of these walls.

In the practice of the art of annealing steel castings and steel forgings, in which latter I

include all wrought-steel, I have discovered that it is not always necessary and oftentimes not useful to prolong the cooling, as in the case where the furnace and its contents are cooled off together. For wrought-steel what is generally required is uniform cooling, and it is only requisite to prolong the cooling to effect its uniformity, and when the metal has a nearly-uniform cross-section the cooling may be accelerated with improvement to the quality of the metal. This points to a separation of the heating and cooling chambers for annealing purposes, and my invention comprehends such a separation and also improvements in both heating and cooling chambers and the mode of charging and discharging the same. The advantages of the improved cooling-chamber cannot be availed of except in conjunction with a heating-chamber; but my improved heating-chamber and the devices for charging and discharging the same may be used, and I contemplate using them, for heating purposes alone, without any connection with an annealing-chamber.

It is one object of my present invention to effect the required annealing of all such castings and forgings of steel continuously, whereby the cooling off of the heating furnace and chamber may be avoided, while the uniformity of cooling heretofore obtained by cooling this furnace and its contents may be maintained, and it is a further object, while effecting the cooling uniformly, to accomplish this result more rapidly than can be done by cooling off the furnace and its contents as heretofore; and to these ends my invention consists in first heating castings or forgings of steel in a suitable furnace to an equable and proper temperature throughout the mass, then transferring such heated metal into an annealing-chamber from which the surrounding air is excluded when this chamber is closed, and then closing this chamber, so that the heated metal within it shall be cooled by the circulation of the air within this chamber; and it further consists in first heating castings or forgings of steel in a suitable furnace to an equable and proper temperature throughout the mass; then transferring such heated metal into an annealing-chamber from which the surrounding air is excluded when this chamber is closed; then closing this chamber, so that the heated metal within it shall be cooled by the circulation of the air within this chamber; then regulating the capacity of the walls of this chamber for conducting the heat to determine the time in which the heated metal shall be cooled; and it further consists in heating castings or forgings of steel in a suitable furnace to an equable and proper temperature throughout the mass; then transferring such heated metal into an annealing-chamber from which the surrounding air is excluded when this chamber is closed; then lowering such castings or forgings upon suitable supports within the annealing-chamber, so that the air within the chamber can circulate about all parts of such heated metal, and then closing the chamber, so that the heated metal within it shall be cooled by the circulation of the air within this chamber; and it further consists in heating castings or forgings of steel in a suitable furnace to an equable and proper temperature throughout the mass; then transferring such heated metal into an annealing-chamber from which the surrounding air is excluded when this chamber is closed; then transferring to suitable supports within this chamber, bars of metal heated to the temperature of the castings or forgings of steel to be annealed; then lowering such castings or forgings upon these heated bars, and then closing the annealing-chamber, so that the heated metal within it shall be cooled by the circulation of the air within this chamber.

In order that my invention may be clearly set forth, I will now describe a furnace embodying my invention, which I have constructed and used in the manufacture of steel eye-bars for bridges and other structures. For the purpose named the furnace must be very long, and it is therefore fired from both ends to obtain a more uniform distribution of the heat. (See Fig. 2, Sheet 1, in which the grate-bars *w* are shown clearly in full lines at one end and the outline of a similar firing-chamber is shown in dotted lines at the other end.) The downtake N′ is placed midway between the two firing-chambers and connects with the flue leading to the chimney, (shown by dotted lines,) passing under the last-mentioned firing-chamber.

In order more effectually to obtain a uniform distribution of the heat, each firing-chamber discharges a very small proportion of its gaseous products of combustion into the heating-chamber A′ above it. The larger portion of these heated gases enters the flues between the firing-chambers and the downtake N′, and they pass out of these flues through the openings *a a a a* in the top of the fire-brick covering of these flues and firing-chambers, (see Figs. 1 and 2,) which covering forms the bottom O′ of the heating-chamber. As thus arranged the passage of the heated gases into the heating-chamber may be controlled at will by placing fire-bricks partially or entirely over such of the openings *a a a a* in which it may be desired to retard or to exclude the delivery of the heated gases; and, lastly, to further facilitate the equal distribution of the heat I provide the firing-chambers with fan-blast or other forced blast, so that the heating-chamber may be worked under a pressure above that of the atmosphere, whereby the heated gases may be forced to any part of the heating-chamber, and the oxidizing-currents, due to a minus pressure, may be avoided. To sustain the bars which are to be annealed, I provide rectangular cast-iron hollow supports *b b b b*, the sides of which are perforated with circular openings, (see Figs. 1, 2, and 3,) which supports rest upon the bed or

hearth of the heating-chamber O′, and to open and close this chamber for the purpose of charging and discharging the material to be annealed I divide it upon a horizontal plane below the top of the supports *b b b b* and near the plane of the bed or hearth, so that the cover P′ P′, which forms the sides and top of this chamber, might be removed as a whole at that horizontal plane. This cover is supported in an iron frame-work, which can rock or tilt upon the pins *c c*, Fig. 3, and such pins are provided at each of the vertical posts *c′ c′ c′ c′* on the sides of the furnace. (See Fig. 1.) The corresponding vertical supports for the cover P′ P′ are provided at their lower ends with semi-cylindrical sockets, which fit over the pins *c c*, forming, with the sockets, open hinges, upon which the cover may be rocked or tilted in such manner as to open the heating-chamber upon one side or the other at will. This cover is shown by dotted lines in Fig. 3 as tilted to the position for charging the chamber. As thus arranged the cover of the heating-chamber can be raised by a force but little in excess of half the weight of the cover, and the chamber can be charged and discharged from either side in the plane of its bed. When the chamber is to be charged and discharged from one side only, the cover may be counterbalanced so as to still further reduce the force required to raise it.

I have availed myself of the iron framing, which is required to support the cover when tilted, as shown, to support the corrugated iron roof, which protects the furnace and its machinery from the weather.

To tilt the cover P′ P′, I provide two hydraulic cylinders Q′ Q′ at each end of the furnace. (See Figs. 1, 5, 6, and 7.) The axes of these cylinders are inclined and their pistons and piston-rods are connected to the ends of the beams R′ R′ by the pins *x*, Fig. 5, and are arranged to vibrate in the cylinders, to accommodate themselves to the curve in which the ends of the beams R′ R′ will move as they are raised from one side or the other. The cover of the cylinder Q′, Fig. 12, rests loosely upon the ends of the cylinder, and the piston-rod sliding freely through the cover causes it to move back and forth across the cylinder with the vibration of the piston-rod. The piston itself is not cylindrical, but rather a section of a sphere, provided with the usual hydraulic packing. The vibration of the piston is so slight that the packing is sufficient to accommodate it. High-pressure water from an accumulator or other supply is admitted by a valve to the two cylinders on the side it is desired to raise or open. The weight of the cover is sufficient to close it when the exhaust-valve is opened and the water is permitted to escape from the cylinders. In raising and lowering this cover upon either set of hinges it is important that the under side of the cover on its open side should be maintained parallel to the bottom of the heating-chamber, as otherwise it would be twisted and its brick-work would fall to pieces. If mechanical force were employed for this purpose, some devices for maintaining the cover in position when raised, as also some squaring devices to maintain its parallelism while raising, would be required; but by the use of the two hydraulic cylinders operated from the same source of supply and through one valve further devices for maintaining the cover in position when raised or its parallelism while raising are not required.

To charge and discharge the materials to be annealed, I provide on each side of the furnace a series of wrought-iron frames *d d d d*, the top of each one of which is composed of a pair of rectangular bars riveted together upon interposed thimbles to receive and to support the material as it comes to the furnace and as it is discharged therefrom. The thimbles between these top bars are about one and one-half inch in length and six inches apart to afford convenient fulcra for the hand-levers, which move the material to its proper position. On the discharging side the top rail is divided into two, for a purpose hereinafter described. (See Figs. 1, 2, 3, and 5.) Between these wrought-iron frames I provide on each side of the furnace pairs of cast-iron boxes *s s s s*, each one of the pair set opposite to the other, so as to work together, as hereinafter described, and these boxes are provided at each end with a vertically-sliding frame or box *e e e e*, which carries a roll upon its upper end, having its axis parallel to the side of the furnace and a roller at its lower end having its axis at right angles to the side of the furnace. These lower rollers rest upon inclined planes *i i i i*, Figs. 2, 3, 5, 8, and 9, which are secured to and are carried upon the channel-bars *m m m m*, which bars extend the whole length of the furnace, and are supported upon rollers having their axes fixed in the boxes *s s s s* at right angles to the furnace. The two channel-bars on one side of the furnace are united together by the cross-bracing T′ and T″, Fig. 6, and are attached to the piston-rod of the hydraulic cylinder Z, Fig. 6, by the cross-bracing T″, and a similar cross-bracing connects the two other bars. These two sets of channels are connected together by the lever U′, which vibrates about the pin *n* in the end of the iron framing of the furnace, (see Fig. 1,) so that the two sets of channel-bars on the opposite sides of the furnace when moved must move in opposite directions. The inclined planes *i i i i* are secured to these channel-bars, so that when moving in opposite directions they will raise or lower the boxes *e e e e* on both sides of the furnace simultaneously by means of the rollers in the lower ends of these boxes resting upon the inclined planes. (See Fig. 8.) The inclined planes *i i i i* are provided with horizontal surfaces at their larger ends, so that when the rollers on the bottom of the boxes *e e e e* are raised

or lowered by the inclined surfaces they will rest upon these flat surfaces or upon the channel-bars, for which purpose the channel-bars *m m m m* have a greater movement than the length of the inclines *i i i i*. I have shown and described the raising device as a series of inclined planes, these being the simplest in form and perhaps the least liable to get out of order; but other well-known mechanical devices—such as screws or toggle-joints—may be substituted, or the lifting may be done with hydraulic jacks under each of the vertically-sliding frames or boxes *e e e e*, all of the hydraulic jacks being connected to one supply-pipe and to one discharge-pipe, so as to be operated by one valve. The upper rollers in the boxes *e e e e* next the furnace on each side are supported and turned by the shafts W′ W′, resting in bearings upon the top of the boxes *e e e e*, which, for the purpose of being turned with facility, are provided with the hand-wheels *p p p p*, Figs. 1, 2, and 5. The rollers on these shafts are gear-pinions shrouded, the shrouding being wide enough to support the weight while the gear-pinions impel it, as hereinafter described. (See Figs. 8 and 9.)

For the purpose of supporting and moving the materials into and out of the heating-chamber, I provide a series of transferring-racks *t t t t*, Figs. 8 and 9, having a length at least sufficient to cover three rollers—that is to say, to cover two rollers on one side of the furnace and to extend across and through the lower edge of the cover of the heating-chamber far enough to rest upon the roller on the opposite side of this chamber, for which purpose openings *r r r r* are provided in the sides of the heating-chamber. These racks are composed of two rectangular bars of iron, having a cast-iron rack suitable for meshing with the pinions on the shafts W′ W′, riveted between them. The openings *r r r r* are provided with vertically-sliding covers, which can be readily raised to admit the racks. The annealing-chamber B′ has about the same capacity as the heating-chamber. The cover X is composed of plate-iron riveted together and stayed with angle-irons to give it sufficient stability to be hoisted and lowered when the chamber is being charged and discharged, and when lowered to place is supported in a channel-groove extending all around the base and filled with sand. The bottom is composed of plate-iron riveted to the channel-groove and supported from the wrought-iron frames *d d d d*. Openings through this bottom are provided to admit the outer row of boxes *e e e e;* but as these openings are the only ones into this chamber no circulation of air can occur through them, and, moreover, they are provided with close-fitting covers to protect the rollers in the top of the boxes *e e e e*, when lowered to place, from the heat of the cooling mass in the annealing-chamber. The cover X when raised is suspended at two points by chains passing over the pulleys Y Y and the top of the heating-chamber down to and under other similar pulleys Y′ Y′ on the sides of the boxes *s s*, (see Fig. 7,) from whence they go around similar pulleys Y^2 Y^2, carried by the cross-bracing T′ T′, and from thence to the sides of the boxes *s s*, where they are attached. The movement of the channel-bars carrying with them the lower pulleys will move the cover double the distance traversed by the channel-bars, and when raised the cover may be maintained in this position by passing keys through the chain-links below the pulleys on the sides of the boxes *s s*, and the channel-bars may be operated thereafter to perform any of their other functions.

I have described the cover B′ as of plate-iron; but it may be made of fire-brick as well, and I contemplate making it so whenever it is requisite to prolong the cooling beyond what can be readily accomplished in the plate-iron structure. The time of cooling in the plate-iron structure, however, may be greatly modified by varying the thickness of the metal, or the plates may be double with an air-space between them, and the width of this air-space may be less or more, or the plates may be covered with asbestus or other refractory felting, any one of which modifications will affect the rapidity with which the heat of the air within the chamber can be transmitted to that exterior to it without affecting the uniformity of its transmission, and such modifications will consequently affect the rapidity of the circulation of the air within the chamber and its cooling effect.

It is possible that with very great irregularities of section in the metal to be annealed it may be desired to accelerate or to retard the cooling of certain sections of the annealing-chamber, which can be effected by modifying the structure of any part of this chamber, as above indicated. I prefer, therefore, to use the plate-iron annealing-chamber, not only because its cooling properties can be readily modified, but because it is lighter and can be more easily transported than a fire-brick chamber.

In practicing the art of annealing I have discovered that at least for certain classes of work it takes much longer to cool the metal to be annealed than it does to heat it, and under such circumstances I provide two or more annealing-chambers mounted upon wheels or otherwise arranged, so that each chamber can be in turn brought up to the heating-chamber to be charged and then transported to some other locality to cool and to be discharged.

The furnace shown and described having been built for annealing eye-bars, and such a bar being shown supported in position in the heating-chamber, (see Fig. 2,) I will now describe the operation of charging and discharging such bars, which are first assembled on the charging side and arranged edgewise—that is, with their flat sides vertical. Distance-

pieces are placed between to permit a free circulation of hot gases around each bar. They are bolted together through the holes in the eye to maintain this position and rest on the wrought-iron frames *d d d d*, so that the center of gravity of the mass of bars will fall just inside the outer set of rollers—that is, between these rollers and the annealing-chamber. The boxes *e e e e* are now in their lowest position, and the racks are passed under the mass of bars and over the rollers, and so that the end of the racks will mesh with the pinions on the shaft W′. The rollers are now raised by admitting the high-pressure water to the cylinder Z, which actuates the channel-bars *m m m m*, by which operation the load will be transferred from the wrought-iron frames *d d d d* to the racks *t t t t*. The cover P′ P′ of the heating-chamber is now raised to the position shown by dotted lines in Fig. 3, and then by turning the hand-wheels *p p p p* the mass of bars will be carried into the heating-chamber over the cast-iron hollow supports *b b b b*. When in this position, a rectangular bar of iron *u*, that will pass freely between the wrought-iron supports *d d d d*, is now laid on top of each cast-iron hollow support *b b b b*. The channel-bars *m m m m* are then moved in the opposite direction, which will lower the mass of bars upon the rectangular bars resting upon the top of the cast-iron supports. The racks may then be withdrawn and the cover lowered to the position shown by the full lines in Fig. 3. As soon as the mass of bars has acquired the proper heat the cover should be tilted in the opposite direction, the racks inserted as before, but from the opposite side, then raised upon the rollers, so as to transfer the load upon the cast-iron supports to the racks. The rectangular bars upon the top of the cast-iron supports *b b b b* should then be transferred to the wrought-iron supports *d d d d*, in the annealing-chamber and placed between the two bars, of which each of these supports is composed, so as to rest upon the thimbles. The heated mass may then be run out over the wrought-iron frames on the discharging side and lowered upon the red-hot rectangular bars just transferred from the heating-chamber to these frames, and the racks can then be withdrawn. The cover P′ P′ of the heating-chamber is now lowered into place. The covers on the bottom of the annealing-chamber are then placed over the outer row of boxes *e e e e*, and the cover X of the annealing-chamber is lowered to its position in the channel-grooves, the sand in which makes it air-tight, and in this position it remains until the bars are sufficiently cooled to be removed. In the meantime another charge of bars may be placed in the heating-chamber. The rectangular bars which are placed upon the top of the cast-iron supports in the heating-chamber serve a twofold purpose. The space which they occupy upon the top of the supports affords ample clearance for the mass of material which is being transferred to the heating-chamber and avoids the necessity, which otherwise would exist, of lowering this material to the level from which it started; but their main object is to provide a support to this material in the annealing-chamber having a temperature equal to that of the metal which is to be annealed, so as thereby to avoid a local cooling, which would frustrate the object for which the annealing is resorted to. The bars may be removed from the annealing-chamber with safety before they are cool enough to handle, and to facilitate this operation the wrought-iron frames *d d d d* are extended beyond the annealing-chamber, and when the cover X of this chamber is raised a bridge is thrown across the opening between the two top rails of the frames *d d d d*, the bars are disconnected, and they are slid one by one onto the outer end of the wrought-iron frames, from which they may be removed at any time.

When articles of smaller dimensions are to be annealed, they may be placed in cast-iron boxes provided with openings for the circulation of air, or on grates, which may be charged into the heating-chamber or discharged from the heating-chamber to the annealing-chamber, as above described.

The heating-furnace and its devices for opening and closing, charging and discharging, which are shown and described, form no part of the invention claimed herein, said furnace and devices being claimed in another division of this application, Serial No. 274,072, filed May 16, 1888. I have also filed a division of this application relating to process in the art of annealing steel castings and steel forgings which application was filed September 8, 1888, Serial No. 284,901, and in which the subject-matter is an improvement in the art of annealing steel castings and steel forgings which consists in supporting the castings or forgings to be annealed upon heated supports within the annealing-chamber, which annealing-chamber is cooler, then said heated supports, and the improvement in the art of annealing steel castings and steel forgings which consists in treating the articles to be annealed in an annealing-chamber and regulating the heat-conducting capacity of the walls of said chamber, so that all parts of said casting or forging shall be uniformly and properly cooled.

Having now set forth my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. The hereinbefore-described improvement in the art of annealing steel castings and steel forgings, which improvement consists in first heating such castings or forgings of steel in a suitable furnace to an equable and proper temperature throughout the mass, then transferring such heated metal into an annealing-chamber, from which the surrounding air and the heated gases of the heating-furnace are excluded when this chamber is

closed, then closing this chamber, then recharging the heating-furnace with other metal to be heated and annealed, then replacing the charged annealing-chamber with another similar one not charged, the number of annealing-chambers and their movements being so proportioned to the heating capacity of the heating-furnace that the heating-chamber of this furnace may receive heat and discharge the metal to be annealed consecutively and continuously, substantially as described.

2. The hereinbefore-described improvement in the art of annealing steel castings and steel forgings, which improvement consists in first heating castings or forgings of steel in a suitable furnace to an equable and proper temperature throughout the mass, then transferring such heated metal into an annealing-chamber, from which the surrounding air and the heated gases of the heating-furnace are excluded when this chamber is closed, and then closing this chamber, so that the heated metal within it shall be cooled by the circulation of the air within this chamber, substantially as described.

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Witnesses:
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