Aug. 21, 1945. J. M. LEE 2,383,203

HEAT TREATING SYSTEM

Filed Dec. 9, 1941 5 Sheets-Sheet 1

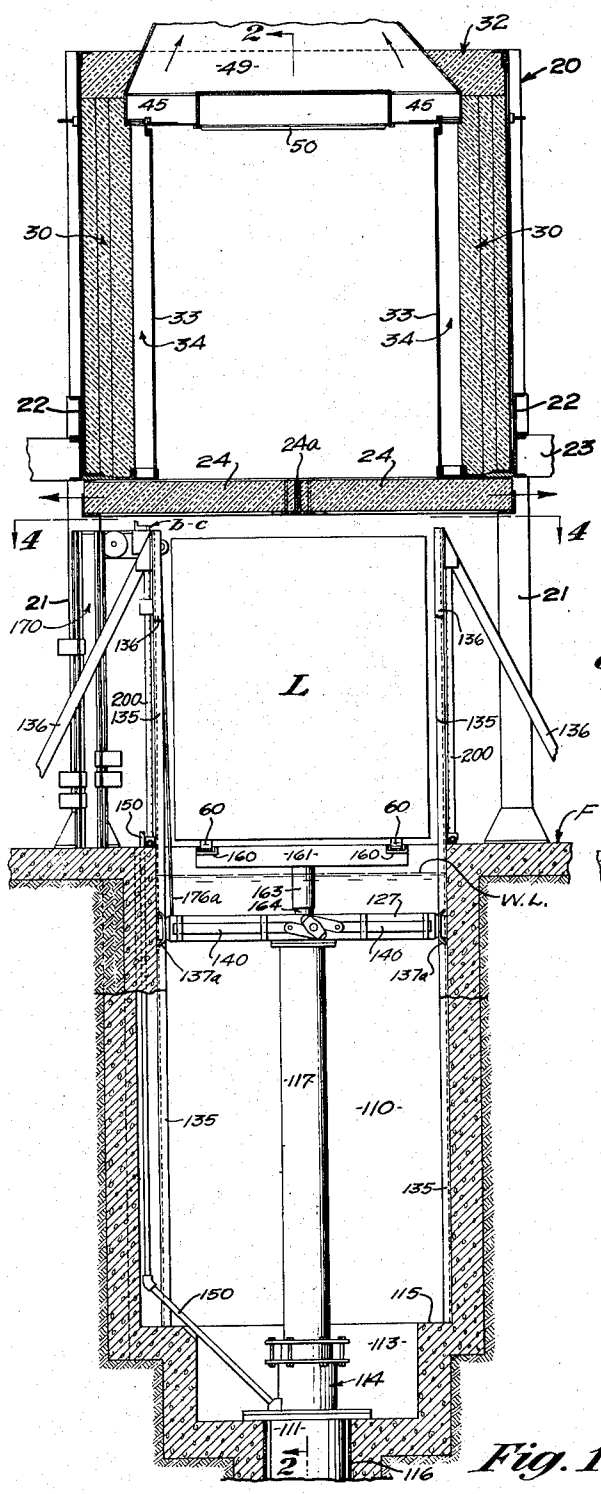

Fig. 1.

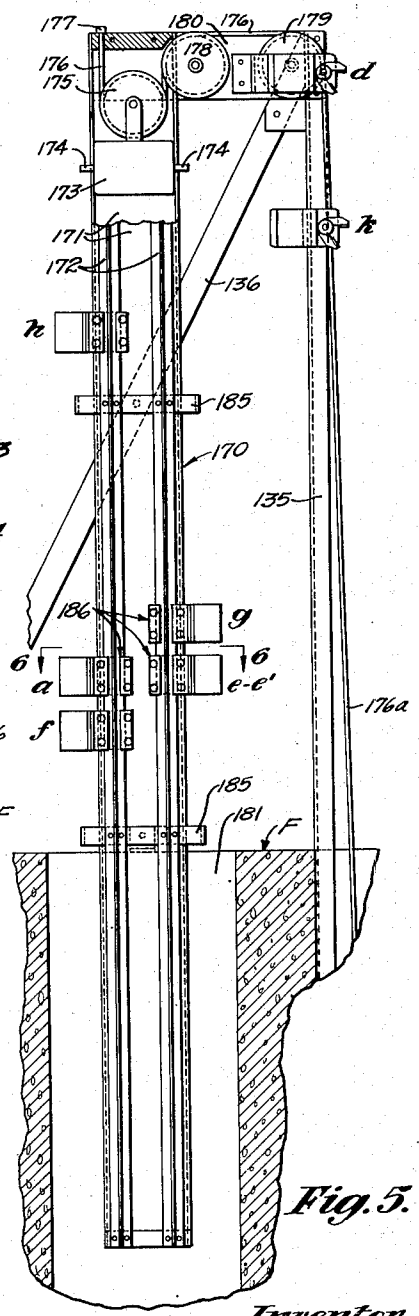

Fig. 5.

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HEAT TREATING SYSTEM

Filed Dec. 9, 1941 5 Sheets-Sheet 2

Fig. 2.

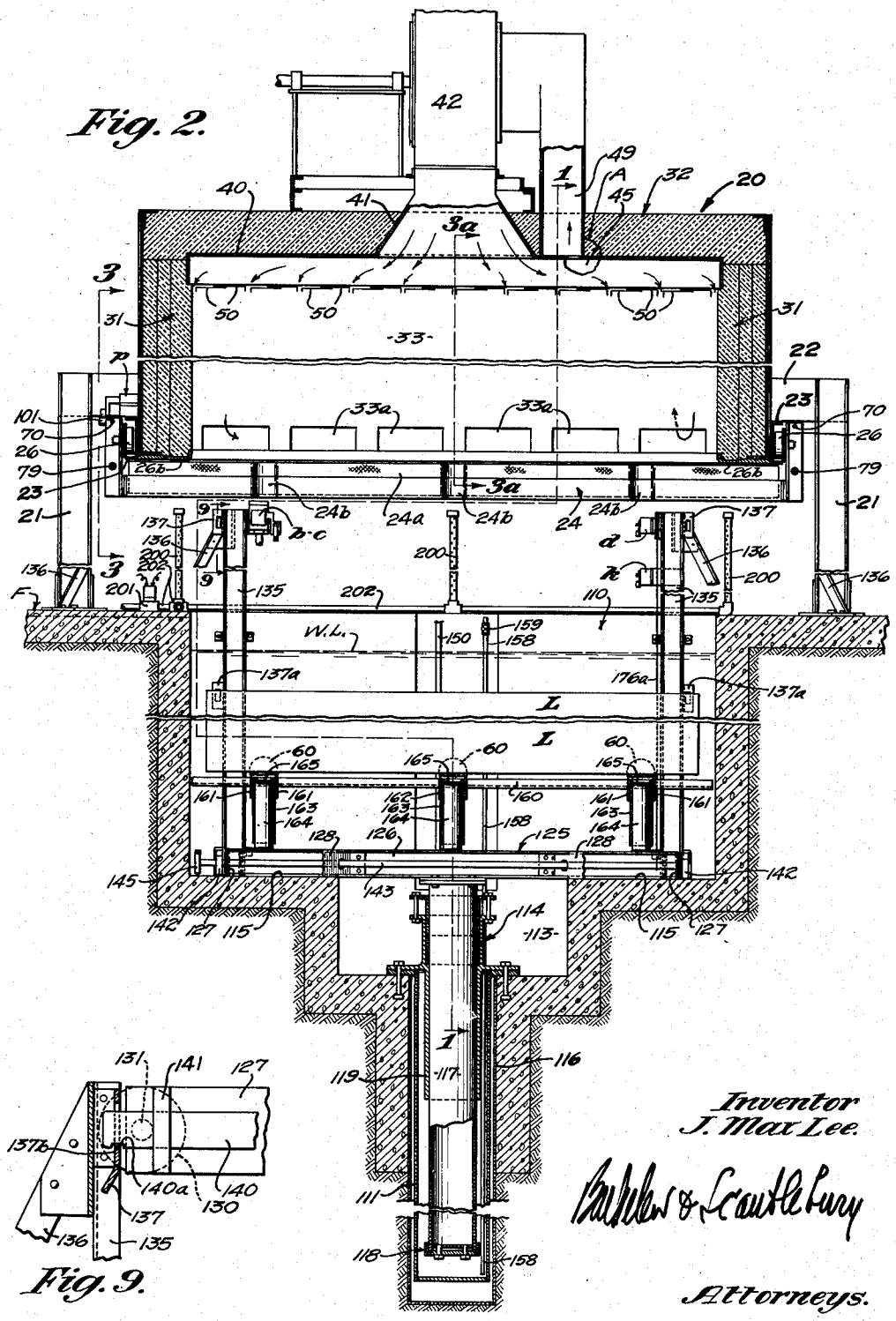

Fig. 9.

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Aug. 21, 1945. J. M. LEE 2,383,203

HEAT TREATING SYSTEM

Filed Dec. 9, 1941 5 Sheets-Sheet 3

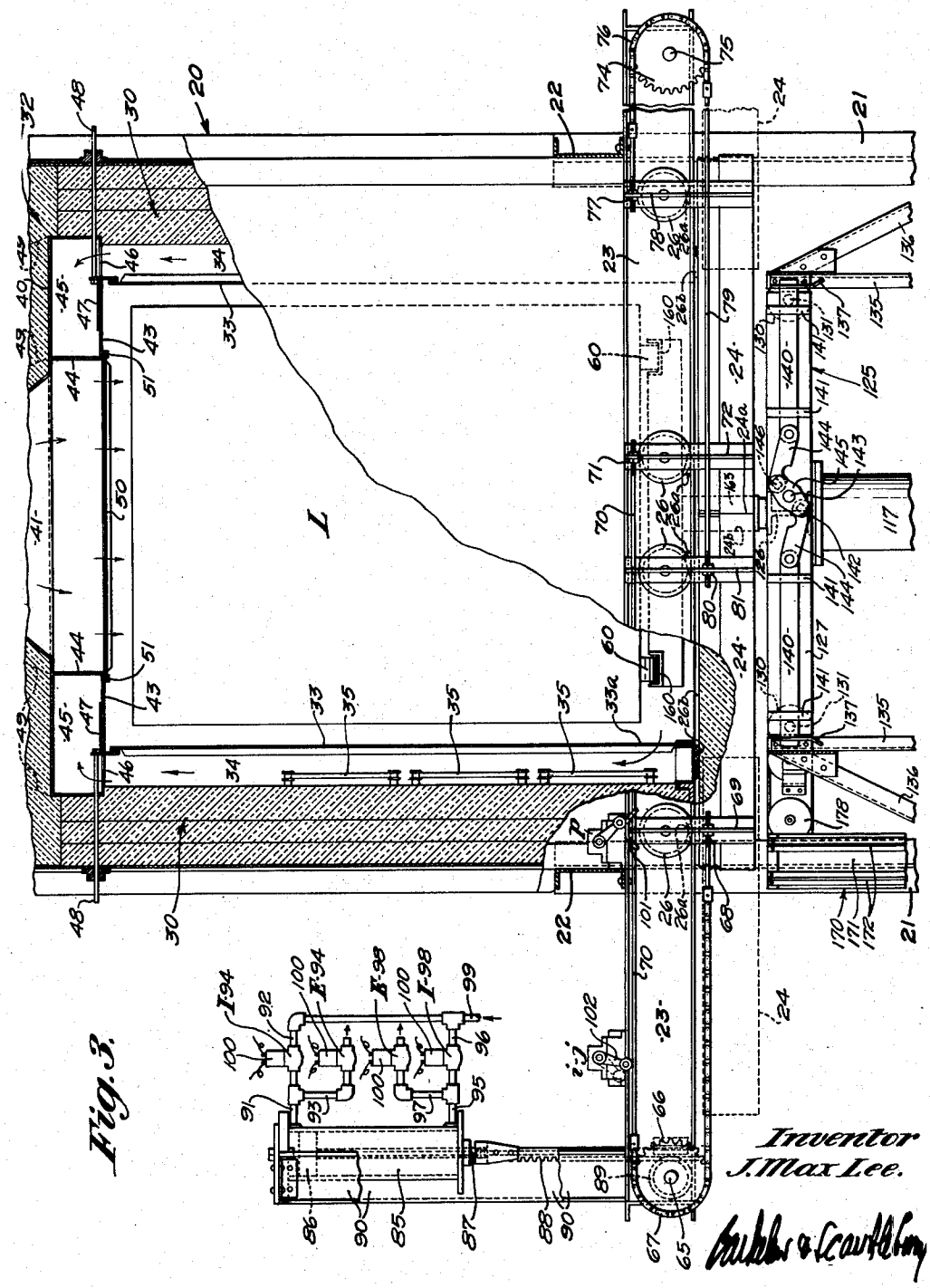

Fig. 3.

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Aug. 21, 1945. J. M. LEE 2,383,203

HEAT TREATING SYSTEM

Filed Dec. 9, 1941 5 Sheets-Sheet 4

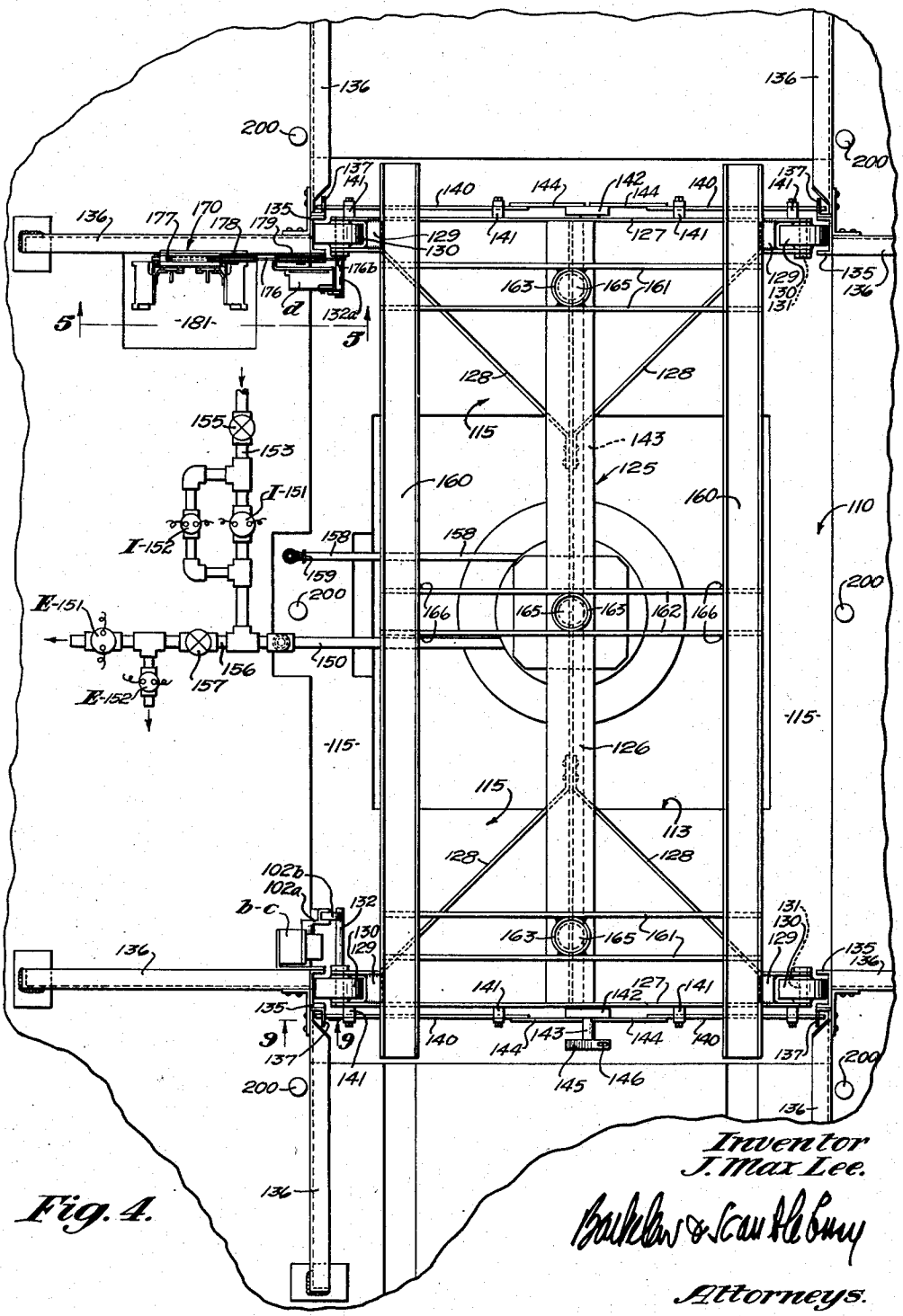

Fig. 4.

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Aug. 21, 1945. J. M. LEE 2,383,203

HEAT TREATING SYSTEM

Filed Dec. 9, 1941 5 Sheets-Sheet 5

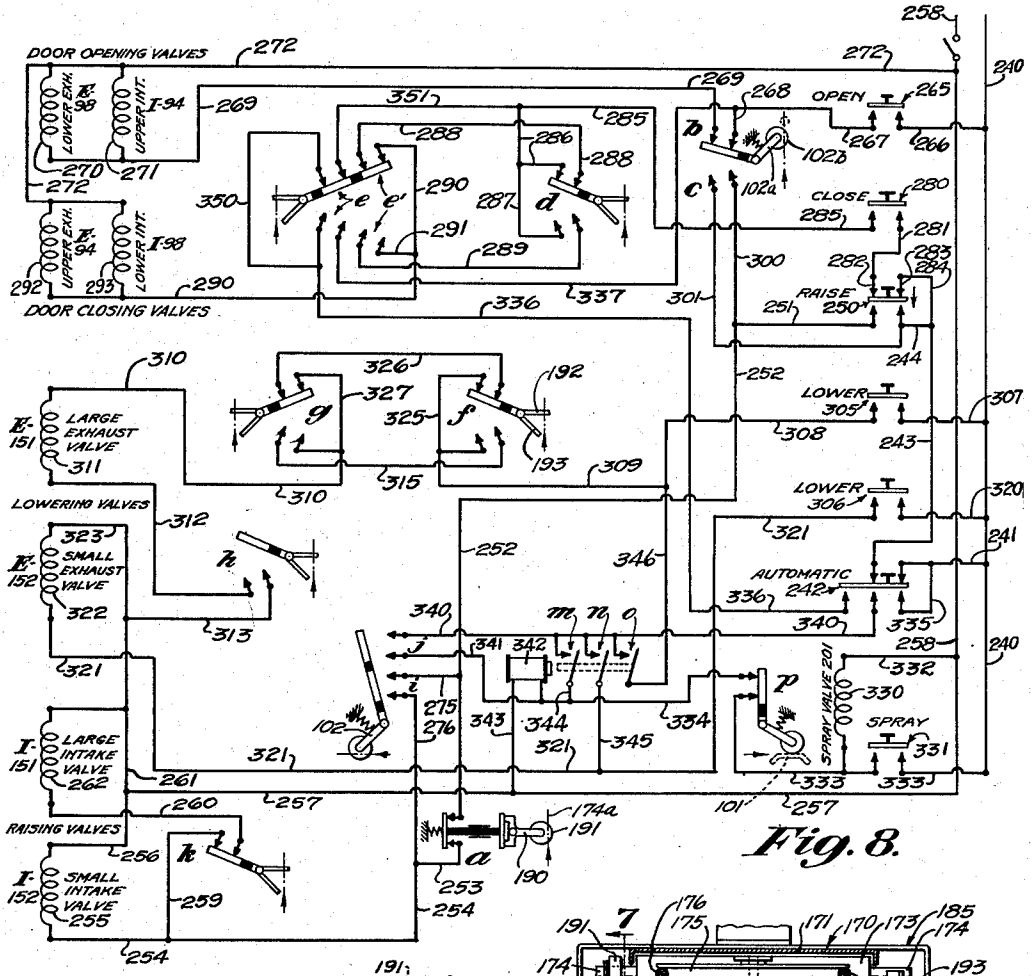

Fig. 8.

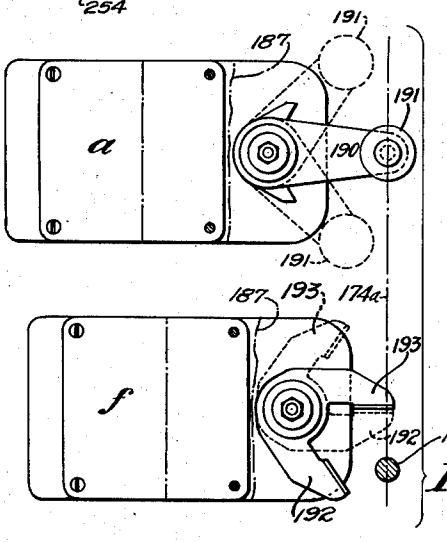

Fig. 7.

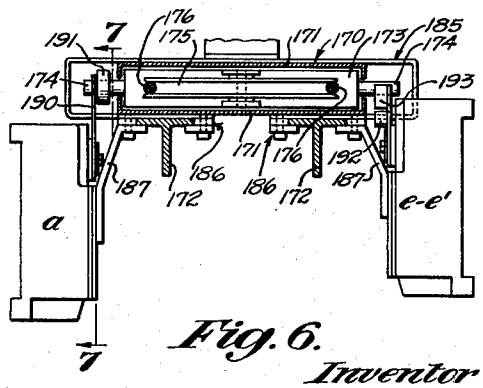

Fig. 6.

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Patented Aug. 21, 1945

2,383,203

UNITED STATES PATENT OFFICE

2,383,203

HEAT-TREATING SYSTEM

Jess Max Lee, Los Angeles, Calif.

Application December 9, 1941, Serial No. 422,214

4 Claims. (Cl. 266—4)

My invention has reference to heat treating systems of a type wherein metals are sequentially heated and quenched. The objects and purposes of my invention will appear from what follows.

In its present typical and preferred form my invention has been developed specifically with a view to heat treatment of aluminum alloys, such as are extensively used in aircraft construction. The invention will be typically and illustratively described particularly as applied to the treatment of such alloys; but the invention is not necessarily limited thereto.

Past experience and practice in the heat treatment of aluminum alloys indicates that best results, including maximum resistance to corrosion and best grain structure and strength, are obtained when the alloy is completely quenched within a period of five seconds removal from the high temperature zone. The alloy (in the form of sheets, shapes, etc.) is first heated to a temperature of around 950° F. to 1050° F. (depending on the alloy) and maintained at that temperature for a length of time which depends upon the thickness or mass of the piece or pieces, and is then quenched quickly. The quenching operation is usually performed by removing the parts from the heat treating furnace or oven and quickly immersing them in water. Practice indicates that, for best results, not more than approximately five seconds should intervene between removal from the furnace and final attainment of a specified low temperature. (The Army and Navy respectively specify that the quenching water shall be kept below temperatures of 150° F. and 100° F.; that is, that the temperature of the alloy articles shall be brought to approximately those maximum water temperatures within the quenching period.) The quenching operation thus necessarily requires rather fast movement of the alloy articles.

At the high temperatures to which the alloy is initially heated, the metals are comparatively soft and have little physical strength. Particularly in the treatment of thin sheets and plates, the impact forces generated by fast immersion in the body of water is very likely to warp and distort the articles; and that distortion is very difficult to remove satisfactorily after the articles have been quenched; in some cases impossible.

It is one of the general purposes of my invention to provide a heat treating system and apparatus in which metal articles of any size, shape and mass may be expeditiously removed from the heating furnace and quickly immersed and quenched, and complete cooling attained within the indicated time limits, with the minimum amount of distortion.

One of the primary objects of the invention is to carry out the complete quenching operation in a very short period; and that objective entails the objects of attaining fast movement of the load of metal from the furnace into the quenching bath, and of rapid heat transfer in the bath. And in connection with those objectives it is also a general object to provide an apparatus and a method wherein the sequences of operations can easily be standardized, and wherein a certain amount of automatic control makes standardization comparatively easy of attainment. It is consequently one of my general objects, and a corresponding accomplishment of the invention, that the system is easily capable of standardized operation.

Other general objectives of the invention are the provision of apparatus which is relatively simple and compact, occupies a minimum floor space, and has low maintenance requirements. All these and further purposes and objects will be best understood from the following descriptions.

The features of the system and apparatus which accomplish these purposes will be best understood from the following detailed and specific description of an illustrative form of the invention. I may however preliminarily mention that, among other features which will appear, my invention is characterized by provisions for fast removal of the load of metal from the furnace and movement into the body of quenching water or other fluid with a slowing down of movement at the point of entry; and also characterized by the application of water spray to the load for a short period just prior to entry into the body of water. These provisions give the metal greater strength and rigidity by the time it enters the water body, materially reduce the forces generated by water impact, and enable the complete quenching of the metal within the indicated time limit with minimum distortion.

In connection with the following illustrative description I refer to the accompanying drawings in which:

Fig. 1 is a vertical central section of the complete apparatus, with certain parts shown in elevation, the sections and elevations being as indicated by line 1—1 on Fig. 2. This figure shows the load-carrying elevator in its floor level position;

Fig. 2 is an enlarged fragmentary section taken as indicated by line 2—2 on Fig. 1, but with the load-carrying elevator in its lowermost position;

Fig. 3 is an enlarged view partly in vertical section and partly in elevation, the elevation being taken as indicated by line 3—3 on Fig. 2 and the section as indicated by line 3a—3a on Fig. 2. In this figure the load carrying elevator is in uppermost position with the load in the furnace;

Fig. 4 is an enlarged horizontal plan of lower parts of the apparatus, taken as indicated by line 4—4 on Fig. 1;

Fig. 5 is an enlarged detail elevation and section taken as indicated on line 5—5 of Fig. 4;

Fig. 6 is an enlarged horizontal section on line 6—6 of Fig. 5; but showing the traveler 173, 175 as if in a position below line 6—6;

Fig. 7 is a diagrammatic section taken as indicated by line 7—7 on Fig. 6;

Fig. 8 is a diagram of the electrical parts of the operating and controlling system;

Fig. 9 is an enlarged detail section taken as indicated by line 9—9 on Fig. 4 with the elevator locked in its uppermost position as shown in Figs. 3 and 4.

The furnace or oven chamber designated generally by the numeral 20 is supported on a suitable supporting structure which includes columns 21 and horizontal beams 22. Incorporated in the structure of the furnace and its support are two horizontal door supporting rails (channels or similar structural members) 23 which extend along lower opposite exterior edges of the furnace structure and act as supports and guiding rails for the two horizontally movable doors 24 which close the otherwise open lower end of the furnace chamber. In Fig. 1 the section is taken in a vertical plane which lies longitudinally of the movement of the doors. In that figure the doors are shown closed, meeting each other at their inner edges at 24a, and their opening movements are outwardly in the direction indicated by the arrows. The two doors are hung at each of their ends on rails 23 through the medium of roller hangers 26. Their inner edge faces 24a which meet when the doors are closed, are provided each with a plurality of registering semi-cylindric notches 24b which accommodate certain load supporting columns of the elevator when the elevator is supporting the load within the furnace and the doors are closed. The mechanism for moving the doors will be described presently, after I first give a brief description of the furnace structure.

The furnace structure proper is made with side walls 30, end walls 31 and roof 32, of suitable heat insulating and heat refractory material. Spaced inside the side walls I provide partitions 33, enclosing spaces 34 for heated air circulation and for the installation of electrical heating elements where such are used. For clarity of illustration the electrical heating elements are not illustrated in Fig. 1 but are illustrated at 35 in Fig. 3.

Mounted directly under the furnace roof is a metal box-like structure which provides circulation ducts for the air and also provides for distribution of the heated air over and throughout the load in the furnace. This box-like structure has an upper wall 40 into the center of which the air duct 41 opens from the circulation blower 42. The box-like structure has lower walls or panels 43 and longitudinal partitions 44 which enclose two longitudinal air ducts 45. These ducts 45 are in communication with air channels 34 through the openings at 46. Openings 46 are controlled by dampers 47, adjustable through the medium of damper rods 48. Blower 42 takes air from ducts 45 through an air intake 49 which has openings communicating with ducts 45. (The small localized section within the break line indicated A in Fig. 2 shows a communication of 49 with 45. The dotted lines labeled 49 in Fig. 3 indicate the positions of the communication openings.)

The lower wall 43 of the box-like structure, between the two longitudinal partitions 44, is open except for the adjustable louvers 50. These louvers, preferably of sheet metal and of the sectional shapes indicated in Fig. 2, extend transversely across the opening in the bottom of the box-like structure and are adjustably slidable longitudinally of the furnace in guides 51 which support their ends. They are arranged in overlapping pairs; and the pairs may be slidably adjusted so that adjusted gaps are left between the pairs to distribute the heated air which is circulated downwardly by blower 42. By adjusting the louvers the hot air can be directed and distributed so as to obtain even heating and even temperatures throughout any load. Thermocouples may be distributed in the furnace and the load to facilitate the obtaining of even temperatures by louver adjustment. And of course automatic temperature controls may be used to keep the heated-air at any selected temperature.

As will be understood from what has been said, the circulation of air takes place upwardly through passages 34 over heated elements 35, thence through ducts 45 and the intake 49 to the blower 42, thence downwardly from the blower through 41 and distributively through the adjusted louvers. The heated air flowing downwardly from the louvers is distributed evenly upon and through the load, and thence the air passes again to the bottom of channel 34 through openings 33a near the lower edge of partitions 33.

The load of metal which is being heat treated is represented diagrammatically at L. The load is usually carried upon a suitable truck (not specifically illustrated) and the diagrammatic showing at L merely illustrates the space which the load and the truck may occupy. The wheels of such a truck are indicated in Fig. 3 at 60. The trucks commonly have three or more pairs of such wheels, symmetrically spaced lengthwise under the truck. And the elevator platform which I will subsequently describe is, among other things, especially designed to carry such a multi-wheeled truck. In the subsequent detailed description of the elevator I specifically describe a platform designed for a six wheeled truck; but that is intended to be typical of any multi-wheeled arrangement.

I revert now to the mechanism for moving the doors 24. Fig. 3 shows, in full lines, the closed position of the doors as does also Fig. 1. Fig. 1 shows the positions of the parts when the loaded truck is standing at the floor level F and the doors are closed. This is the position of the parts either just before the load is lifted into the furnace chamber, or just after the load has moved out of the furnace chamber to the floor level. Fig. 3, in full lines, shows the positions of the parts when the load is in the furnace chamber and the doors are closed.

At one end of rails 23 there is a transverse shaft 65 which carries at each end a sprocket 66. (Only one of these sprockets is shown; but the door moving arrangement at the other end of shaft 65 is the same as shown in Fig. 2 and now described.) A sprocket chain 67 is trained over each sprocket 66. One end of each chain is secured at 68 to a bracket 69 which is attached to one of the doors 24—the left-hand door in Fig. 3. The other end

of each sprocket chain 67 has a rod extension 70 which is attached at 71 to a bracket 72 mounted on the other door 24.

At the other ends of rails 23 there are two sprockets 74 mounted on cross shaft 75; and over each of these sprockets a chain 76 is turned, one end of each chain being secured at 77 to a bracket 78 mounted upon the right hand door, and the other end of the chain, extended by rod 79, being connected at 80 with a bracket 81 mounted on the left hand door. The arrangement is such that rotation of shaft 65 will cause equal and opposite translation of the two doors, keeping them at all times parallel to themselves.

The power medium which is applied to move the doors may be any suitable medium. But, for reasons which will hereinafter appear, I prefer to utilize compressed air for operating the elevator of my system, and consequently find it preferable to also utilize compressed air for operating the doors. Accordingly I show a door operating cylinder 85 and piston 86. Piston rod 87 is connected with the gear rack 88 which meshes with a gear 89 on shaft 65, so that vertical movement of piston 86 will rotate shaft 65 to move the doors in and out. The cylinder is suitably supported in any manner, shown as supported on a framework 90 mounted on one of the rails 23. In the arrangement as shown, downward movement of piston 86 opens the doors to the positions indicated in dotted lines in Fig. 3, while upward piston movement closes the doors to their full line positions. Operation of the piston is controlled by inlet and exhaust valves arranged in pairs. Fig. 3 is not intended to illustrate the actual physical arrangement of the valves, but illustrates the valve and piping connections diagrammatically merely for clarity of illustration. Thus, I show diagrammatically a pipe 91 connecting into the upper end of the cylinder and having two branches, an inlet pipe 92 and an exhaust pipe 93. Inlet pipe 92 is controlled by a valve I—94 which will be hereinafter referred to as the upper inlet valve. Exhaust pipe 93 is controlled by a valve E—94 which will be referred to as the upper exhaust valve. Another pipe 95 connects into the lower end of cylinder 85 and its inlet and exhaust branches 96 and 97 are controlled respectively by the lower inlet valve I—98 and the lower exhaust valve E—98. The two inlet pipes 92 and 96 are diagrammatically shown as joining a common pressure supply pipe 99 which leads from any suitable source of air pressure, conveniently the common source from which air pressure is obtained for operating the other parts of the complete apparatus. The four valves (as are all the other control valves which are referred to hereinafter) are assumed to be of a type normally closed by a spring and opened only when electrical energy is supplied to their solenoids 100. Operation of the doors to open or close, as may be, is effected by supplying electrical energy simultaneously to the upper inlet valve I—94 and the lower exhaust valve E—98, or simultaneously to the upper exhaust valve E—94 and the lower inlet valve E—98.

A four pole single throw switch *i—j* is mounted on one of the rails 23 in a suitable position to be operated by an operating lug 101 mounted on one of the doors when the doors are in or approaching their open positions. This switch *i—j* is of a type which is normally open and which is closed by engagement of lug 101 with its operating arm 102. This occurs when lug 101 moves to the left in Fig. 3. Lug 101 moves under switch arm 102 and throws it to its dotted line position just as door 24 reaches its open position. Fig. 8 indicates how the switch will be closed when such movement occurs. As will later appear, this is one of the controlling switches of the control system. Another switch *p*, single throw double pole, and of a type normally open, is mounted in such a position as to be actuated to closed position by the lug 101 when the door 24 has moved to the right to its closed position. The control functions of these two switches will be explained later. Switch *p* is of the same physical type as switch *i—j*; see Figs. 3 and 8.

Furnace chamber 20 is supported on columns 21 at a sufficient height above floor line F to accommodate the truck and load L, supported at the floor line, with reasonable clearance under doors 24. The relative positions are shown in Fig. 1. In this position the truck with its load may be rolled off the floor onto the elevator, and vice versa.

A quenching pit 110 is formed in any suitable manner below the floor line and centrally under furnace chamber 20. The depth of this pit may be varied; it is only necessary that the pit be deep enough to contain a body of quenching fluid deep enough to completely submerge the load when it is lowered to the bottom of the pit and of sufficient volume to have no excessive temperature rise when quenching a maximum load. The pit may be made larger or deeper for the purpose of accommodating a larger body of quenching fluid if that is found desirable in order to keep the maximum fluid temperature below the prescribed limit. On the other hand, as will be well understood, fluid may be constantly flowed through the pit in order to keep the temperature from rising above the limit. In the drawings water is shown in the pit to the level indicated W. L. in Fig. 2.

I will commonly refer to water as the quenching fluid but without intending to limit myself to its use. In the variety of uses of which my system is capable, various quenching fluids may be used. Thus, for heat treating different metals the quenching fluid may be either water, or oil or other liquids, or even cooled gases, such as refrigerated air. And what I here say about the quenching bath is also true of the cooling sprays subsequently described; the spray fluid may be whatever liquid or gas best suits the particular operation being carried on, although there also I refer to use of water as typical.

Extending downwardly from the bottom of pit 110 I provide a vertical elevator cylinder 111. The walls 112 of the pit may typically be of concrete and the bottom of the pit may be formed with a floor recess 113 to accommodate the packing gland 114 and to form shoulders 115 on which the elevator carriage may rest when fully lowered. Through and below the lowermost parts of the concrete work a downward casing 116 may be extended, with the elevator cylinder 111 contained within it. Elevator plunger 117 has a shouldered head 118 on its lower end which preferably engages with cylinder head sleeve 119 to form a positive stop to the upward movement of the elevator plunger and of the elevator as a whole, thus to position the elevator carriage and platform and the load accurately within furnace chamber 20.

Use of a vertical elevator of the hydraulic ram type, in and below the quenching pit directly under the furnace, is one of the features of my system which greatly simplifies the structure and operation of the apparatus and conserves floor space.

Fig. 1 shows an air pipe 150 which extends down

from the floor level and enters cylinder 111 at its upper end. The valves for controlling the flow of air through this pipe are not shown in Fig. 1 but are diagrammatically shown in Fig. 4. Fig. 4 is not intended to show the actual physical placement of the valves, but only their functional relation to air pipe 150. In the actual apparatus these valves, as well as the valves which control operations of doors 24, may be mounted in some suitable remote location, as on a valve panel.

As shown diagrammatically in Fig. 4 two intake valves I—151 and I—152 are connected in parallel relation between air pipe 150 and air supply pipe 153. Valve I—151 has a relatively large aperture and will be referred to as the large inlet valve, while valve I—152 has a relatively small aperture and will be referred to as the small inlet valve. Also connected to air pipe 150, in parallel relationship, are a large exhaust valve E—151 and a small exhaust valve E—152. The speed at which air under pressure is introduced into the elevator cylinder, or exhausted from it, depends upon whether the large or the small inlet or exhaust valves are opened, or both the large and small. Further, the main air pressure supply pipe may be provided with a manually settable valve 155 and the exhaust pipe 156 may be equipped with a similar manual valve 157 so that the speed of elevator operation may be, additionally, regulated in a general way by the setting of these valves. The valves are all of the same type as hereinbefore described; that is, they are normally spring closed and are opened when supplied with suitable electrical energy.

In Fig. 2 a pipe 158 is indicated communicating with the lower end of cylinder 111. The figure also shows diagrammatically that this pipe extends to the floor level and is controllable by a manual valve 159. One purpose of this pipe is to facilitate blowing off any excess liquid which may accumulate in the lower end of the cylinder by condensation or otherwise. It may also be used for introducing and maintaining any predetermined amount of liquid, such as oil or water or both, in the lower end of the cylinder so as to effectively vary the air capacity of the cylinder. As will appear afterwards, I may wish to controllably adjust the elastic compression and expansion characteristics of the air in the cylinder, so as to adjust the length and the time period of the vibratory stroke which the piston may go through when supported by the elastic body of air under certain conditions. When the elevator is lowered toward its bottom position both exhaust valves are normally open. Shortly before the bottom is reached, the large exhaust valve is closed. The momentum of the elevator compresses the remaining body of air in the cylinder, and the elevator bounces. In bouncing it may reopen and then again close the large exhaust valve; but in any case it bounces until the water in the quenching pit damps the elevator movement and until the slow release of air through the small exhaust valve lets it settle down to bottom position.

An elevator carriage frame 125, best shown in Figs. 2, 3 and 4 is mounted upon the upper end of elevator plunger 117. This frame preferably includes a single longitudinal beam 126 which is centrally mounted on the upper end of plunger 117. At each end of longitudinal beam 126 there is a transverse horizontally extending plate 127 whose vertical width is equal to the height of beam 126. Diagonal braces 128 are secured to beam 126, and their outer ends are secured to spacer blocks 129 which are also secured to the outer ends of plates 127. All of the parts so far described may be welded or otherwise suitably secured together. Guide rollers 130 are mounted on pins 131 supported between the spaced ends of plates 127 and braces 128. These guide rollers may be of any suitable and known form; for instance they may be in the form of interconnected gears and the vertical rails 135 may have racks with which the gears mesh to prevent the elevator carriage from tipping when unsymmetrically loaded. The carriage frame also carries operating pins 132 and 132*a* for certain controlling switches which are mounted on two of the four vertical rails 135 which form guides for the carriage rollers. Of these switches, the one which is hereinafter identified as *b*—*c* is mounted on one of the vertical rails 135 to be actuated by pin 132; and the ones hereinafter identified as *d* and *k* are mounted on another vertical rail to be actuated by the pin 132*a*. The natures and functions of these switches will be hereinafter described.

The vertical guide rails 135 extend from the shoulder 115 at the bottom of the well upwardly to a level just under doors 24. The lower portions of the rails may be anchored to the walls of the well in any suitable manner, and their upper portions braced by such braces as indicated at 136. At or near their upper ends, the rails 135 carry apertured locking lugs 137 which form one element of a locking means for positively locking the elevator in the uppermost position shown in Fig. 3. At a lower level rails 135 have another set of similar apertured locking lugs 137*a* which form one element or means for positively locking the elevator with its platform or rack at the floor level, in the position shown in Fig. 1. These latter locking lugs are somewhat below the floor level—at the level of the elevator carriage frame in Fig. 1.

Slidable locking bolts 140 are mounted in guiding brackets 141 on each of the end plates 127 and are extended and retracted by manual rotation of pivoted arms 142 mounted on a shaft 143 which extends the length of the carriage frame so that both pivoted arms 142 may be simultaneously rotated. Links 144 connect arms 142 with bolts 140. At one end of shaft 143 another similar arm 145 (or a disk) is mounted, and this arm has sockets 146 adapted to receive a bar for the manual rotation of shaft 143. By manipulation of the parts, it will be readily understood how locking bolts 140 may be projected into the apertured locking lugs 137 or 137*a* or retracted from them. The socketed part 145 is somewhat below the floor line when the elevator is locked in the position of Fig. 1 at the floor level, but the sockets may readily be reached with an operating bar. Alternatively, any suitable known means of remote operation may be applied to the locking bolts.

Automatic means are later described for keeping the elevator and its load supported by adequate air pressure at all times, and for automatically maintaining the elevator and load in their proper uppermost positions when the load is in the furnace in the position of Fig. 3. The positive locking means are provided as safety devices to hold the elevator and load in either of the two described positions in case there should be failure of the operating air pressure, and also to hold the elevator rigid at the floor level position while loads are being transferred to and from the elevator. It is desirable that the arrangement be

such that the positive locking means cannot be released unless the elevator and load are adequately supported by the fluid pressure, in order to preclude the possibility of uncontrolled descent of the elevator and load. Ordinarily, the frictional engagement of locking bars 140 with locking lugs 137 under the downward pressure of the unsupported elevator and load will be sufficient to either make it impossible for the locking bars to be manually retracted, or at least to make that retraction sufficiently difficult to give the operator a definite indication that the elevator and load are not fully supported by the air pressure. This action may be enhanced by providing rough or corrugated surfaces of engagement between the locking bars and locking lugs; or it may be made positive by providing small notches 140*a* in the lower edges of locking bars 140, the notches being adapted to hook over the lower edges 137*b* of the apertures in locking lugs 137 if the elevator and load are not fully supported by the fluid pressure. See Fig. 9.

For purposes which will appear, I do not mount the load-carrying truck directly upon the elevator carriage frame, but upon a platform which is removably mounted upon that carriage frame in such a manner that the platform is the only part of the elevator structure to be subjected to the furnace heat, and so that the platform may be easily removed and replaced in case it should deteriorate under the heat. The preferred form of structure is shown in the drawings. The platform includes two longitudinal rail beams 160, preferably composed of channel irons and supported on three spaced pairs of transverse supporting plates or bars 161 and 162. I show three, to accommodate a truck with three pairs of wheels; the number of course will vary, three are to be taken only as typical. All of these pairs of bars are welded at their centers to the upper ends of tubes 163 which telescopically fit down over three vertical posts 164 which are mounted and secured at their lower ends, as by welding, to the central longitudinal beam 126 of the carriage frame. Cap disks 165 are welded to the upper ends of tubes 163 and rest on the upper ends of posts 164 to carry the load thrust. The outer ends of the central bar pair 162 are welded as indicated at 166 to the rail beams 160. The outer ends of the other two pairs of supporting bars 161 merely extend under the rail beams 160 but are not welded to them. This arrangement allows longitudinal expansion and contraction of rails 160 without warping the structure. The longitudinal spacings of the pairs of supporting bars 161, 162, are such that the wheels 60 of the load-carrying truck, when on rails 160, will come directly over the transverse supporting bars. The load weight is thus not carried on rails 160 at points intermediate the rail supports, and thus the structure is protected against distortion which might otherwise be due to the weight forces when the platform is at elevated temperature.

When the elevator and load are in the position shown in Fig. 3 and the doors closed, the door edge notches 24*b* accommodate the columnar supports of the elevator platform. In this position the platform has a substantial vertical clearance above the doors and the carriage 125 has clearance below the doors. The platform clearance over the doors is somewhat more than the amount of elevator movement required to actuate the automatic controls which keep the elevator fully supported in its uppermost position. That control is described later.

With the load in the furnace, the only part of the elevator that is in the furnace is the platform. All other elevator parts are outside the furnace where they are not subject to heat deterioration. The platform itself is of small mass; consequently little heat is wasted in heating the elevator—the "no pay" load in the furnace is a minimum.

I have described how certain of the elevator control switches are mounted on vertical guide rails 135 at or near their upper ends. These switches are the ones which, in the control system, control the elevator movements at or near the upper end of its travel, and for that reason are preferably mounted on the guide rails. Other switches which are now to be described and which control the lower movements of the elevator are not conveniently mountable upon the guide rails as they would thus be close to or under the water level in the pit. For such reasons a vertical switch-carrying panel 170 is provided adjacent one of the vertical guide rails 135 (the guide rail shown at the upper left in Fig. 4). The body of this panel is made up of two channel-shaped members 171, and longitudinal T-beams 172. Within the space between members 171, and guided by them, is a vertically movable traveler 173 which carries two protruding switch actuating pins 174 and which has a cable sheave 175 mounted upon it. A cable 176 is secured at one end at 177 to the upper part of the switch panel and extends down and under sheave 175 and then upwardly to pass over a sheave 178 and thence over another sheave 179 and thence downwardly, as shown at 176*a* in Fig. 5 to be secured to some part of the elevator carriage frame. Fig. 4 shows how the end of the cable may be secured, at 176*b* to the switch actuating pin 132*a* which is carried on the carriage frame. Sheaves 178 and 179 may be mounted on a brace plate 180 which is secured to the upper end of guide rail 135 and to the upper end of the switch panel. The whole arrangement is such that traveler 173 and its switch actuating pins 174 move vertically along the switch panel through distances equal to one-half the elevator travel. The switch panel may thus be materially shorter than the length of the elevator travel; the lower end of the switch panel may be accommodated in a well 181.

The two T-rails 172 form mounting rails for the various switches. The structure of the whole switch panel may of course be varied widely but as shown in the drawings the two channel-shaped members 171 are spacedly secured togetner by rectangular frames 185 which surround and are secured to members 171 at spaced levels. T-rails 172 are secured to the outer faces of the rectangular frames 185 so that the rails are somewhat spaced from member 171, as shown in Fig. 6. Switch mounting clamps 186 are mounted upon the rails in such a manner as is shown in Fig. 6 and are adjustable to any selected vertical position, and settable in the selected positions by tightening the clamps. These clamps carry brackets 187 upon which the several switches are mounted, and the switches are thus very accurately adjustable as to their vertical positions. Typical positions of the switches are shown in Fig. 5.

The uppermost one of these switches, the one which is actuated when the elevator is nearest the bottom of its travel, is the switch labeled *h*.

This switch is located, in effect, a short distance above the bottom of elevator travel, say about 24 inches above the bottom. This switch *h* is of the two-pole, single-throw, snap-over type, as indicated diagrammatically in Fig. 8.

Proceeding in downward order on the switch panel but in upward order with reference to elevator travel, the next switch on the panel is the one labeled *g*, which is actuated when the elevator is just a short distance below its floor line position—the elevator position shown in Fig. 1. This switch *g* is of the two-pole, double-throw, snap-over type, as indicated diagrammatically in Fig. 8.

Next in downward order on the switch panel, and upward order with reference to elevator travel, are the two switches which are labeled respectively *a* and *e—e'*. These two switches are in effect located substantially at the floor level. Switch *a* is a two-pole-single-circuit switch of a type which is normally closed and which is temporarily opened by movement of its switch arm in either direction. The diagram of the switch in Fig. 8 indicates its mode of operation. It is temporarily opened by the elevator movement at the floor level when one of the switch actuating pins **174** wipes by its roller **191** on its actuating arm **190** in either direction. Figs. 6 and 7 show the typical relation of the pins **174** to the switch arms, Fig. 7 showing typical relation of pin **174**, travelling along line **174***a*, to the actuating arms of switches *a* and *f*.

Next in downward order on the switch panel and upward order on the elevator movement is a switch labeled *f*. This switch is similar to switch *g* and is located to be actuated by one of the actuating pins **174** when the elevator is a short distance above the floor level.

The relationship of the several switch operating arms to the switch actuating pins **174** is shown in Fig. 6, which shows the two switches *a* and *e—e'*. Switch *a* is shown as having an operating arm **190** with a pin-engaging roller **191** at its end. Switch *e—e'* is shown as having a double operating arm **192**, **193**. From Figs. 6 and 7 it will be readily understood how the arms and rollers protrude into the vertical travel path of actuating pins **174** so that the pins, by their up and down travel, either wipe by the actuating arms to temporarily actuate such a switch as *a*, or to snap the operating arm of such a switch as *e—e'* from one position to the other. The arm structure of switch *f* is typical of all the switches of snap-over type herein described.

Fig. 7, which is an enlarged section taken on line 7—7 of Fig. 6, shows the relation of typical switches *a* and *f* to one of the switch operating pins **174**. The pin travels along the dot-dash line **174***a*. Operating arm **190** and roller **191** of the single throw switch *a* are shown in normal (switch closed) position. The dotted lines show the two positions to which the arm is thrown to open the switch as pin **174** wipes by the roller in either direction. The double operating arm **192—193** of the typical snap-over switch *f* is shown in full lines in one of its positions. It will be snapped over to the dotted line position by upward travel of pin **174** (downward travel of the elevator) and then back again to the full line position by downward travel of the pin.

Switches *d*, *e—e'*, *g*, *h*, and *k* are all snap-over switches of the same general physical nature as switch *f* and are operated in the same manner, either by one of the pins **174** on the switch panel or by one of the pins **132**, **132***a* on the elevator carriage. Some of these switches are double-throw, some single-throw, as shown in Fig. 8. Switch *b—c* (mounted at the top of a guide rail **135** and actuated by pin **132**) is of a physical nature similar to switches *i—j* and *m*. It is normally held in one position to close the switch *b*, as indicated in Fig. 8; that is, it is normally open as regards the switch *c*. Actuating pin **132** moves vertically past roller **102***b* on the end of its operating arm **102***a*. The arm normally stands at such an angle (see Fig. 8) that pin **132** wiping by in either direction will throw the switch blade temporarily to close switch *c* and open *b*. As soon as pin **132** has passed the switch goes back to normal position with *c* open and *b* closed.

Spray pipes **200** are shown in positions spaced around the space occupied by load L when it is at floor level position as shown in Fig. 1. The placement and positions of the spray pipes as here shown are merely typical; they may be placed and mounted in any manner around or over the load, so as to thoroughly spray the load with cold water or other cooling fluid as the load moves down toward the water bath. An electrically operated control valve **201** controls water supply to the spray distribution pipes **202**. Switch *p* controls valve **201**.

The general sequence of operations will now be explained, followed by an explanation of the control system which effects the sequences.

At the start of a heat-treating sequence the elevator is at the floor level as shown in Fig. 1; preferably locked in position by the positive locking bars **140**, but also supported by air pressure in the elevator cylinder. A previously treated load has been removed with the elevator in that position. A truck loaded with a fresh batch of metal to be treated is rolled onto the elevator platform and made fast in any suitable manner. Locking bars **140** are then withdrawn, doors **24** are opened, and air pressure admitted to the elevator cylinder to move the elevator up until the elevator platform and the load are completely within the furnace chamber above the level of the doors. See Fig. 3. The doors are then closed, the load brought up to the required temperature, and maintained at that temperature for the desired length of time. When the doors close they are moved into tight sealing engagement with the lower edges of the furnace walls. The door carrying rollers **26** roll up on small wedges **26***a* as the doors reach closed positions, moving the doors up against sealing gaskets **26***b* (see Figs. 2 and 3).

While the load is in the furnace the elevator is supported in its upper position by air pressure, preferably maintained automatically as will be described. The elevator may also be positively locked in that position, as a safety measure to prevent the load weight from being imposed on the doors in case the air pressure should fail for any reason. Also, in long continued heatings the air pressure and the automatic controls may be shut off if desired, for conservation of energy. In any case, however, the elevator cannot be unlocked (or at least readily unlocked) for lowering unless the air pressure fully supports it and the load.

When high temperature treatment is completed the elevator is unlocked and the doors opened. Air pressure is then exhausted from the elevator cylinder to lower the load. As soon as the load clears the doors they are again closed. The doors are normally kept closed to conserve furnace heat, only being opened temporarily for

passage of the load in and out. In the present design door closure occurs as the lowering elevator near its floor level position (Fig. 1). The clearance of the load under the doors at floor level position may be made to be as large as desired, although it is preferred to keep it restricted so as to minimize the distance that the load has to travel between the furnace and the water bath and so as to minimize the necessary speed of that travel.

As the load approaches the floor level position and just before entering the water bath, its speed is momentarily checked and the sprays are turned on. The exact sequence of those two operations is not significant. It is desirable that the load be sprayed, before entering the water, sufficiently to sharply lower its temperature and increase the strength of the metal before striking the water. But it is preferred to close the doors before starting the water spray, to prevent spray entering the furnace. Checking the speed of the load just before entering the water has the effect of decreasing the impact forces but of course lengthens the time period elapsing between load emergence from the furnace and entry into the water. While some pre-entry hesitation of the load may be had without preventing full quenching of the load within the prescribed time limit solely in the water bath, the preliminary spraying is advantageous because it starts the quenching operation immediately after emergence from the furnace and thus not only strengthens the metal to withstand the water impact but also facilitates the travel hesitation because the time required in the water bath to complete quenching is thus reduced. The preliminary cooling caused by spraying also facilitates the maintenance of the water bath at any required low temperature, less heat having to be absorbed by the bath.

As hereinafter explained, the spraying continues until the load is submerged. The hesitation in travel takes place just before load entry into the bath, and after the load strikes the water at reduced speed it then moves on downward at what would be full speed except for the water resistance. Near the bottom of the elevator travel the downward speed is again checked by closing the larger one of the elevator-cylinder exhaust valves. Momentum of the elevator and load causes the load to bounce on the air cushion in the elevator cylinder, and in bouncing it may repeatedly open and close the large exhaust valve, until release of the pressure through the smaller exhaust valve lets the elevator gradually settle to the bottom on the floor shoulders **115**. The bouncing action agitates the water bath and promotes fast heat transfer to the water.

After the load of metal is completely quenched, the elevator is raised again to the floor level, locked in that position, and the loaded truck removed to be replaced by a truck carrying a fresh load to be treated.

The electrical control system which effects the operational sequences is shown in Fig. 8. In this figure the various switches are not shown in their proper vertical locations with relation to elevator travel; Figs. 2 and 5 show the relative vertical locations of the switches. However Fig. 8 shows each individual elevator-actuated switch in the vertical orientation it would assume if the switch were actuated directly by the elevator movement rather than by a member which moves oppositely to the elevator. And in the following part of the description, I refer to switch movements as "up" or "down," having reference to the orientations of Fig. 8 and reference to movements of the switch blades. In Fig. 8 switches of the snap-over type (whether single or double throw) are diagrammatically shown with two operating arms, as for instance the two operating arms **192**, **193** shown for switch *f*. Switches of the type which are normally closed or open in one position and are operated only temporarily to the other position are shown with a single operating arm and roller, as arm **190** and roller **191** of switch *a*, or arm **102***a* and roller **102***b* of switch *b*—*c*, or the roller carrying arm **102** of switch *i*—*j* or *p*. Fig. 8 shows all the switches in the positions assumed when the elevator is resting on bottom.

Starting with the elevator on bottom, the operator moves the "raise" button **250** in the direction indicated by the arrow in Fig. 8 to close the raising circuit which leads from power supply line **240** through **241**, then through the "automatic" button **242** thence through **243**, **244**, the "raise" button **250**, and thence through **251** and **252** through the normally closed switch *a*, and thence through **253** and **254** through the actuating coil **255** of the small intake valve I—**152**, and thence through **256** and **257** to power lead **258**. At this time switch *k* is closed to close a parallel circuit **259**, **260**, **261** to energize solenoid **262** of the large intake valve I—**151**. The elevator then moves upwardly and during this upward movement it first closes switch *h* (which is located say about 24" from the bottom of the elevator travel) and then, just before the elevator reaches its floor level position (Fig. 1) it throws switch *g* to a position opposite to that shown in Fig. 8. Those two switches are in the lowering control circuit which is only operative when either one of the "lowering" buttons are closed. The effect of actuation of these two switches during upward travel of the elevator is merely to leave them both in their positions effective for the subsequent lowering operation of the elevator.

Next, as the elevator moves upwardly, switch *a* is actuated to open it at or about the floor level position of the elevator. Opening of switch *a* breaks the described raising circuit, deenergizing both the intake valves, and the elevator comes to a stop at its floor level position, with switch *a* still held open. Switch *a* is located in such a position, and the physical engagement of operating pin **174** with its operating roller **191** is of sufficient vertical extent to allow the elevator to come to a stop before switch *a* is allowed to close again. In this position the elevator may be physically locked and the loaded truck run on to it.

The loaded elevator cannot now be moved further upwardly until furnace doors **24** are opened. When these doors are fully opened they close the switch *i*—*j*. Switch *i* parallels switch *a* by reason of the connections **275**, **276**. Closing switch *i* thus again completes the raising circuit.

The furnace doors are normally closed as the elevator moves upwardly into its floor level position. To open the doors the operator closes the "open" button **265** which closes the door opening circuit which leads from power leads **240** through **266**, the "open" button, and through **267**, **268**, switch *b*, **269**, and thence in parallel through winding **270** of lower exhaust valve E—**98**, and winding **271** of upper intake valve I—**94**, and thence through **272** to the other power lead **258**. As a result, piston **86** of the door operating mechanism is moved downwardly to open the doors.

At the end of the door opening movement,

switch actuating lug 101 (see Fig. 3) engages the roller on operating arm 102 of switch *i*—*j* to close that switch and hold it closed as long as the doors remain open. Switch *i* is in parallel with switch *a*, by connections 275 and 276, so that the closing of switch *i* again closes the raising circuit of "raising" button 250, which was broken by the opening of switch *a*. Consequently the subsequent closure of the raising button again energizes both the large and small intake valves I—151 and I—152 of the elevator to introduce air under pressure to the elevator to cause further upward movement.

In passing, it should be noted that about the same time that switch *a* is opened by the elevator arriving at the floor level, or at least at a time before the elevator moves its load up between the furnace doors, the switch *e*—*e'* is thrown to a position opposite to that shown in Fig. 8 (down, in that figure). The general function of switch *e* has to do with the automatic lowering operation of the elevator, which will be described later. The general function of switch *e'* is to prevent closing of the furnace doors at any time while the load is between the doors. The action of these switches, as well as of switch *d* will presently be described. The switch *e*—*e'* is located on the switch panel 170 (see Fig. 5) at substantially what corresponds to the floor level position of the elevator.

As the elevator moves up from the floor level position, switch *f*, which is located on switch panel 170 in effect just above the elevator floor level position, is thrown down to a position opposite to that shown in Fig. 8. This switch, like switch *h* and *g*, has only to do with the lowering operations.

As the elevator proceeds on upwardly, and at a distance of say about 12 inches from its uppermost position, switch *k* (mounted on one of the guide rails 135, see Fig. 5) is snapped down to a position opposite to that shown in Fig. 8, and thus opened. Switch *k* controls the individual circuit of winding 262 of the large intake valve I—151. The large intake valve thus closes as the elevator approaches its uppermost position, leaving only the small intake valve I—152 open, and the elevator slows down.

Finally, as the elevator reaches or approaches closely to the top of its movement, switch *d* (also located on one of the guide rails 135—see Fig. 5) is snapped over to a position opposite to that shown in Fig. 8. As will be explained, switch *d* has to do with the door closing circuit, and its movement to the last stated position enables the door closing circuit to be operated. That circuit was broken when switch *e'* was thrown down at the floor level position, and is now re-made by switch *d* being thrown down.

Also, at about the same time that switch *d* is snapped over, and just as the elevator approaches its final uppermost position, the switch *b*—*c* is transiently operated to throw it to position opposite to that shown in Fig. 8 as the actuating pin 132 wipes past it. In the uppermost elevator position the pin has passed above the rollers 102*b* on switch arm 102*a*. The switch *b*—*c* is of the type which has a normal spring actuated position which is shown in Fig. 8. If the elevator moves down a short distance, its operating pin 132 moves down into operative re-engagement with the arm roller of the switch and again opens switch *b* and closes switch *c*. The function of this switch, as later explained, is to automatically feed air under pressure into the elevator cylinder to keep the elevator supported in its uppermost position.

The door-closing circuits and functions of switches *e*—*e'* and *d* will now be explained.

The circuit which effects and controls the closing operation of the doors is as follows: "Close" button 280 is connected at one side by 281 to a contact 282 which is connected through "raise" button 250 with contact 283 when the "raise" button is in normal position—open as regards the previously described raising circuit. The last named contact 283 is connected by 284 to 243 which is connected through the "automatic" button and 241 with power lead 240. (The purpose of this circuiting of the "close" and the "raise" button is to make them ineffective whenever the "automatic" lowering button is used to lower the elevator.) The other side of "close" switch 280 is connected by 285 and 286 with one of the upper pair of contacts of switch *d*, and by 287 with one of the lower pair of contacts of that switch. The other upper contact is connected by 288 with one of the upper pair of contacts of switch *e'*; and the other lower contact of switch *d* is connected by 289 with one of the lower pair of contacts of switch *e'*. The other upper contact of *e'* and the other lower contact of that switch are both connected by 290, 291 with both the energizing coils 292 and 293 of the upper exhaust valve E—94 and the lower inlet valve I—98 of the door operating mechanism, the two coils being connected in parallel between 290 and 272 which leads to the other power lead 258. The circuiting arrangement is such that the described door closing circuit cannot be energized unless the switches *e'* and *d* are both in their upper or both in their lower positions. With the two switch blades in relatively opposite positions no circuit can be established because 288 is in circuit only when both switches are up and 289 in circuit only when both switches are down. As has been stated, switch *e'* has been snapped down when the elevator passed its floor level position, while switch *d* was still up. Thus, until switch *d* is thrown down when the elevator reaches its uppermost position, the door closing circuit cannot be closed to energize valve coils 292, 293 to operate the door mechanism to close the doors. But as soon as the elevator, in or close to its uppermost position, snaps switch *d* down then the doors can be closed.

As stated before, the elevator is stopped mechanically at the upper end of its travel by engagement of plunger shoulder 118 with the lower end of sleeve 119. The operator keeps "raise" button 282 closed until the elevator reaches its upper position, and then, or any time just before, closes the door "close" button 280 until the doors close. The elevator may then be mechanically locked in its upper position for safety.

Switch *b*—*c* is a two-pole double throw switch normally held in its upper position (in Fig. 8) by its spring. In that position it puts the opening button 265 in circuit to be effective to open the furnace doors. As the switch operating pin 132 (see Fig. 4) moves up with the elevator approaching uppermost position, the lug wipes by roller 102*b* of the switch, momentarily reversing it but allowing it to move again to normal position (Fig. 8) when the elevator reaches top position. The doors are at this time open, so the temporary breaking of the opening circuit at switch *b* is of no effect. The temporary closing of switch *c* is neither of any effect because its two contacts are connected by 300 and 301 in parallel with the raising button 250 which is at this time supposed

to be closed. (If the operator should release the raising button **250** just before the elevator reaches the top, the closed switch *c*, in parallel with the raising button, will cause the elevator to move on to its uppermost position.) However, after the raising button is opened then if the elevator sinks by reasons of air leakage, the operating pin **132** wipes down onto switch roller **102***b* and again throws the switch down (Fig. 8). This occurs before the elevator has sunk far enough to let the elevator platform contact the doors. Closing of switch *c* closes the previously described raising circuit to feed air to the elevator to raise it until the switch is allowed to go back to normal position (Fig. 8). The elevator and its load are thus automatically kept at uppermost position if the elevator is not mechanically locked. And if it is mechanically locked, the elevator is constantly fully supported by the air pressure so that it will not drop when unlocked. And while switch *b* is open (whenever the elevator has sunk) the door opening circuit controlled by that switch cannot be closed to open the doors. This provision makes certain that the doors cannot be opened when there is any liability of the elevator load being upon them.

When the elevator and load are to be lowered, it is first necessary to open the furnace doors and mechanically unlock the elevator. For reasons which have been stated, neither of these operations can be performed unless the elevator and load are fully supported in their upper positions. And, as will be seen, in one of the modes of control operation the elevator cannot be then lowered until the furnace doors are fully opened.

When the furnace doors are opened, switch *i—j* is thrown to closed position and held there until the doors subsequently start their closing movement. The function of switch *i* in conjunction with switch *a* has been explained. Switch *j* when closed energizes a relay to close certain relay switches which have control functions in the circuits which control the automatic lowering operation of the elevator—an operation in which the lowering necessarily automatically follows door opening. In manual operation of the system the doors are opened as previously explained. In that mode of operation the elevator must remain in its upper position in order to open the doors due to the control of switch *b* on the door opening circuit; but manual control is depended on to not start the lowering of the elevator until the doors are fully open.

Manually controlled lowering of the elevator is controlled by either or both the lowering buttons **305** and **306**. The circuit for button **305** is from lead **240** through **307** to the button, thence through **308** and **309** to and through the set of switches *f* and *g*, and thence through **310**, coil **311** of the large exhaust valve E—**151**, and **312**, switch *h* and **313**, **261** and **257** to the other lead **258**. The lowering button **305** thus controls the large exhaust valve E—**151**, subject to the controls of switches *f*, *g* and *h*. Switch *h* is always closed except when the elevator is near the bottom of its travel. Switches *f* and *g* were left in their position opposite to that of Fig. 8 (snapped down) when the elevator passed the floor line position on its previous movement up. The circuit through *f* and *g* at the time now under consideration is as follows: from **309** through the lower contacts of switch *f*, thence through **315**, the lower contacts of switch *g* to **310**.

The circuit for lowering button **306** is from lead **240** through **320**, the button, thence through **321**, winding **322** of small exhaust valve E—**152**, and thence through **323**, **261** and **257** to the other lead **258**. The small exhaust valve will remain open as long as lowering button **306** is held closed, being subject to no other manual control.

If lowering button **305** is closed the large exhaust valve E—**151** opens and the elevator moves down until switch *f* is snapped over (up in Fig. 8) just above the floor line position. Switch *f* now being in its upper position, the circuit through *f* and *g* is broken and the elevator may stop before it reaches switch *g* at a position just below the floor line. However if at this time, or previously, the operator has closed button **306** to open small exhaust valve E—**152**, the elevator will proceed on downwardly, but at slowed pace until it reaches switch *g* to snap it over to its upper position (Fig. 8). The circuit to the large exhaust valve is then re-established through switches *f* and *g* as follows: from **309** through **325**, the upper contacts of switch *f*, then through **326**, the upper contacts of switch *g*, and **327** to **310**. The opening of the large exhaust valve begins to accelerate the elevator in its downward motion at just about the time the loaded truck L enters the water. The load consequently strikes the water at low speed, but is increasingly accelerated as it enters, so that the load is quickly submerged and quenched. The relative degree of retard, or hesitation of movement, as the load approaches the water depends on several factors, such as the distance between the two switches *f* and *g* and the sizes of the two exhaust valves, all of which may be adjustably changed.

Just as the elevator starts down switch *d* is reversed to its upper position in Fig. 8. With switch *e'* still in its lower position the door closing circuit is broken, making it impossible to close the furnace doors until the elevator reaches the floor level position where it reverses switch *e'* back to its upper position. The doors may then be closed by closing the button **280** either at that time or previously. The door closing circuit is then the same as before stated except that it extends through the switches *d* and *e'* as follows: from **285**, through **286**, upper contacts of switch *d*, **288**, upper contacts of switch *e'*, to **290**.

Incidentally, switch *c* is momentarily closed immediately after the elevator starts down and has the momentary effect of energizing the raising control circuit. But at that time switch *k* is open and disables the large intake valve I—**151**, so that the closing of *c* only opens the small intake valve I—**152**. The large exhaust valve E—**151**, if not both exhaust valves, being open, the elevator continues down. Shortly afterwards the switch *k* is thrown back to its closed position.

Also incidentally the switch *a* is momentarily opened as the elevator passes the floor level position, but its opening is ineffective as the circuit of the raising button **250** is open at that time. Switch *a* functions only to stop the elevator at the floor level on its way up.

As the elevator approaches its bottom position switch *h* is again opened, breaking the circuit of the large exhaust valve E—**151**. The closure of that valve, at about two feet above bottom, produces the bounce and agitation before explained. The elevator then settles to the bottom with the small exhaust valve open. The generator then releases the lowering button or buttons. The parts of the control circuit are

then all in the positions initially described and shown in Fig. 8. The next operation is to raise the quenched load as previously described.

In Fig. 8 the energizing coil 330 of spray valve 201 is shown as connected across leads 240 and 258, by connectors 332 and 333, in series with spray button 331. In lowering the elevator under manual control, the operator applies the spray during the slow travel of the heated load, before and as the load enters the water bath. Automatic operation of the spray will be explained after the automatic lowering operation has been described.

The electrically controlled operations when the automatic button 242 is used for lowering the elevator will now be described. At the beginning of these operations the elevator is in uppermost position and the doors are closed. The several switches are in the same positions before described; the positions to which they are thrown by the upward travel of the elevator to its uppermost position.

The automatic button 242 in its normal or "open" position closes the circuits 241, 243, 244, 284 and 281 which connect the raising button 250 and the door closing button 280 to power lead 240. In the operated or "closed" position of automatic button 242 these circuits are broken, so that the manual closing button and raising button cannot be used simultaneously with the automatic button.

When the automatic button is closed, circuit is established from lead 240 through 241, 335, the button, 336, the two lower contacts of switch *e* (which is then down), 337, 268, switch *b* (which must be closed to complete the circuit), 269, door operating valve coils 270 and 271, and 272 to the lead 258. The doors then open, provided the elevator is clear up and switch *b* is closed. The door operating valves remain open until their circuit is broken when switch *e* is thrown up as the elevator passes the floor level.

When the doors are fully open, switch *i—j* closes and establishes a circuit from button 242 through 340, switch *j*, 341, relay magnet 342, and 343 to 257 and lead 258. The relay switches *m*, *n* and *o*, close. Relay switch *m* closes a self-holding circuit 344 (between 341 and 340) in parallel with switch *j* to hold the relay closed after switch *j* opens and as long as the automatic button 242 is held closed. (It is held closed until the elevator reaches bottom.)

Switch *n* closes a circuit 241, button 242, 340, switch *n*, 345, to conductor 321, in parallel with the manual lowering button 306. Closure of switch *n* (with 242 closed) consequently opens the small exhaust valve E—152 by the same circuit control as has been explained for button 306.

Switch *o* closes a circuit from lead 240 through 241, button 242, 340, switch *o*, 346 to conductor 309 leading to switches *f* and *g*; this circuit being in parallel with lowering button 305. Closure of switch *o* (with button 242 closed) consequently closes the energizing circuits of the large exhaust valve E—151 in the same manner that lowering button 305 closes them; that is, subject to the described controls of switches *f*, *g* and *h*. These switches, operate as before described; the elevator goes through the same hesitation as described, and switch *h* and the "bounce" near the bottom are operated in the same manner. After the elevator settles to the bottom the automatic button is released and all the switches are then again in the positions of Fig. 8.

During the downward movement before reaching the floor level switches *b—c*, *d* and *k* are operated in the same manner as in the manual operation and with the same effects. At the floor level switch *e—e'* is snapped over to its upper position (Fig. 8) as before described; but it now has the automatic function of causing door closure without closing button 280 being manually operated.

When the automatic button 242 is originally closed it establishes the circuit through 336, switch *e* (then down in Fig. 8), 337, and switch *b* (then down) to open the furnace doors. This has been described. This circuit is finally broken when switch *e—e'* is thrown to its upper position at the floor level position of the elevator; and then switch *e* automatically establishes a door closing circuit as follows. With button 242 closed the circuit goes from 336, through 350, the upper contacts of switch *e*, 351, 286, the upper contacts of switch *d* (then up), 288, upper contacts of switch *e'*, 290, the coils 292, 293 of the valves which effect door closure, and thence through 272 to lead 258. In this operation the automatic switch *e* acts in these circuits in parallel with the manual closing button 280 and thus effects the same functions as that button, but automatically.

Automatic operation of the spraying system is such as to begin spraying at about the time the load approaches or reaches the floor level, and to continue spraying until the load is submerged. As the doors close substantially at the time desired for spray inception, and because it may be undesirable to start the spray until the doors are closed or nearly closed, I may control the spray in the manner now described.

Switch *p*, of the same mechanical type as switch *i—j*, is mounted in such a position on the frame of furnace as to be closed by the switch operating lug 101 mounted on door 24, when the doors close. This switch is held closed only as long as the doors are closed and opens as they begin to open.

In Fig. 8, switch *p* is shown in a circuit which leads from lead 258 through 332, coil 330, 333, switch *p*, relay switch *m*, 340, button 242, and 335, 241, to lead 240. With the automatic button 242 closed to operate the doors and lower the elevator, relay switch *m* is closed when the doors are fully opened. The elevator then starts down, as described, and the doors then automatically close. As they close, the circuit through switch *p* is closed, switch *m* remaining closed as long as button 242 is closed. Spraying then starts and continues to be applied to the load until it is completely submerged. The spray thus operates in a general way coincidently with the slow travel of the load. After the load submerges, the spray is of course ineffective; but in the illustrated control system it is finally shut off when button 242 is released and relay switch *m* opens.

Many changes and variations may be made in the described apparatus and methods, within the scope of my invention as defined in the following claims. In the claims as well as in the description I use the term "bath" without any limitation to requirement of a solid body of fluid; it may be as well a heavy spray or shower. In other words the bath in which the heated load is submerged may be either a bath of solid fluid or may be a spray or shower bath.

I claim:

1. In systems for heat treating metal articles and the like by first heating and then quenching them, and which comprise a heating furnace

having a closure at its lower side and means for opening and closing the closure, a quenching bath spaced below the furnace, and an article carrying elevator mechanism adapted to move articles vertically into and between the furnace and bath; the improvement which comprises an elevator having a lower fluid pressure cylinder located below the quenching bath, a lift plunger extending upwardly from the cylinder through the bath, an elevator carriage frame mounted on the upper end of the plunger, a columnar supporting means extending upwardly from the carriage frame, a load receiving platform mounted on said columnar supporting means so as to be vertically spaced above the carriage frame, said furnace closure comprising oppositely movable doors arranged to have their inner ends meet when the doors are closed, and the inner ends of said doors having openings for receiving the columnar supporting means when the doors are closed and the platform is moved into the furnace, so that the carriage frame below the doors is not subjected to the furnace heat.

2. In systems for heat treating metal articles and the like by first heating and then quenching them, and which comprise a heating furnace having a closure at its lower side and means for opening and closing the closure, a quenching bath spaced below the furnace, and an article carrying elevator mechanism adapted to move articles vertically into and between the furnace and bath; the improvement which comprises an elevator having a lower fluid pressure cylinder located below the quenching bath, a lift plunger extending upwardly from the cylinder through the bath, an elevator carriage frame mounted on the upper end of the plunger, a centrally arranged columnar supporting member extending upwardly from the carriage frame, a load receiving platform, means removably mounting the platform on the columnar supporting member vertically spaced above the carriage frame, the furnace closure comprising oppositely moving doors arranged to have their inner ends meet when the doors are closed, and the inner ends of said doors having openings for receiving the columnar supporting member when the doors are closed and the platform is moved into the furnace, so that the carriage frame below the doors is not subjected to the furnace heat.

3. Systems for heat treating metal articles and the like as specified in claim 1, further characterized by the load receiving platform being skeletal and comprising a plurality of longitudinally spaced transverse beams, the columnar supporting means comprising a columnar support arranged centrally under and supporting each beam, and a pair of transversely spaced longitudinal rails mounted on the outer ends of the transverse beams, the rails adapted to take a load carrying truck whose supporting wheels may be positioned over the several transverse beams.

4. Systems for heat treating metal articles and the like as specified in claim 1, further characterized by the carriage frame comprising a horizontal longitudinal beam mounted centrally on the upper end of the elevator plunger, the platform being skeletal and comprising a plurality of longitudinally spaced transverse beams in a horizontal plane spaced above the carriage beam with their transverse centers directly above that beam, and a pair of transversely spaced longitudinal truck receiving rails mounted on the outer ends of the transverse platform beams, and the columnar supporting means comprising longitudinally spaced central columnar supports one for each platform beam on the carriage beam, the platform beams and rails being removable as a unit from the carriage frame.

J. MAX LEE.