April 15, 1941. H. E. SOMES 2,238,082

CYLINDER TREATING MACHINE

Original Filed Jan. 7, 1937 4 Sheets-Sheet 1

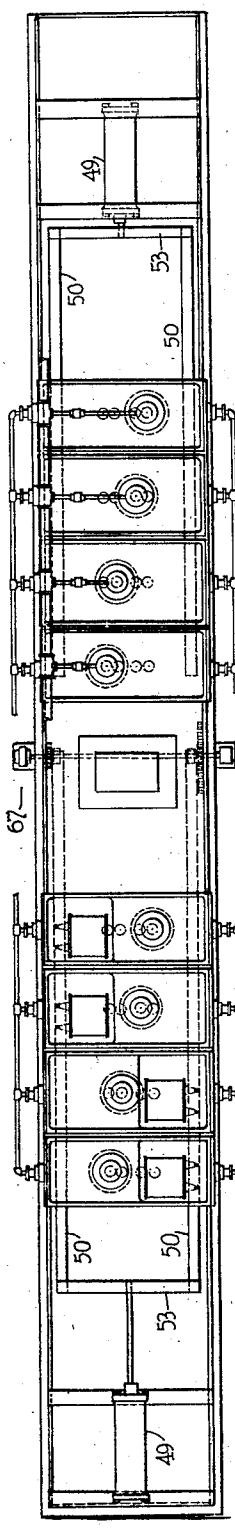

FIG. 2

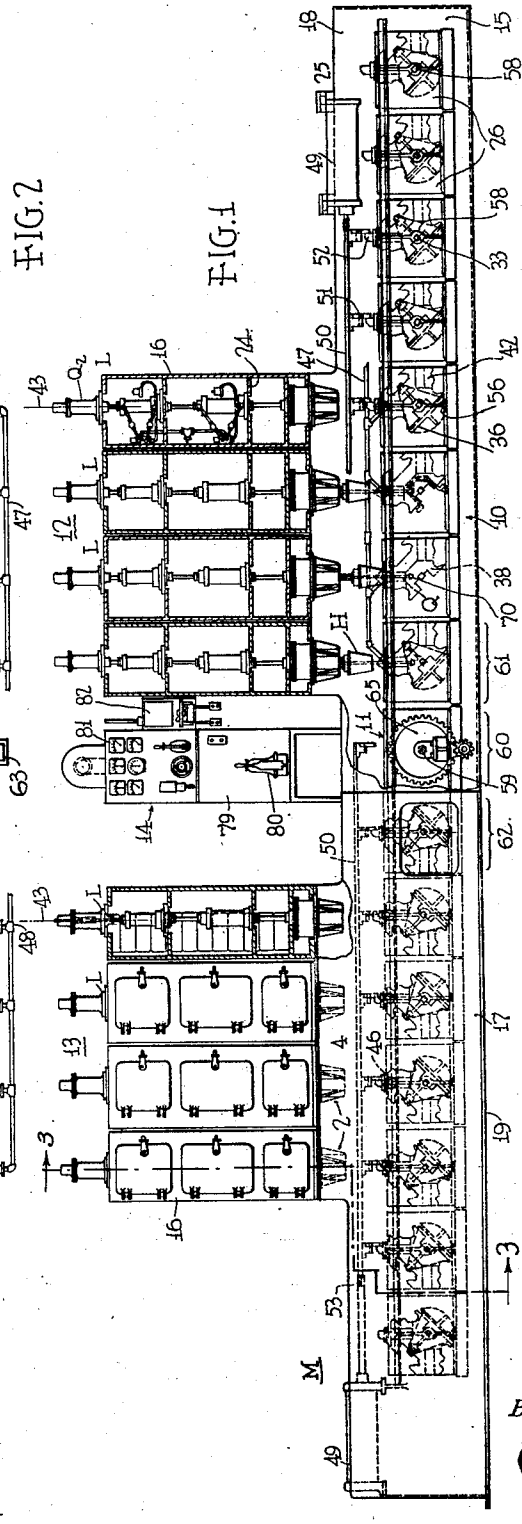

FIG. 1

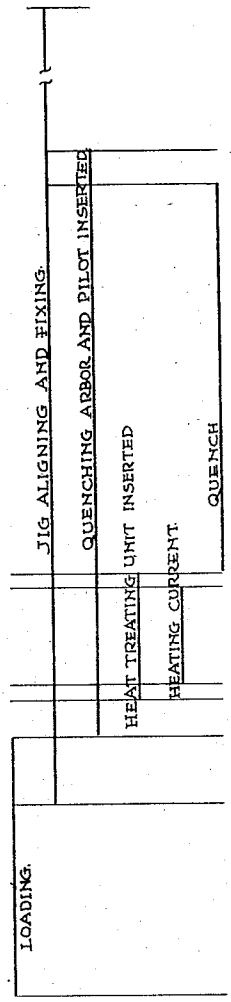

FIG. 5

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FIG. 3.

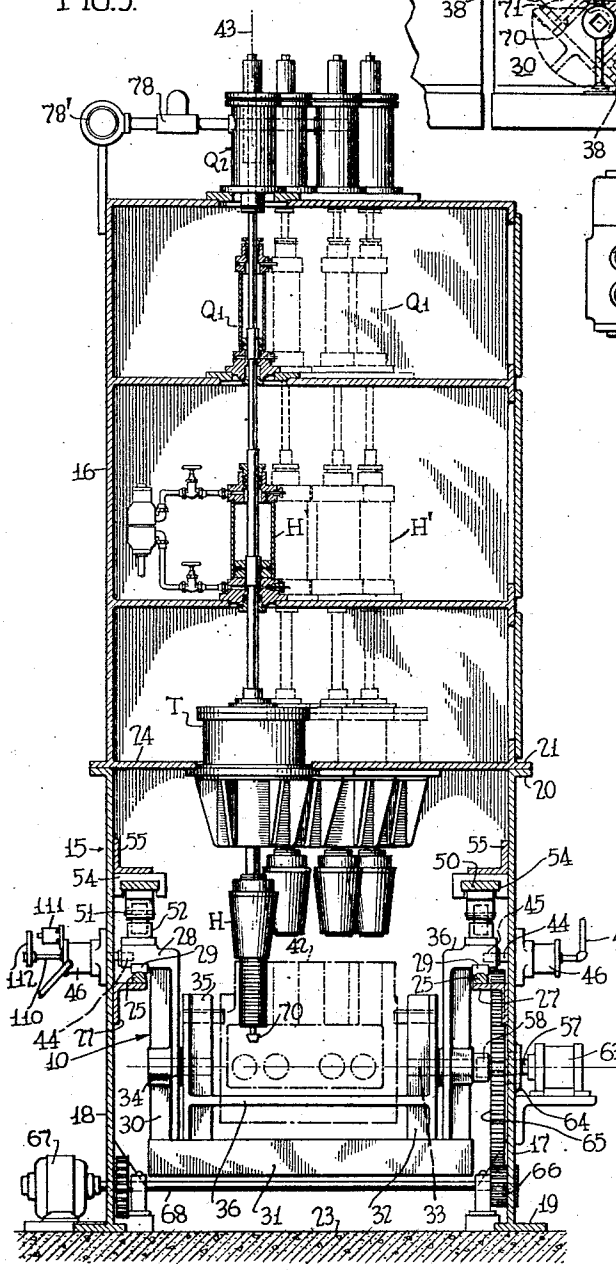


FIG. 11

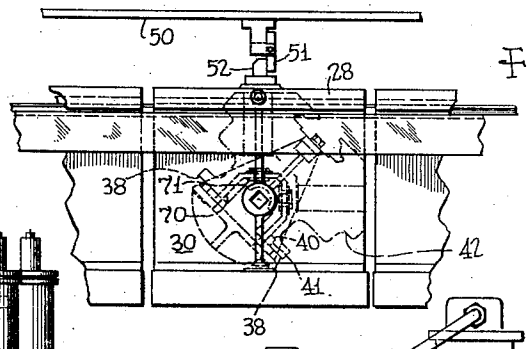
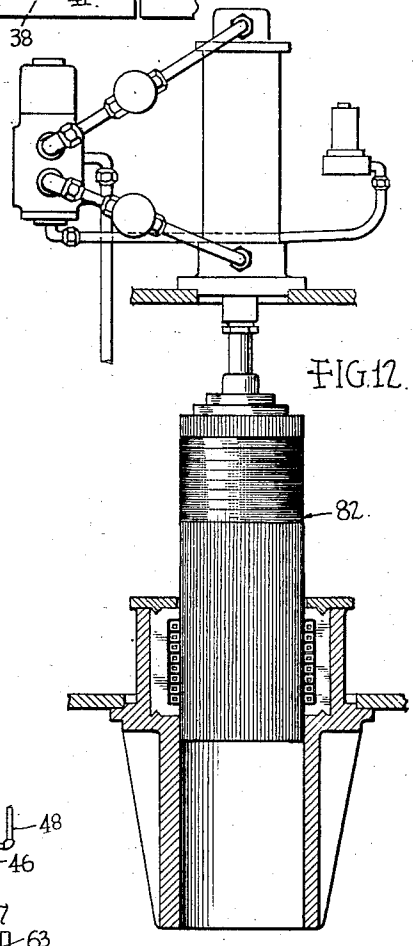


FIG. 12



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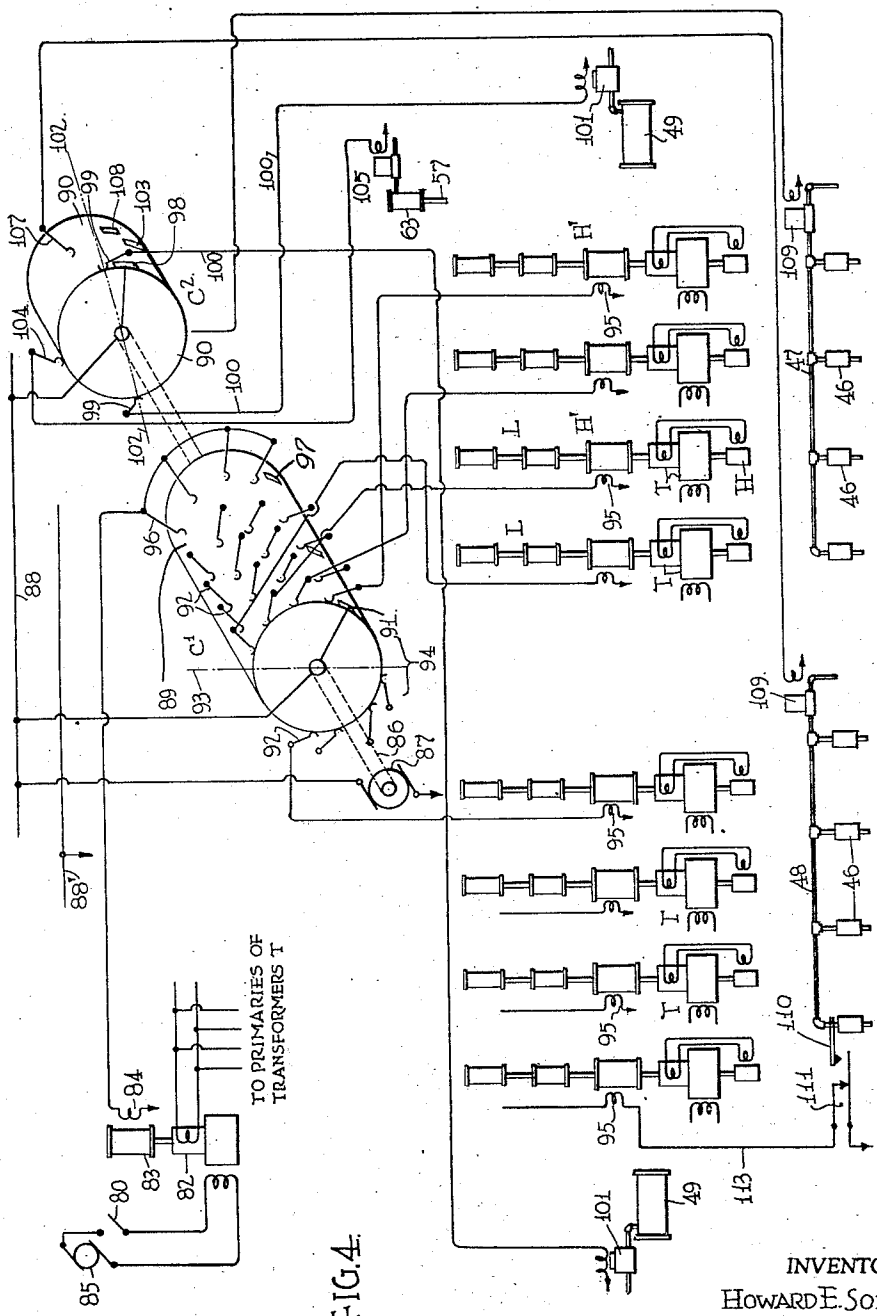

FIG. 4.

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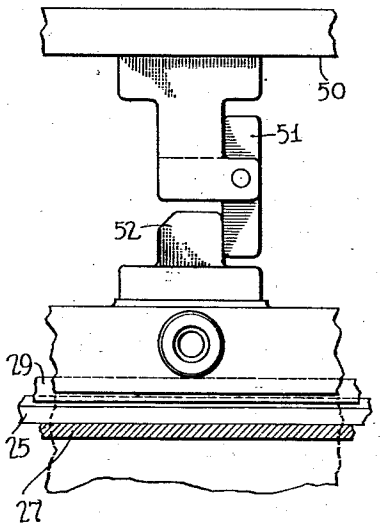


FIG. 7

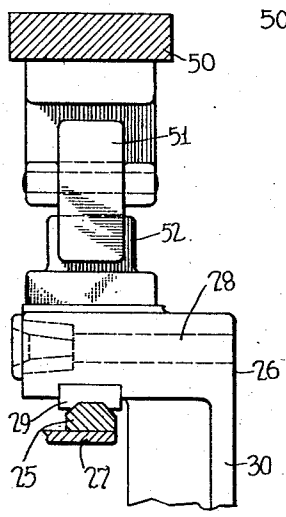


FIG. 8

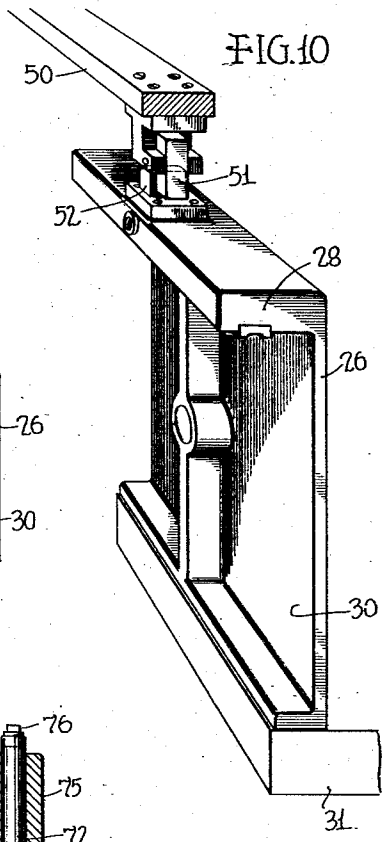
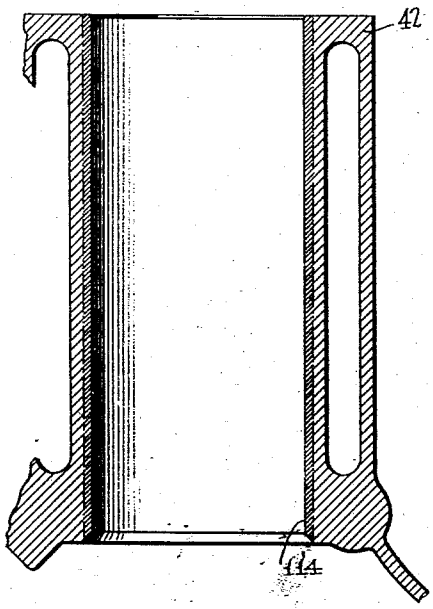


FIG. 10

FIG. 9



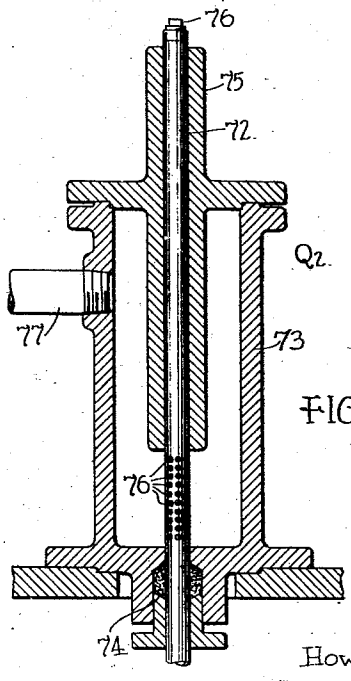


FIG. 6

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Patented Apr. 15, 1941

2,238,082

UNITED STATES PATENT OFFICE

2,238,082

CYLINDER TREATING MACHINE

Howard E. Somes, Detroit, Mich.

Application January 7, 1937, Serial No. 119,400
Renewed March 8, 1939

19 Claims. (Cl. 266—4)

Under date of August 17, 1936, I filed in the United States Patent Office, a patent application Serial No. 96,346, having to do with the heat treatment of relatively hollow thin-walled objects upon their internal surfaces.

Under date of August 20, 1936, I filed in the United States Patent Office, a patent application Serial No. 96,930, directed to such heat treatment of the cylinders of internal combustion engines, particularly automobile engines.

I have now invented a large scale production machine for the treatment of automobile engine cylinders. This application relates particularly to this machine. While of this particular relation, however, I desire to have it understood at the outset that not only is such a machine certainly adapted for treating the internal wearing surfaces of cylinders of other classes of internal combustion engines, but also very probably suitable in some, if not all of its phases to the treatment of the cylinders of engines of other types and the treatment on a production scale of hollow objects of their internal wearing surfaces, irrespective of the character thereof.

It is an outstanding object of my invention to apply the heat treating tool or machine, the subject particularly of my first-named invention, to work on large scale production with a high degree of efficiency. The form of that tool or machine which I prefer for this purpose is substantially that form disclosed in my copending application Serial No. 96,346, filed August 17, 1936. This machine comprises, speaking in general terms, the following. First there is the means for mounting, centering, clamping and aligning the work piece which I have designated, the work piece mounting mechanism. Second, there is the heating unit comprehending the heating element per se and its immediate adjuncts which coact in the heating of the work piece. The third is the switching unit through which power is cut on and cut off the heating unit. The fourth is a quenching unit through which the quenching medium is applied to and removed from the work piece. Fifth, there is the control unit through which these operations of all the foregoing units are primarily controlled and timed with respect to each other.

The several heat-treating units are arranged in coaxial relation vertically to operate upon the work piece axially arranged upon the same axis. In the present invention I make use of a multiple number of these heat-treating tools (and hereinafter I shall call them tools because I desire to apply the broader term "machine" to the ensemble which is the present invention), a number corresponding in the present instance to a number of cylinders in a given block, say for example, an eight cylinder V-type of block. I progress cylinder blocks before these several heat-treating tools upon a conveyor upon which they are mounted in a jigged relation to each other and to the heat-treating tools. This jigged relation is such and the relative positional relation of the multiple tools is such that they operate upon a number of blocks equal to the number of cylinders per block, and a different cylinder is operated upon in each block. In this arrangement I achieve one of the principal objects of my invention, the avoidance of interference irrespective of the relative arrangements of the cylinders and their relative proximities to each other in a given block.

In this and the provision for successive operations of the multiple tools, I attain economy in the first cost of equipment and efficiency in the use of the power required. According to my invention not only do I operate the tools individually in an ordered succession, but also I operate especially in connection with the V-type (or more broadly speaking, angle type cylinder blocks), the tools in successive groups. Thus, in an eight cylinder block I operate in succession the tools in one group of four and then in a succeeding succession the tools in another group of four. Thereby a single control panel and line switching equipment and a single high powered, high frequency generator and transformer and perhaps a single group of capacitors, which equipment suffices in power capacity for the heat treatment of a single cylinder, is utilized in common for the entire machine.

In the two foregoing arrangements and a third, to wit, a unit conveyor the mechanism of which is operable successively in group sections, I attain an ordered feeding of the work to the tools, a certainty and accuracy of jigging, and the uniform and high speed work flow which greatly contributes to the efficiency of a production machine of this order. The cylinder blocks are mounted on jigging fixtures, in the case of a V-type engine, each fixture capable of carrying a cylinder block in each of two jig positions (and in a multi-angled motor in a corresponding number of positions). The conveyor supports these jigging fixtures in a spaced relation corresponding to the spaced relation of the tools and of the groups of tools and with the axes of the cylinder blocks transversely of the conveyor. The series of jigging fixtures so car-

ried are divided into two groups with a space being equal at least to the accommodating space for one jigging fixture of the series. (Additional spaces and multiples of the single jigging fixture space may be provided, if desired). The two groups of tools are arranged to co-act with the jigging fixtures on opposite sides of this space. Acting on the jigging fixtures in the space between the groups is the mechanism for shifting the fixture to change from the presenting of the bank of cylinders treated by the one group of tools to the bank to be treated by the other. This is achieved by an automatic rotation of the jig fixture through the angle of the banks, from the position in which the one bank has been presented, the first group of treating tools axially thereof to that angle at which the other bank of cylinders is presented to the next succeeding group of tools axially thereof. During the period when one group of blocks is being treated by an advanced group of treating tools, the next succeeding group of blocks, as borne by the next succeeding group of jig fixtures, is moved. Also, while the blocks of the first group are being treated, the intermediate block opposite the shifting mechanism is shifted through the angle between the banks, ready to constitute the first block of the succeeding group on the next feeding movement of the succeeding group. The sum of the time required for the angular shifting from one bank to another and that required for feeding one jig spacing ahead is less than the total time required for successive operation of the treating tools in a single group. Therefore, that jig fixture which has been shifted through the bank angle is moved forwardly with the advance group movement to carry the fixtures to the next succeeding position before the succeeding bank of tools. Thus the space before the bank angle shifting mechanism is left free to receive the advanced fixture of the first group on its forward feeding movement. Treatment by the first group of tools being completed, treatment by the second group of tools begins and during the period of operation of the second group of tools the fixtures juxtaposed to the first group are advanced forwardly to bring fresh cylinders before the corresponding tools and to bring the advance fixture before the bank angle shifting mechanism.

Yet the fourth object of my invention is to so arrange the various groups of treating tools about the unitary power equipment as to attain the maximum efficiency of electrical transmission from the power equipment to the various tools. Thus the power equipment is arranged centrally of the groups of treating tools in the case of treatment of cylinders in two banks, midway between the two groups of treating tools or thereabouts.

The accompanying drawings show the best form of my invention at the moment known to me, but it will be quite apparent before one has gone very far into detailed understanding of the invention as delineated by them, that the invention is susceptible of a number of other embodiments beside those shown.

Of the drawings, Fig. 1 is a side elevation of the machine with certain parts broken away to show the interiors of the tool frames.

Fig. 2 is a top plan view of the same.

Fig. 3 is a vertical transverse section in the axial plane of a cylinder block.

Fig. 4 is the circuit diagram showing an improvement in switching connections.

Fig. 5 is a diagram showing the time sequence of operation.

Fig. 6 is an axial cross section of a quenching valve unit.

Figs. 7 and 8 are respectively, side and end elevation of one of the feeding pawls.

Fig. 9 is an axial cross section of a treated cylinder, showing the heat-treated inner zone.

Fig. 10 is a perspective view of one side wall of a jig fixture.

Fig. 11 is a side view of a jig fixture on the same scale as Fig. 3.

Fig. 12 is an elevation, partly in section, of the main or common transformer.

Referring to the drawings, 10 designates the conveyor at large. 11 designates the bank angle shifting mechanism located midway of the conveyor. 12 designates an advance group of heat-treating tools, 13 a succeeding such group and 14 a power equipment arranged intermediate the two groups 12, 13.

The main frame 15 of the conveyor constitutes the foundation frame for the machine at large. The frames 16 of the treating tool groups 12 and 13 are sectionally constructed and surmount the frame 15 of the conveyor. Frames of the various parts of the machine may be cast in their entirety or may be built up of plates arc welded together.

The conveyor frame 15 is comprised of a pair of spaced side walls 17, 18 rising from floor flanges 19 vertically a few feet and substantially parallel in their extent. Their upper edges are also provided with flanges 20 to which the super-imposed flanges 21 of the frames 16 of the tool units are removably secured by any suitable means, not shown. The side walls 17, 18 are transversely braced by the transverse walls and partitions of the superstructure. A strong element in their transverse bracing consists of the concrete or metal foundation 23 and the transverse bottom plate or beam 24 of the respective tool units of the groups 12 and 13.

Interiorly of the walls 17 and 18 intermediate the top and bottom thereof are provided a pair of through-running V-slide rails 25, one on each side wall, constituting the support for the jig fixtures 26. These V-rails are supported from the side walls by through running angles 27 to which they are secured directly to the walls and to which the V-rails 25 are secured by any suitable means, not shown. The jig fixtures 26 are provided with laterally extending arms 28 which overlie the rails 25 and extend longitudinally thereover a considerable distance. Substantially throughout this distance they bear upon the rails 25 through the intermediary of a hardened steel V-groove wear plate 29, wherethrough the jig fixture is enabled to slide easily upon the conveyor rails 25 and whereby the fixture is afforded longitudinal stability.

The body of the jig fixtures 26 themselves are suspended from these arms 28 through vertically hanging substantially H-shaped frames 30 transversely interconnected at their bottoms by sturdy and rigid cross members 31. In fact, the jig fixture frames embodying arms 28, hangers 30 and cross members 31 are preferably integrally cast.

The jig per se 32 of the fixture is pivotally connected with the body frame 28, 30, 31 by means of a pair of axially aligned stub shafts 33 fixedly mounted in opposite sides of the jig

32 and rotatably journaled in the hangers 30, whereby the jig 32 may be angularly shifted with respect to the fixture frame 28, 30, 31. Appropriate lateral thrust bearings 34 on each side accurately fix the jig against lateral lost motion with respect to the fixture frame at large, and the fixture frame at large is prevented against lateral lost motion through the V rail mounting 25, 29. Thereby the cylinder block is held transversely accurately in alignment once placed in position.

The jig 32 per se like the main fixture frame 26, is a U-shaped casting comprising the vertically extending arms 35 upon which the stud shafts 33 are mounted, and appropriate cross members 36 located generally in the present embodiment below the axis 37 of the stub shafts 33. Alignment of the cylinder blocks 42 is obtained through the use of accurately machined surfaces 38 on the bottom of the cylinder block and the two jigging holes 40 in the bottom of the block at one side, the surfaces 38 being engaged by complementary surfaces on the jig and the holes 40 by suitable aligning plugs 41. This alignment is such as to position the cylinder block 42 in the same position with respect to the axis 37 of the jig fixture as the block will occupy with respect to the crank shaft of the completed motor. This means that the cylinders of the engine block will have their axes perpendicular to the axis 37 of the jig.

A number of jigs 26 are shown upon the conveyor as depicted in side elevation in Fig. 1, one for each tool position as illustrated in the groups 12 and 13, one intermediate the groups, and several in front of the advance group 12 and several beyond the succeeding group 13. The jig fixtures in advance of the machine are provided for loading. The jig fixtures behind the machine are provided for unloading. The jig fixture between the groups 12 and 13 is provided jointly for the purpose of shifting from the one bank of cylinders to another of the same block and for the purpose of providing a ready inspection of the work of the first group of tools and the accuracy of the jigging with respect to the succeeding group of tools.

The spacing between the jig center fixtures 26 is uniform and equal to the correspondingly uniform spacing between the individual tool centers of the respective groups 12 and 13. This is in order that the feeding may be by increments of such spacing, one step forward for each feeding operation and that step equal to the spacing between jig centers. In each position of rest the axis 37 of each jig fixture juxtaposed to a tool fixture lies in the same plane as the axis 43 of the tool. The fixture 26 is in each case accurately aligned in this plane by means of a tapered aligning pin 44 thrust securely home in a correspondingly tapered socket 45 in the side of one of the longitudinally extended arms 28 of the jig. The pin is reciprocable into and out of aligning and location fixing position by means of an air or hydraulic cylinder 46. There is one of these aligning and fixing devices for each position and for each side of each position of a jig fixture, as clearly appears in Figs. 1 and 3. As shown, these devices are connected with the side walls 17, 18, respectively, but they may, if desired, for greater rigidity be connected also with the side rails 25 and their supports 27, or they may be otherwise braced. Those cylinders 46 of the positions associated with advance group 12 are controlled in common from one connection 47 to a source of fluid pressure, and those in connection with group 13 and adjoining that group from another and independently controlled connection 48 to the source of fluid pressure.

The jig fixtures are progressed along the rails by means of a conveyor motor mechanism 49, 50, 51, 49 being a fluid pressure cylinder preferably hydraulic, 50 being reciprocable bars, 51 being pawls depending from the bars, 52 being dogs carried by the arms 28, and 53 being a yoke interconnecting bars 50 on opposite sides of the conveyor base with the common motor cylinder 49. There is provided one such motor mechanism for each the advanced and the succeeding group of jig fixture positions. The dogs 52 and the engaging ratchet 51 are shown in detailed relation in Figs. 7 and 8 and need no detailed explanation save the comment that as usual, the pawls 51 during their retracting movement pivot and pass freely over the dogs 52, but fixedly engage the dogs on the progressive forward movement. The operating bars 50 are carried in inverted channel shaped overlying guides 54 secured at intervals to through running angles 55 connected with the inner side walls of the conveyor base.

The block mounting frame 32 of each jig fixture as movable about its axis 37 is stopped fixedly in each of two angular related positions by means of what is in this embodiment a V-shaped stop 56 (see Fig. 1) located in the vertical plane of the axis 37 and engaging the jig frame 32 beneath one faced edge of cross member 36 when the frame is tilted to the left as we face one end of its axis 37 and under the opposite faced edge of member 36 when the frame 32 is turned clockwise about the axis 37. The angle through which frame 32 is so turned is equal to the angle between the cylinder banks of the block 42. With this stop 56 and the faces of the member 36 engaged thereby accurately adjusted, when the frame 32 is stopped, the work cylinders are axially accurately in the plane of the axes 37, 43 of the machine. When the shift is made between cylinder banks through this mechanism, the shift is in each case maintained by the pre-ponderating weight of the cylinder block 42 itself, that is to say, by the pre-ponderating weight of the work piece.

The block angle shifting mechanism 11 intermediate the groups of work tools 12, 13, is the mechanism through which this shift is made. This mechanism as appears clearly from the center of Fig. 1 and the cross section of Fig. 3, comprises in the first instance a polygonal pin and socket clutch 57, 58, the pin of which is located on the axis 59 of jig fixture position 60 which lies intermediate the last position 61 of the advance series and the first position 62 of the succeeding series. While there is provided but the one pin member 57 there is provided a socket member 58 on the end of each stub shaft 33. The pin 57 is projected into and out of driving relation with the socket 58 of the clutch of each jig fixture as it is propelled into position 60 and dwells there. The engagement is effected by a fluid pressure motor 63 which projects the pin slidably in keyed relation (key not shown) through the hub 64 of a gear wheel 65 driven by pinion 66 from an electric motor 67 through shaft 68. The sequence of operation which brings this about is an initial energization of the fluid pressure motor 63 following energization of the motor 67 to shift the cylinder banks through the required angle and until stop 56 is

engaged by member 36 on its opposite side, a removal of power from motor 67 and a removal of fluid pressure from the cylinder 63. These means are not shown but are sufficiently well known in the arts to require no showing.

Those work pieces 42 whose one bank of cylinders have been treated through the advance group of tools 12 are projected by the conveyor motor mechanism 49, etc., associated with that group to jig fixture position 60, the bank angle is changed to present the other bank to the vertical plane for coaction with the work tools of the succeeding group 13, and immediately following the work piece whose bank angle has been changed is engaged by the conveyor motor mechanism 49 of the succeeding group 13 and carried to a jig fixture position 62 at which point both the character of the work done by the tools of group 12 and the jigging of the work may be inspected and checked. Such a progression is readily achieved by providing that the bars 50 which carry the pawls are extended in the one case in advance of the positions of the group 12 and in the other case to the rear of the positions of the group 13 as clearly illustrated in Fig. 1

The frames 16 which surmount the side walls 17, 18 of the conveyor mechanism are comprised of units essentially the same as those disclosed in my copending application, as heretofore indicated. The designations of the units of these tools used herein are the same as those used in my said copending application. Thus the work piece mounting mechanism is comprised of the jig fixtures 26 and is generally designated M, thus the heating unit mechanism is designated generally H, thus the transformer power switching mechanism T, thus the quenching unit Q, and thus the motor mechanisms for the heating and quenching units are respectively designated H^1 and Q^1. There are provided a complete set of these units in connection with each one of the tools L of the groups 12 and 13. Their construction is in all essential respects the construction of the corresponding units of my application Serial No. 96,346. Thus the heating unit H embodies a work coil adapted to be projected interiorly of the bore of the cylinder to be treated. Thus quenching unit Q embodies a perforated pipe section adapted to be projected into axial juxtaposition to the walls to be quenched. Thus this mechanism embodies a pilot 70. In this case, however, the pilot 70 engages in a socket 71 provided not in the work piece 42 but in the work piece mounting block 38, for in the cylinder block there is no part in which the pilot 70 could socket, the bottom end of the bore being open for the full diameter of the cylinder. However, these units H, T and Q and their associated parts Q^1, H^1 and 70 are operated into and out of functional relation to the work in the same manner as are the corresponding units of the application referred to.

In addition to the units of the various tools L referred to, there are provided above and in axial alignment with the fluid pressure motor, units Q^1 and H^1 of the quenching and heating units, respectively, a supplemental quench control valve Q^2, the detail of which is shown in axial cross section in Fig. 6. The axially innermost nozzle Q of the quenching mechanism extends axially vertically throughout the remaining units H, T, H^1, Q^1 and also through the unit Q^2 in the form of a pipe member 72. The unit Q^2 comprises a cylindrical axially disposed casing 73 entered by pipe 72 at the bottom through a gland 74 and left by pipe 72 by way of an elongated axial slide gland 75, the tightness of which depends on the length of the gland as shown. The pipe 72 is provided with a plurality of perforations 76 in that part of its main body which lies in the free space of the cylinder 73 below the gland 75 when the pilot device 70 is in its socket 72 in the mounting block 42 and when the quenching unit Q is in proper axial juxtaposition to the walls of the cylinder bore to be quenched. At such time cooling fluid may flow from the interior of the cylinder 73 through to perforations 76 to the interior of the pipe 72. The upper end of the pipe 72 is closed by a plug 76', but entry of fluid to the casing 73 is by way of a supply pipe 77 and under the control of a solenoid valve 78 governing the connection of the casing 73 in each case individualy to a manifold supply pipe 78'. This solenoid valve is operated to apply pressure to the casing 73 just at the time that it is desired that quenching fluid be projected through the unit Q upon the walls being treated.

The function of this additional quenching valve unit Q^2 is to supplement the valved action of the quenching unit Q as described in my copending application referred to, whereby the more effectively and directly, and in close connection with the tool unit itself, to apply and remove the pressure of the quenching fluid than can be done through a more remotely located device. This function becomes the more important upon the return stroke of the quenching unit Q than upon the advance stroke. After the quench has been achieved it is important that the fluid pressure be summarily cut off in order that there may not be high pressure jets thrown about the work and about the work coil during the retrogressive movement of the quenching and heating units Q and H. This more important function is achieved by the immediately closing of all the apertures 76 (see Fig. 6) as the pipe 72 moves up into the contiguous lower end of the slide gland 75, as the quenching unit Q is removed from the work.

So much has been said of the operational relations of the several mechanisms of this machine, the conveyor mechanism 10, the jig fixtures 26, the bank angle shifting mechanism 11 and the heat treating tool unit sections 12 and 13, that there seems little required to make the general operation entirely clear. As a premise to describing the general operation, it will be called to mind that the power equipment 14 also mounted upon the general base of the conveyor mechanism is located intermediate the heat treating tool groups 12 and 13. On this mechanism is also mounted the control panel 79 carrying the high frequency generator line switch 80 in the form of an oil circuit breaker, various and sundry instruments 81, and those controllers which have to do with the individual tools L of the groups 12 and 13 and the inter-relational activities of its several mechanisms 10, 26, 11, 12 and 13.

First to be mentioned in detail in the control system is the supplemental main line switching transformer 82. This in form and general arrangement is like the tool unit switching transformers T disclosed in my copending application aforesaid. However, it may be somewhat larger in capacity and at will its windings are given any desired ratio simply by taking out one winding and substituting another, or else I may provide one of the many usual systems of adjustable taps on the transformer, or in other ways vary the transformer ratio. This switching trans-

former is operated by the switching fluid pressure cylinder 83 controlled in turn by a small solenoid operated fluid pressure control valve 84.

Referring now to Fig. 4 which is a schematic diagram of control connections between the sources of power and the various working and controlling agencies of the machine, it will be seen that the supplemental switching transformer 82 is in series with the main line circuit breaker 80 which controls the application of power from the high frequency source 85 to the various switching transformers T of the tool units L. The utilization of this supplemental switching transformer 82 in supplement to the switching transformers T individual to the tools L affords these several advantages: First, as hereinbefore mentioned it enables me to vary the transformer ratio between the high frequency generator 85 and the tool units L, and thereby vary the power imposed upon the work without changing the ratios of the multiple number of individual transformers T connected with the tools L. Second, if operated simultaneously with the switching transformers T of the tools L, it affords a supplemental energy cut-off which renders the energy cut-on and cut-off action the more complete and thorough and certain. Third and of chief importance, it enables me to apply and remove the power independently of the work coil movement into and out of relation to the work to be treated and thereby to obtain a more uniform work treatment than is possible if I depend entirely for switching upon the switching transformers T within the individual tools L. Thus, after a work coil has been moved into juxtaposition with the work and the switching transformer T moving with the work coil has been moved to power on position, the supplemental switching transformer 82 operating together with or independently of (preferably independently of) the line circuit breaker 80 can cut the power on. When the power is so cut on the work coil is in complete juxtaposition to the work. Similarly it can be operated to cut the power off just before the work coil is removed. The retention of switching transformers T individual to the tools enables me to cut the tools on and off individually without open-contact successive-switching arrangements in connection with low voltage secondaries. The supplemental transformer 82 as clearly shown in Fig. 1 is mounted on a supporting framework contiguous to the control panel 79.

With further reference to Fig. 4 there is provided a unit controller C^1 for all of the tools L and a unit controller C^2 for all operations of the conveyor 10 and of the bank angle shifting mechanism 11. Both of these controllers C^1 and C^2 are driven by a common shaft 86 in turn rotated by the synchronous motor 87 supplied with power from an ordinary 60-cycle line 88—88'. By means of this motor, cylinders 89 and 90 of these controllers are continuously driven. To simplify the circuit diagram, all connections to one side 88', of the 60-cycle power supply line 88—88' are indicated by a short arrow-ended line.

Both controllers are mounted upon or in connection with the control panel 79 as heretofore indicated.

The controller C^1 is that which covers the sequential operations of the tools L of the groups 12 and 13. As illustrated the controller is comprised of a drum 89 of non-conducting material carrying conducting segments 91 which coact with stationary brushes 92. However, it will be understood that the controller may be of any of the well known forms the equivalent of this, as for example, cams and cam followers, which in turn control electric circuit contacts. There are provided as many axially spaced annular series of segments 91 as there are electrical control devices in each heat-treating tool unit. These devices may be in the form of electrically operated fluid pressure control valves, but sometimes in the form of electro-magnetically actuated electric switching devices as fully set forth in my copending application referred to and need not be referred to here. Likewise, in said application is clearly disclosed one practical cycle of their operation. This invention involves not sequential operation of the devices in each tool unit L, but the sequential operation of the tools L in their relation to the conveyor and angle shifting mechanisms.

Thus I provide a plurality of axially extending series of brushes 92 annularly arranged about the cylinder 89, one such axially extending series 92 for each tool L. The annular spacing between the axially extending series 92 I proportion according to the relative times of successive operation of the tools L. Thus, on one side of the diameter 93 of the controller I place four series 92 in equally spaced relation indicative of successive operation of the tools L of say the advance group 12 at equal periods. On the other side are similarly placed another group of axial series 92 similarly equally spaced and associated with the tools L of the succeeding group 13. The spaces 94 annularly of the commutator between the two groups may be equal to or greater than the spaces between the series 92 of the respective groups, depending upon the relations of the heating, quenching and shifting times as will be apparent presently.

It is not deemed necessary to show connection from each brush of each axial series 92 to each control device of each tool L. Instead there are shown connections only from the first brush of each axial series 92, that connection leading to the electro-magnetic solenoid valve 95 controlling the application of fluid pressure to the fluid pressure units H^1 by means of which are operated the work coils H and the associated switching transformers T. Connections to other units in these devices are similarly made. Thus it will be apparent that the heating coils H and the switching transformers T are operated successively into and out of operative relation as the segment 91 connects with this first row of brushes (the lowermost row on the right). For each set of control units of each tool L the sequential annular control of controller C^1 is the same, and there is a different set of control units for each brush position of the axial series 92.

In addition to controlling the control units of the tools L, controller C^1 controls the main line switching transformer 82. This it does through a supplemental annular series of control contacts 96 connected in multiple and engaged successively by a single cut-on and cut-off segment 97. The angular spacing between the brushes 96 and their relation to the angular extent of segment 91 and angular spacing between the brushes of the first annular row which controls switching transformers T of the tool groups, is such that transformer 82 is cut on and cut off, respectively, after and before transformer T is cut on and cut off.

The controller C^2 for the conveyor 10 and the bank angle shifting mechanism 11 carries a segment 98 coacting with a pair of substantially diametrically opposite brushes 99 which respectively

control over circuits 100 the electro-magnetic fluid pressure valves 101 which control the admission and exhaust of fluid pressure from the conveyor shift motors 49. The diameter 102 upon which brushes 99 are located is substantially at right angles to the diameter 93 about which the groups of control brushes of controller C^1 are arranged with respect to the advance and succeeding tool groups 12 and 13. This precise angular relation is not essential. It suffices if the brushes 99 are engaged by the coacting segment 98 within the total heating period of the group being supplied with heating power. The controller C^2 also carries axially spaced from segment 98 a segment 103 coacting with brush 104 to control the fluid pressure solenoid 105 by means of which the angle shifting mechanism 11 is governed through fluid pressure motor 63 and driving motor 67. The segment 103 and the brush 104 have such angular relation as to achieve this angular shift during the period that the succeeding group of tools 13 is being operated.

Also carried by controller C^2 is a pair of brushes 107 coacting with segment 108 axially spaced from those aforementioned. Brushes 107 lie at opposite ends of a diameter set back clockwise in advance of the brushes 99 of the conveyor motor controls 101. This position and the angular extent of the segments 108 is such that the electro-magnetic fluid pressure control devices 109 each governing one of the groups of motor devices 46 of the jig fixture centering mechanism are first operated each to remove fluid pressure to retract their associated groups of centering devices before the conveyor shift is accomplished and after it has been accompilshed are then operated to restore the fluid pressure and effectively engage the centering members 44 and 45.

In addition to the timed or sequence control, a safety control is provided whereby the heat-treating heads are prevented from descending into a heating position unless a jig fixture and engine block are in position to receive the heat-treating head. This comprises a rearward extension 110 of the piston rod of one of the centering cylinders 46 of each jig position arranged to operate a normally closed push button switch 111, through an actuating arm 112 carried on the rod extension 110, upon overthrow of the aligning pin 44 occurring only in the absence of a jig fixture. The normally closed push-button switch 111 is included in the return circuit lead 113 of the electro-magnetic solenoid valve 95 of the tool L of the corresponding jig position as shown for one such connection in the circuit diagram Fig. 4.

Such is the electrical relation of the control elements. The timed relation is shown in the linear diagram of Fig. 5, where a combination of legends and numerals applying to the mechanisms and circuits just now described makes entirely clear a practical timed sequence achievable by my production machine.

Speaking in general, those jig fixtures in advance of the first group 12 are loaded with cylinder blocks by a group of workmen either as they rest upon the conveyor or before they are placed thereon and for the initial operation are moved up individually as loaded, within reach of the first two pairs of the conveyor shifting pawls 51. Assuming power on the line, circuit breaker 88 closed, the controllers C^1 and C^2 revolving under the time control of motor 87 and the control circuit power cut on from the 60-cycle lines 86, the various parts of my production machine are being carried through their various cycles of operation in accordance with the schedules just now set down, with particular reference to Figs. 4 and 5. The advance pawls 51 would then on the first reciprocation of the advance motor 50, engage the advance loaded jig fixtures at the entrance end of the machine and advance them along the conveyor to the first of the tools L. In these positions L would be operated. Their treatment completed, a succeeding movement of the conveyor shift motor would feed the treated blocks to the succeeding tools L in succession for treatment of the succeeding cylinders of the first bank. Each such feed movement of the advance motor 50 would bring into the first tool position a fresh block to be treated.

The processing having given the complete treatment to all the cylinders in the first bank of the first jib fixture to go through the entire advance group 12 of tools L, the next succeeding conveyor shift movement takes the advance jib fixture to the position of the bank angle shifting mechanism 11. In this position, while the next succession of treating operations is being carried out by the tools of group 12, the bank angle is shifted to bring the second bank of cylinders into the vertical plane. Also in this heating period and immediately following this bank angle shift, the conveyor shift mechanism of the second group of tools 13 engages by its advance pawl 51 the jig fixture the work piece of which has been so shifted, and moves it to that work position which intervenes between the bank angle shift mechanism 11 and the succeeding tool group 13. This conveyor shift, together with the bank angle shift takes less time than the total heating and quenching time of all the tools of the advance group 12. Thus at the end of that time the space before the bank angle shifting mechanism 11 is opened to receive the next jig fixture upon the next succeeding conveyor shift movement of the advance group 12. Such jig fixture having been fed forward, its cylinder banks are shifted by the mechanism 11 and a succeeding conveyor shift of the second group 13 feeds this second jig fixture forward toward the succeeding group 13 and likewise feeds into the work position of the first tool L, the advance jig fixture of the lengthening train. From this point on the operation of the second group of tool devices 13 upon the work pieces as they progress through it becomes identically that of the first group 12. After processing through the succeeding group 13 all the cylinders have been treated and in their movement to succeeding jig fixture positions, inspecting and dismounting may be carried out. Preliminary inspection of the first bank has previously been carried out in one or both of the positions intermediate the tool groups and therefore in this final progressing, it is probably unnecessary to inspect the second bank of cylinders.

Upon unloading of the work from the jig fixtures the jig fixtures themselves may be returned to the advance end of the machine by any suitable return conveyor device. Such devices are common and well known in the art in many forms. The combinations of lifting and lowering, elevating mechanisms to and from endless running devices, pusher devices and the like are well known. It suffices that the jigs individually are moved in their final stage either by the motor mechanisms 49, 50, 51 or by supplemental mechanisms not shown, moved free of the conveyor rails 25 and free of the side walls 17, 18 of the conveyor foundation, whereby they can be mechanically or manually handled to the return conveyor

device and mechanically or manually then reloaded and replaced upon the rails 25 at the opposite end of the machine.

There obviously are innumerable variations which may be made in the organization of the machine of my invention and the sequence of its operations without departing from those central ideas which constitute its generic spirit. In the annexed claims it is attempted to express in a manner wholly intelligible to those skilled in the art these central ideas, and it is submitted that the generic spirit of my invention be interpreted through them in the light of the principles involved, rather than the light of the present embodiment only.

What I claim is:

1. Apparatus for heat treating the cylinders of similar multi-cylinder engine blocks by electrical induction, comprising a plurality of inductive heating coils equal in number to the number of cylinders in each engine block, and each adapted to be moved into a cylinder for heat treating the same, means for successively moving different coils into different cylinders of different blocks respectively, of a group of blocks in one position of the group, and means for connecting the coils to a source of energizing current one at a time in recurring cycles.

2. Apparatus for heat treating the cylinders of a multi-cylinder engine block by electrical induction, comprising a plurality of inductive heating coils each adapted to be moved into a cylinder for heat treating the same, means for moving different coils into different cylinders of the same engine block and selective means for energizing less than the total number of coils at one time and the remainder at another time, whereby the total power necessary to energize all of the coils at one time is not required and a similar operation may be immediately performed on other cylinders without immediate repeated use of any one coil.

3. Apparatus for heat treating the cylinders of a multicylinder engine block by electrical induction, comprising a plurality of heating elements each arranged to be moved into a cylinder to be treated, means for moving a multicylinder engine block to be treated to bring different cylinders of the block into axial alignment with different heating elements at different times, means for moving each of the heating elements into a cylinder when in axial alignment therewith and means for energizing said heating elements one at a time.

4. Apparatus for heat treating the cylinders of a multi-cylinder engine block by electrical induction, comprising a plurality of heating elements whose axes are spaced from each other a distance greater than the distance between the axes of the adjacent cylinders of the engine block to be treated, means for moving a multi-cylinder engine block to be treated to bring different cylinders of the same block into axial alignment with different heating elements at different times, means for moving each of the heating elements into a cylinder when in axial alignment therewith, and means for energizing said heating elements one at a time.

5. Apparatus for heat treating the cylinders of a multi-cylinder engine block by electrical induction, comprising a plurality of inductive heating elements arranged to be moved into and out of the cylinders to be treated, means for moving a multiple number of multi-cylinder engine blocks to be heat treated to bring different cylinders into axial alignment with different heating elements, means for moving all of said heating elements into and out of said cylinders in the interval between movements of said engine blocks, and means for energizing said heating elements one at a time.

6. Apparatus for heat treating the cylinders of a multi-cylinder engine block by electrical induction, comprising a plurality of inductive heating elements whose axes are spaced from each other a distance greater than the distance between the axes of the adjacent cylinders of an engine block, means for moving a multiple number of multi-cylinder engine blocks to be treated to bring different cylinders of different blocks into axial alignment with different heating elements, means for moving each of said heating elements into and out of said aligned cylinders in the interval between movements of said engine blocks, and means for energizing said heating elements one at a time.

7. Apparatus for heat treating the cylinders of multi-cylinder engine blocks by electrical induction, comprising a plurality of heat treating tools each comprising an inductive heating element and an associated quenching element, means for holding a plurality of engine blocks in position to be operated upon by said heat treating tools, said tools being arranged to operate each upon a cylinder of a different engine block, timed control means for operating said heating elements at different times and timed control means for operating said quenching elements each in connection with a different cylinder block not being operated upon at the same time by a heating element.

8. Apparatus for heat treating the interiors of a plurality of hollow objects by electrical induction, comprising a plurality of inductive heating coils, means for moving different coils each into a given full operative position with different said objects at different times, a distributing circuit, an individual coupling transformer for each heating coil having a pair of windings arranged to move into inductive relation during movement of its associated heating coil into operative relation with one of said objects to inductively couple its associated heating coil with the distributing circuit, a common switching transformer having a pair of windings arranged to move into inductive relation to couple the distributing circuit to a source of supply, and timed operating means for effecting a complete coupling and uncoupling of said common transformer only during a complete coupled position of each of said individual transformers.

9. Apparatus for heat treating the cylinders of multi-cylinder engine blocks by electrical induction, comprising a plurality of inductive heating elements divided into groups, means for holding different groups of engine blocks in position to be operated upon by different groups of heating elements, timed control means for operating said heating elements one at a time in succession through different groups in succession, and timed control means for shifting the position of one group of engine blocks during operation upon the other.

10. Apparatus for heat treating the cylinders of multi-cylinder engine blocks by electrical induction, comprising a plurality of heat treating tools divided into two groups spaced apart, means for conveying engine blocks to be treated into operative relation with the tools in different groups in succession and means for changing the angular

position of each block during its passage between groups.

11. Apparatus for heat treating the interior walls of hollow objects comprising an inductive heating coil arranged to be moved into and out of the hollow object, a spray nozzle arranged to be moved into and out of said hollow object, a hollow arbor carrying said nozzle arranged to conduct fluid to the nozzle and provided with inlet ports in its walls for the admission of fluid, a fluid-tight chamber, a valve sleeve arranged to receive that portion of the hollow arbor containing said ports, said arbor being arranged to slide through said chamber and sleeve to move the port containing portion out of said sleeve into communication with the interior of said chamber upon movement of the nozzle into the interior of the object, and means for supplying quenching fluid to the chamber.

12. Apparatus for heat treating the inside walls of the cylinders of multi-cylinder V-type engine blocks, comprising a plurality of inductive heating coils arranged to be moved along a vertical axis into a cylinder for inductively heating the same, a cylinder-block holding-jig arranged to be tilted from one position holding one line of cylinders parallel to the axes of the heating coils, to another position holding the other line of cylinders parallel to the axes of the coils, means for moving the cylinder blocks when in the one tilted position to bring the different cylinders into coaxial alignment with different heating coils, means for moving different coils into and out of operative relation with different cylinders at different times, means for tilting the holding jig into the other position to hold the other line of cylinders parallel to the axes of the coils, means for tilting the jig to bring the other line of cylinders into parallelism with the coils, and means for energizing said coils one at a time.

13. Apparatus for heat treating the cylinders of a multi-cylinder engine block by electrical induction, comprising a plurality of inductive heating elements arranged in staggered relationship, means for moving a multiple number of multi-cylinder engine blocks to be treated to bring different cylinders of different blocks into axial alignment with different heating elements, means for moving each of said heating elements into and out of said aligned cylinders in the interval between movements of said engine blocks and means for energizing said heating elements one at a time.

14. Means for treating units of multi-unit objects by electrical induction comprising a plurality of inductive heating elements each adapted to be moved into operative relation with one of the units for heat treating the same, means for moving different heating elements successively into operative relation with different units of successively different multi-unit objects and means for energizing the heating elements one at a time in succession whereby different objects are operated upon in succession.

15. Apparatus for heat treating cylinders of multi-cylinder engine blocks by electrical induction, comprising a plurality of inductive heating elements divided into groups, means for holding different groups of engine blocks in position to be operated upon by different groups of heating elements, timed controlled means for operating said heating elements through different groups in succession, and timed controlled means for shifting the position of one group of engine blocks during operation upon the other.

16. Apparatus for heat treating the cylinders of a multi-cylinder engine block by electrical induction, comprising a plurality of inductive heating coils each adapted to be moved into a cylinder for heat treating the same, means for moving different coils into different cylinders of the same engine block and selective means for energizing less than the total number of coils at one time and the remainder at another time, or other times, and means for operating said selective means to effect a timed relation between the energizing times of the various coils, whereby the total power necessary to energize all of the coils at one time is not required and a similar operation may be immediately performed on other cylinders without immediate repeated use of any one coil.

17. Apparatus for heat treating the units of multi-unit objects by electrical induction, comprising a plurality of heating elements each arranged to be moved into operative relation with one of the units for heat treating the same, means for moving a multi-unit object to be treated to bring different units of the object into substantial alignment with different heating elements at different times together with means for locking the unit in substantial alignment with said different heating elements at different times, means for moving each of the heating elements into operative relation with a unit when aligned therewith and means for energizing said heating elements one at a time.

18. Apparatus for heat treating the interiors of a plurality of hollow objects by electrical induction comprising a plurality of inductive heating coils, means for moving different coils each into a given full operative position with different said objects at different times, a distributing circuit and individual switch for each heating coil, a common switching transformer having a pair of windings arranged to move into inductive relation to couple the distributing circuit to a source of supply, and timed operating means for effecting a complete coupling and uncoupling of said common transformer only during a closed position of one of said individual switches.

19. Apparatus for heat treating portions of a plurality of objects by electrical induction comprising a plurality of inductive heating coils, means for moving different coils each into a given full operative position with different said objects at different times, a distributing circuit and individual switch for each heating coil, a common switching transformer having a pair of windings arranged to move into inductive relation to couple the distributing circuit to a source of supply, and timed operating means for effecting a complete coupling and uncoupling of said common transformer only during a closed position of one of said individual switches and while an associated heating coil is in operative relation with one of said objects.

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