Feb. 13, 1940. H. E. SOMES 2,189,819

MULTIPLE TRANSFORMER SWITCHING SYSTEM

Filed Feb. 25, 1937 4 Sheets-Sheet 1

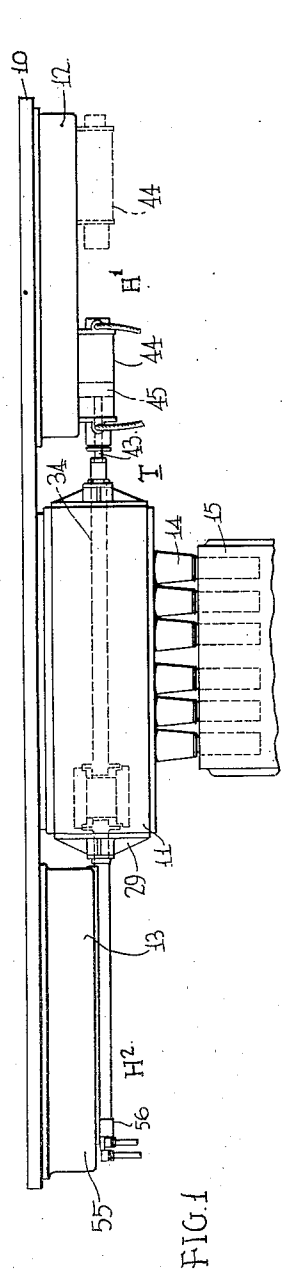


FIG. 1

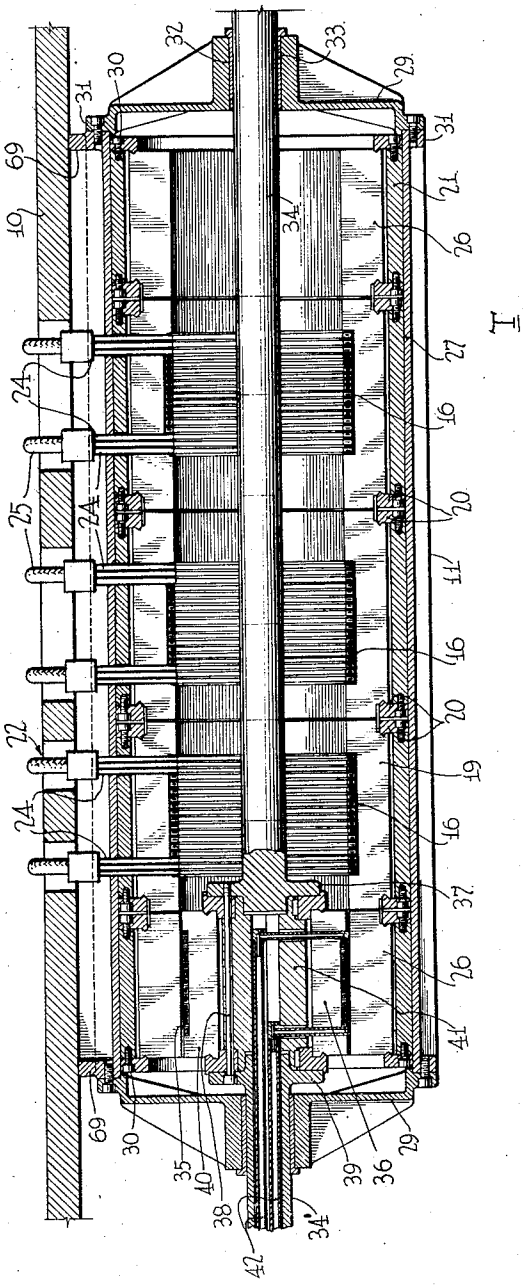


FIG. 1a

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MULTIPLE TRANSFORMER SWITCHING SYSTEM

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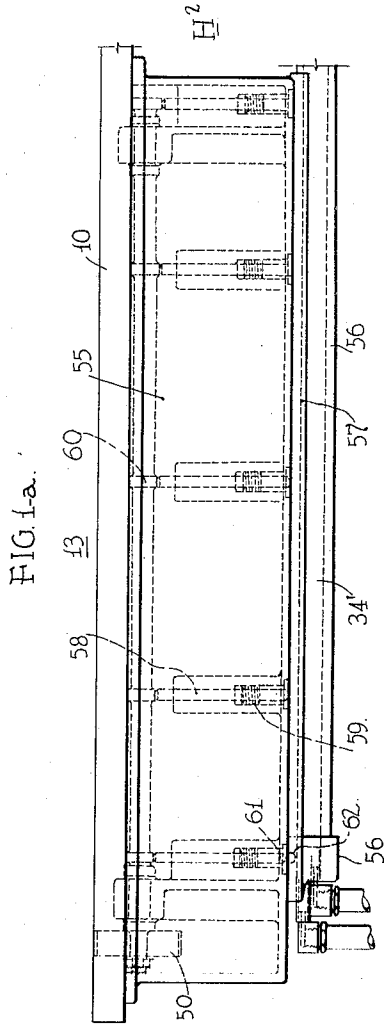


FIG. 1-a.

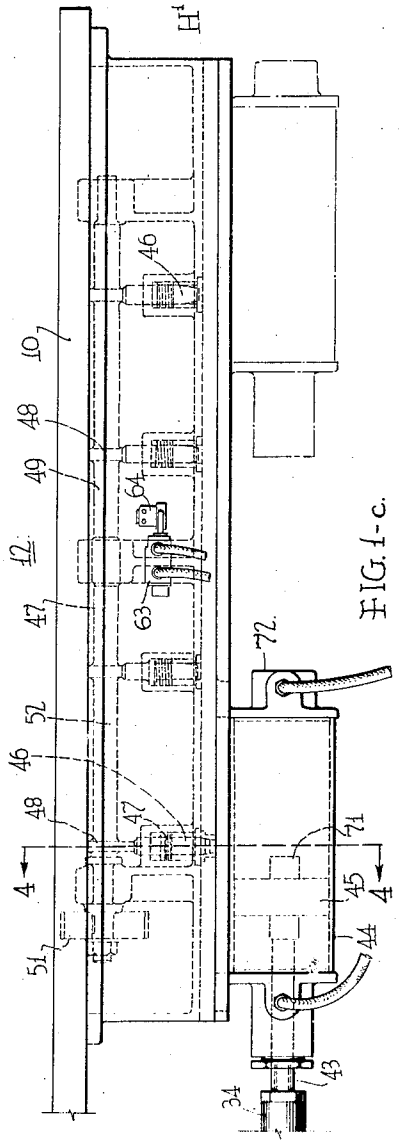


FIG. 1-c.

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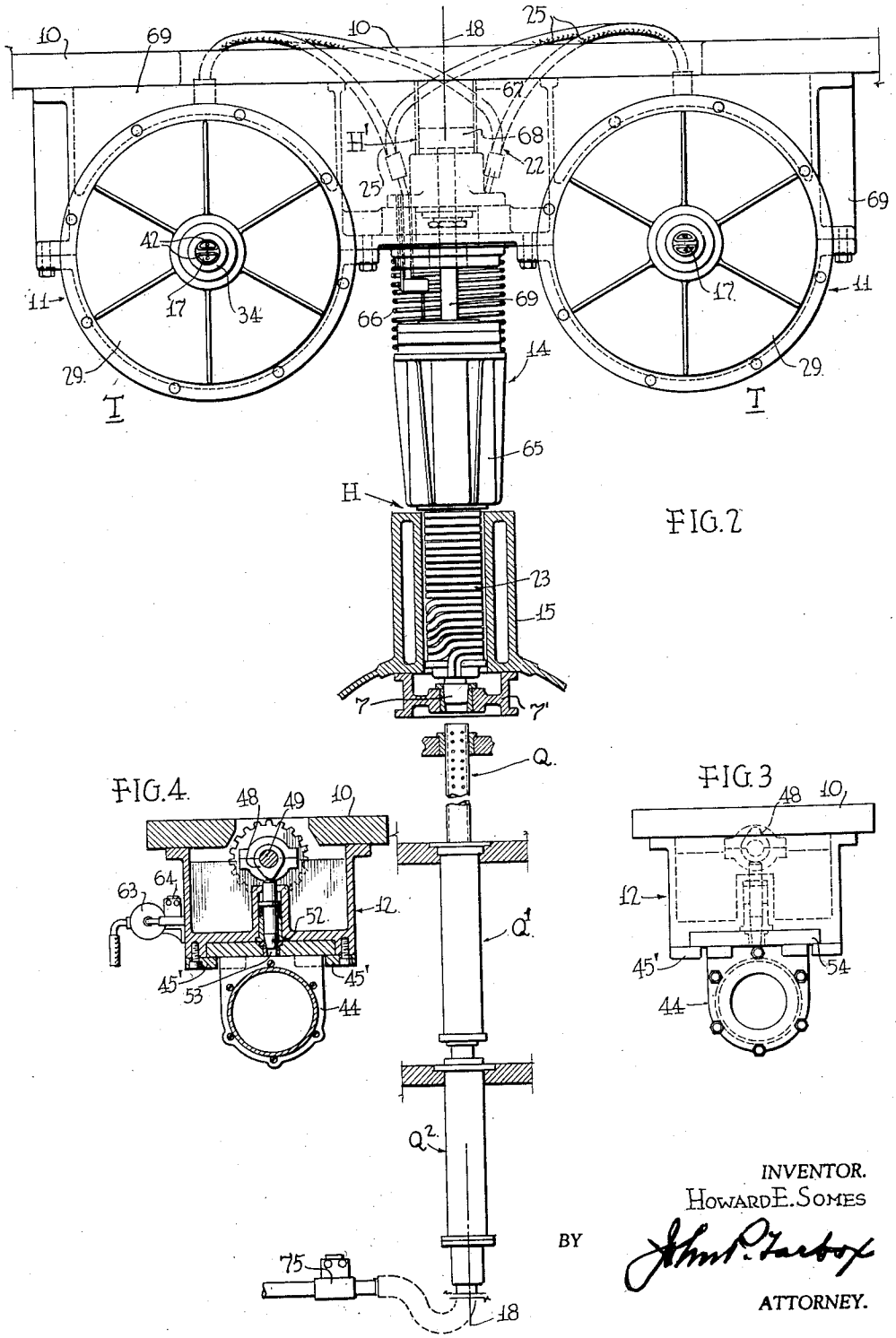


FIG. 7

FIG. 4.

FIG. 3

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MULTIPLE TRANSFORMER SWITCHING SYSTEM

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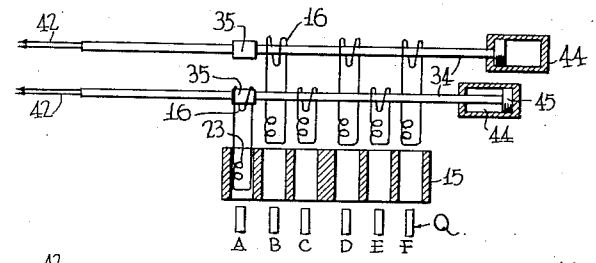


FIG. 5

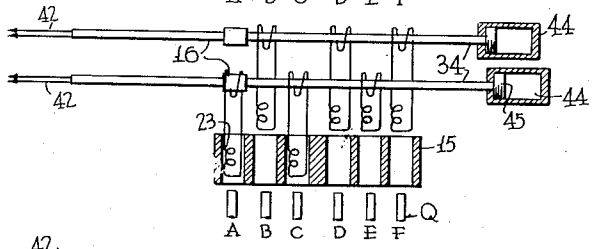


FIG. 6

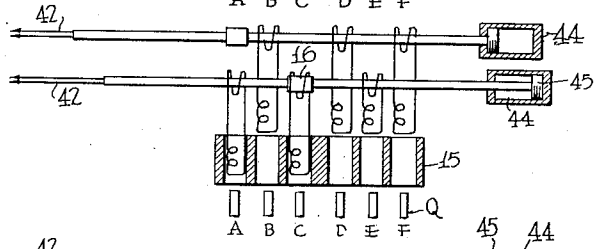


FIG. 7

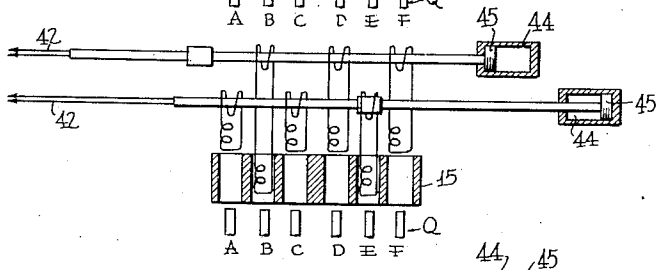


FIG. 8

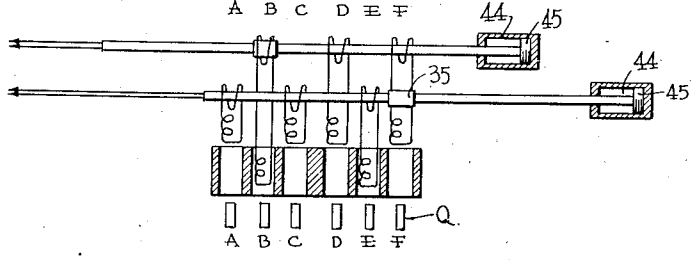


FIG. 9

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UNITED STATES PATENT OFFICE

2,189,819

MULTIPLE TRANSFORMER SWITCHING SYSTEM

Howard E. Somes, Detroit, Mich.

Application February 25, 1937, Serial No. 127,668

10 Claims. (Cl. 219—13)

The hardening of the journals of crank shafts has been achieved by the process of high frequency induction heating. According to the known method, halves of inductive heating coils are complementally engaged with each other about the journal to be treated and supplied with the work current from the secondaries of high frequency induction transformers. These transformers have been built without the use of iron. They also generally, in the case of those crankshafts requiring treatment of a multiple number of journal bearings in succession, have been used in the form of transformers cut into and out of connection with the high frequency generator by means of individual primary and secondary switches. These switches have to be operated, first the primary and then the secondary switch, for each application and removal of treating power from the journal to be treated. This involves an application of switching apparatus with all of its uncertainties and heavy maintenance costs and with all of its deficiencies in the control of the timing of the heating period.

I have invented and disclosed in patent application Serial No. 96,929 a switching transformer which supplies current to the work coil directly from its secondary and which through a joint movement of the secondary into and out of transformer relation to the primary at the same time that the work coil is moved into and out of operative relation to the work, supples and removes the power to the work coil without the making and breaking of either the primary or the secondary circuit. Moreover, this transformer as well as the work coil is provided with a laminated magnetic core, whereby the efficiencies are vastly improved and it is made possible to carry immense power into extremely small spaces without loss of efficiency.

According to this invention I apply the switching transformer of my invention to an object like a crank shaft or engine block containing in one unit a number of portions such as bearings or engine cylinders to be heat treated in one jig position of the work with respect to a multiple number of heating units. In case, of course, a single heating unit is to be used the problem is quite different, involving as it does the relative shift between the heating unit and that product having a number of portions to be heat treated.

The solution of this problem I attain by the organization of a switching transformer in which there are provided a plurality of stationary secondary elements and a single primary element which has a movement of translation in succession from one of the secondaries to another and a dwell before each secondary and in full operative relation thereto sufficient to supply during the dwell to the heating unit connected with the secondary, that energy required. Thereby I may use as many heating coils as there are portions in the product to be treated, bearings for example, or cylinders in a cylinder block, for example, each provided and fixedly connected with its own secondary, and then shift the single primary of the transformer from one to another in succession.

In the accompanying drawings I illustrate that best embodiment of my invention now known to me through the medium of the following figures.

Fig. 1 is a side view of the switching apparatus associated with a work piece.

Figs. 1*a*, 1*b*, and 1*c* show the left hand portion, central portion and right hand portion, respectively, of a longitudinal generally axial cross section of one unit of the switching mechanism in which are mounted three transformer secondaries.

Fig. 2 is a transaxial cross section showing this unit in juxtaposition to a mating unit adapted to operate upon multiple portions of the same work piece to be treated.

Fig. 3 is a right hand end view of one of the motor cylinders.

Fig. 4 is a transverse section of the motor cylinder, taken on the line 4—4 of Fig. 1*c*.

Figs. 5 to 9 are diagrams showing successive phases of operation.

The machine instead of being illustrated in connection with a six journal crankshaft is illustrated in connected with a six cylinder line engine block.

10 is an elongated overhead frame which may be supported overhead by any appropriate number of uprights and braces not shown. 11 is the switching transformer unit in general, 12 the motor device for operating this switching transformer, and 13 is a camming device coacting with the motor device H^1 to effect a variable spacing shift of the primary from one transformer to another, while 14 are the heating units of which there is one for each transformer secondary and one for each motor cylinder of the block 15 to be treated.

The transformer switching device as represented embodies six transformer secondaries 16, three in axial alignment with each of the axes 17 which are symmetrically located with respect to the plane 18 of the heating units 14 and the cylinder block 15, one on either side thereof. These transformer secondaries are internally

wound upon the laminated magnetic cores 19 of annular form held together by the annular end rings 20 which are clamped together upon them through the intermediary of a surrounding casing 21 to which the end rings are bolted. The secondary leads 22 extend radially outwardly toward the plane 18 and then along the plane 18 and to the heating coils 23. The conductors 22 are rigid through the advance portion 24 of their lengths and flexible through the following portion 25, the flexible portions 25 are raised together so that the effective length and general convolutions thereof are substantially unchanged during the axial reciprocations to the heating coils 23.

Reverting again to the switching unit 11, it will be seen that in the length of the unit there is provided a space for two more transformer secondaries, the three shown being in the center and contiguous to each other and the two extra spaces on each end. These extra spaces are occupied by dummy magnetic cores 26 also laminated and similarly clamped together. When the primary of the transformer reaches these cores the cores control the reactance thereof in a manner which will be described. The ensemble of the plurality of secondary transformer cores and dummy cores are carried within a tubular casing 27 within which they are clamped together in contiguity by means of end plates or caps 29 applied to the opposite ends of the tubular casing through bolts 30 which engage in lateral projecting end flanges 31 on the casing 27.

These end caps 29 are provided with central bores 32 which are provided with bushings 33 affording bearing surfaces for an axially mounted and reciprocable shaft or rod 34 which bears the transformer primary element 35 coacting with all of the switching transformers of the series. The shaft 34 is in two sections, the one section at the right adjoining the motor mechanism 12 being solid and connected with the core 36 of the transformer primary by means of a flange 37 which is through bolted as at 38 to the head 39 by means of which the laminations 40 of the core are bound together and about the central arbor 41 of the core structure. Primary coil 35 in this case is exteriorly wound upon the core 40. The other part of the shaft 34 makes a similar connection through the same bolts 38 with the opposite end of the core, that to the left. On its part, however, it is hollow and receives in the hollow the primary leads 42 of the transformer which leads connect with the primary source of high frequency energy either a high frequency transformer or a high frequency generator. This hollow shaft passes through the head 29 on the left hand end of the casing and projects therebeyond a distance substantially equal to the length of the switching unit itself and to that portion of the solid rod 34 required to project the transformer primary the full length of the cage.

The solid portion of the shaft 34 projecting from the right is provided on its end with an extension 43 of reduced diameter which becomes the piston rod of the fluid pressure motor 44 and in connection with which it bears a piston 45 through which it is reciprocated with respect to the casing 44. This casing 44 is arranged in depending stop frame 12 passing vertically through which are a plurality of stops 46 spring pressed upwardly by springs 47 and depressed seriatim by a sequence of cams 48, whereby through rotation of cam shaft 49 which bears the cams (which rotation may be achieved through a gear) effects the sequential downward projection and retrogression of the stop pins 46. When depressed, the pins, as shown by that one on the extreme left, the first of the series, have their tapered points 52 engaged in correspondingly tapered sockets 53 in the upper portion of the casing 44. The casing 44 is arranged in sliding bearings or gibs 45' from which it depends, to move from step to step under various applications of power thereto as will presently be seen.

The hollow section of shaft 34 at the extreme left of Fig. 1 on its part underlies and is moved with respect to an overlying second stop base 55. Its outer extremity is borne by a bearing member 56 in gibs 57 on the under side of the stop base 55 in much the same manner as is the cylinder case 44 borne upon the under side of the stop base 12. Associated with the stop base are a plurality of vertically arranged stops 58 projected upwardly under the influence of springs 59 and movable downwardly under the influence of sequential cams 60 driven by gear 50 which latter and gear 51 for driving the cams 48 are driven through a suitable positive driving connection from a synchronous alternating current electric motor not shown, whereby the cams of the two series are fixedly geared together and operate in a definite relative time sequence. When the cams depress the stop pins 58 their lower extremities 61 engage successively in the single socket 62 provided in the outer extremity of the hollow shaft section 34^1.

Now observe that in connection with the single course of heating units 14 and the single work piece 15 to be treated, there are provided two series 11 of transformers, one set on each side of the plane of symmetry 18 in which the heating units 14 lie. Each one of these units 11 is operated by a system of motor and stop devices like that which has been described in connection with Fig. 1. A timing controller commutator not shown will be provided to afford a sequence of operation through suitably arranged electrically controlled fluid pressure valves exemplified by the valve and control solenoid shown at 63 and 64, respectively, in Figs. 1c and 4. Connections of the valves to the cylinders is through flexible leads as indicated.

The heating units 14 lying in the plane of symmetry 18 consist each of the coil 23 per se associated relatively movable and internally laminated end ring 65 normally spring pressed to position by spring 66, and fluid pressure operating cylinder 67 bearing piston 68 through which, and piston rod 69 connecting with the coil 23, the coil 23, ring 65 and appurtenant parts are reciprocated vertically up and down to project the coil into and out of operational relation to the work. In my copending application Serial No. 119,400, filed January 7, 1937, I have generally designated such units as follows. The heating unit 23 and adjunctive parts as H and the heating unit operating-cylinder 67 and appurtenant parts as H^1. Similarly I have designated the transformer switching units 11 as T. Such numerals are additionally generally applied here for the purpose of clarity and for the purpose of collaboration upon the detailed description of operation in case of need.

In this instance instead of being supported by an independent framework, the units described H and H^1 are supported from the same general horizontally extending overhead frame 10 as are the remaining units of the machine. Preferably

as shown in Fig. 2 a unit casing constitutes at one and the same time the tubular casing 27 and the general framework 69 through which the units H are supported. The same controller commutator through which the sequence of operation of the motor units 44 with relation to the cams is carried out should include control contact segments for the sequence operations of the units H^1.

Likewise, this controller should carry controls for the quenching mechanisms. These mechanisms, the quenching nozzle Q, the quenching motor unit Q^1, and the supplemental quench control valve unit Q^2 are arranged with respect to the units H and H^1 in the same general axial relation which they occupy in my copending application aforesaid, and their relative functionings are the same.

With reference particularly to Fig. 1 and to the diagrammatic showings of the successive operations contained in Figs. 5 to 9 the operation is as follows: At the outset when the sequency cams and the controller (not shown) have started to operate and the primary 35 being connected to its leads 42 with a source of high frequency alternating current, and a source of fluid pressure being connected with the two switch motor cylinders 44, the relation of the parts on both sides of the plane of symmetry 18 of the machine and as applying to both groups of switching transformers T is as shown in Figs. 1 and 2. This is to say that all switching transformers are off, that the primaries 35 are at the extreme left as are also the pistons 45, and that extreme left hand stops 46 and 58 are engaged respectively with the movable motor cylinders 44 and with the shifting left hand shaft end 34^1.

Upon the first exercise of cyclical control of the controller, fluid pressure is admitted through solenoid valve 64 to the left hand end of the switching motor 44 on one side of the plane of symmetry 18, let us say the motor pertaining to the group of switching transformers T in the foreground which would be that on the right of Fig. 2. The action which takes place is diagrammed in Fig. 5. In a fraction of a second approximately $\frac{1}{15}$ of a second, for example, the piston 45 has been driven to the right to the extremity of cylinder 44 where a cushioned stop is effected by the reduced extension 71 engaging in the reduced cylinder extension 72 in a dash pot fashion, and stop pin 58 is engaged with the abutment socket 62 on the left hand end of shaft 34^1. Immediately prior to this, however, and as the first operation of the controller, fluid pressure has been admitted to the operating cylinder 67 to project heating unit 23 into the cylinder in position A in the work block 15, pilot device 7 engaging a suitable centering member 7^1 positioned at the bottom of the engine cylinder bore. The heating unit is therefore preliminarily in position for the heat treatment which is to follow. Incidentally with the shift of the primary 35 into juxtaposition with the first secondary to be energized, the coil 23 of the heating unit H is energized and the work is heated for the required brief period.

After the moment of institution of this heating and within the brief period it endures, the controller removes pressure from the left hand end of piston 45, cam shaft 49 permits the left hand stop pin 46 to lift under the yielding spring pressure of spring 47, and moves down toward engaging position a succeeding stop pin to the right of the first. This results in a shift to the right of the motor cylinder 44 operating the group of switching transformers T (now in action), and its coming to rest stopped by the newly shifted pin 46. This is shown diagrammatically in Fig. 6. Also during this period of heating of the first cylinder the heating unit H in the position C has been dropped into working relation with respect to the cylinder in position C through admission of fluid pressures to its motor cylinder 67. This also is shown in Fig. 6.

The third phase of cyclical movement of the controller then releases the pressure from the right of piston 45 and again applies it to the left hand end of the piston with a resultant quick shift of the transformer primary from the first secondary or that associated with cylinder in position A, to the next in series and associated with cylinder in position C, into which the pilot 7 and work coil have been previously entered as shown in Fig. 6. This third phase is shown diagrammatically in Fig. 7. Cams 60 have operated seriatim to permit this second shift of piston 45 to achieve the second transformer switching operation, the left hand pin in engagement having been permitted to lift from its engagement by the cam and the next succeeding right hand pin moved by the cam into engagement with the shaft and ready to slip into its socket 62 the moment piston 45 reached the right hand end of motor cylinder 44, and was given its cushion stop.

The next phase is, as respects position E and the cylinder in that position, a repetition of those which have been described in connection with positions A and C. After the completion of the foregoing phases, as described in connection with positions A and C, in connection with position E, the next phase of the operation is directed to position B which involves operation of the second group of transformer elements to be found on the opposite side of the plane of symmetry 18 of the switching transformer machine. In this other half the phases of operation of the controller follow each other successively just as they have for the previous half, the phases of which have been described in detail. To make them entirely clear, however, phase diagrams 8 and 9 have been added. Phase diagram 8 indicates the last heating phase of group No. 1 and the projection into cylinder in position B of the first heating unit H of group No. 2 to be ready for the next succeeding phase which is to effect the heating of such cylinder, the first of the alternate series of cylinders B, D, and F to be operated upon by this second half or group No. 2 of the transformer switching machine. Fig. 9 diagrams the first phase complete in itself in connection with the second group, except that it is carried out wholly by the switching transformer devices connected with the second group only. It will be observed by comparison with Fig. 5 that it is identical in operations with the operations of the first phase of the first group, that shown in Fig. 5. That is to say, fluid pressure has been admitted to the left of piston 45 of the motor 44 of this group and has shifted piston 45 to the right and moved the switching transformer primary 35 of transformer group No. 2 for the first time into transformer relation with a secondary 16 to the extreme left of group No. 2, that being the secondary associated with piston B.

From this point on, the shifts are made as heretofore described, successively from position B to position D and to position F, treating successively cylinders B, D and F.

Quickly after the withdrawal of any movable

primary element 35 from a given secondary element 16, the heating coil 23 associated with such secondary element is withdrawn from the cylinder bore just heated and the quenching head or nozzle Q associated with that cylinder bore moved upwardly into the bore by suitable operation of the motor cylinder Q^1 and quenching fluid supplied thereto through the electromagnetic valve 75, the operation of the apparatus elements involved being effected in proper timed relation by the controller in a manner well understood by those skilled in the art and similar to that described in my copending application Serial No. 119,400, filed January 7, 1937.

After the engine block 15 is completely treated, with all the heating coils 23 and quenching heads Q withdrawn, and the movable primary elements 35 and their motor cylinders and pistons 44 and 45 at the extreme right with the primary elements 35 in the extreme right hand dummy secondary cores 26 such treated block is removed and an untreated block located in its place. The operation is then repeated in reverse order, that is with the primary transformer elements 35 moving back step-by-step from out the extreme right hand dummy core 26 into the extreme left hand dummy core 26, the cams 48 and 50 being provided with two sets of projections one for left to right sequence and one for right to left sequence. Likewise, a second or alternate portion of the controller commutator is provided with a reverse arrangement of control contact segments for controlling the various electromagnetic valves for the motor cylinders and quenching fluid supply in reverse order.

To afford sufficient time for unloading and reloading of the cylinder blocks, the controller may be stopped between loadings or may, in any known or other suitable manner be provided with a blank or idle time period at the beginning of which it is locked out of control and during which period only, it may be released for again taking control at the end of such period. Arrangements for effecting such a safety lock out are disclosed in detail in my copending applications Serial No. 96,346, filed August 17, 1936, and Serial No. 119,400, filed January 7, 1937.

While I have thus described a preferred embodiment of my invention by way of example, it is to be understood that the invention is not limited in its application to such specific embodiment but contemplates all such modifications and variants thereof as fall fairly within the scope of the appended claims. For example any known or other suitable form of motor means may be used for imparting the desired intermittent motion to the movable transformer element, and various means other than that shown may be used for holding the movable transformer element in its different working positions.

I claim:

1. Apparatus for heat treating a plurality of different separate portions of a common work piece by high frequency heavy current electromagnetic induction which comprises a plurality of inductive heating coils one for each portion to be treated, a secondary transformer element connected in circuit with each heating coil, and a common primary transformer element telescopically arranged to move telescopically into and out of inductive relation with any one of said secondary transformer elements one at a time to the substantial exclusion of the remainder to effect energization of said heating coils.

2. Apparatus for heat treating a plurality of different separate portions of a common work piece by high frequency heavy current electromagnetic induction which comprises a plurality of inductive heating coils one for each portion to be treated, a plurality of secondary transformer elements each connected in circuit with one of said heating coils, a pair of secondary magnetic core elements, said secondary transformer elements and magnetic core elements being arranged in seriatim with one of the magnetic core elements at each end of the series, and a transformer primary element telescopically arranged to be moved telescopically from a position of inductive relation with one of said magnetic core elements into inductive relation with said secondary transformer elements one at a time to the substantial exclusion of the remainder and said other magnetic core element in seriatim in a continuous direction, whereby the electrical characteristics of the primary element may be maintained without undue variation.

3. Apparatus for heat treating a plurality of different separate portions of a common work piece by high frequency heavy current electromagnetic induction which comprises a plurality of inductive heating coils one for each portion to be treated, a plurality of secondary transformer elements each connected in circuit with one of said heating coils and each provided with a partly closed magnetic core element, a transformer primary element having a partly closed magnetic core element telescopically arranged with respect to and adapted to be closely coupled to any of said first mentioned core elements to bring the two transformer elements into transformer relation, and means for moving said common primary transformer element into transformer relation with any of said secondary transformer elements to the substantial exclusion of the remainder.

4. The system as claimed in claim 3 in which the secondary elements are arranged in a row and provided with means for moving the primary element along the row into transformer relation with each of said secondary elements in seriatim and a magnetic core element situated at each end of the row of secondary elements for maintaining the reluctance of the magnetic circuit of the primary element below a predetermined value upon movement of the primary element beyond either end of the row of secondary elements.

5. A multiple switching transformer apparatus comprising a plurality of secondary transformer elements arranged in a line, a primary transformer element arranged to be moved along said line into coupled relation with said secondary elements, and means for moving said primary element along said line comprising an abutment element arranged to be moved in relation to said primary coil, means for moving said primary coil in relation to said abutment element, and means for locking said abutment element and said primary coil moving means against movement.

6. A multiple transformer switching apparatus comprising a plurality of secondary transformer elements aligned in fixed spaced relation, a trackway extending parallel to the direction of alignment of said secondary elements, a fluid pressure work cylinder mounted to travel along said trackway, a work piston in said cylinder, a primary transformer element, means for transmitting motion from the work piston to the primary element to move the primary element in-

to transformer relation with said secondary elements along their line of extension, means for locking the piston in fixed relation to said secondary elements, means for locking the work cylinder in relation to said secondary elements and means for admitting and exhausting fluid under pressure to and from the work cylinder on opposite sides of the piston whereby the piston and work cylinder may be moved each in relation to the secondary elements when the other is locked in relation to the secondary elements for moving the primary element in relation to said secondary elements.

7. A multiple switching transformer for supplying high frequency heavy current energy for heat treatment comprising a plurality of stationary secondary elements, a single primary element having a movement of translation in succession from one of the secondaries to another, and means for intermittently moving the primary step by step from one secondary to another in one continuous direction throughout its movement of translation into cooperative relation and coaxial alignment with said secondary elements one at a time in succession to the substantial exclusion of the remainder.

8. Apparatus for heat treating as in claim 1 comprising means for maintaining the inductive reactance of said primary element above a predetermined value while out of operative relation with any of said secondary elements.

9. An apparatus for heat treating a plurality of different separate portions of a common work-piece by high frequency heavy current electromagnetic induction which comprises a plurality of inductive heating coils, one for each portion to be treated, means for moving the heating coils into and out of operative relation with their respective portions of the work-piece at different times, a plurality of secondary transformer elements, one connected in circuit with each heating coil, and a common primary transformer element telescopically arranged to move telescopically into and out of inductive relation with anyone of said secondary transformer elements to the substantial exclusion of the remainder to effect energization of said heating coils only while the associated heating coil of that one secondary element which is in operative relation with its respective portion of the work-piece.

10. Apparatus for heat treating a plurality of different separate portions of a common work piece by high frequency heavy current electromagnetic induction which comprises a plurality of inductive heating coils one for each portion to be treated, a secondary transformer element connected in circuit with each heating coil, and a common primary transformer element adapted to be arranged coaxially with each secondary element and arranged to move into and out of induction relation with any one of said secondary transformer elements, one at a time to the substantial exclusion of the remainder to effect energization of said heating coils.

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