March 28, 1933. D. J. STEWART 1,903,230

ELECTRIC VALVE OPERATOR

Filed July 13, 1929 2 Sheets-Sheet 1

Fig. 1.

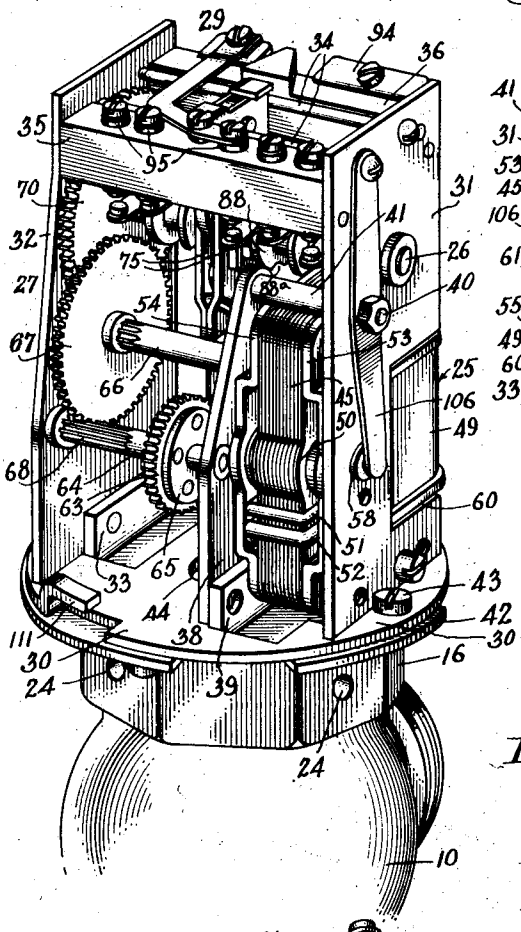


Fig. 2.

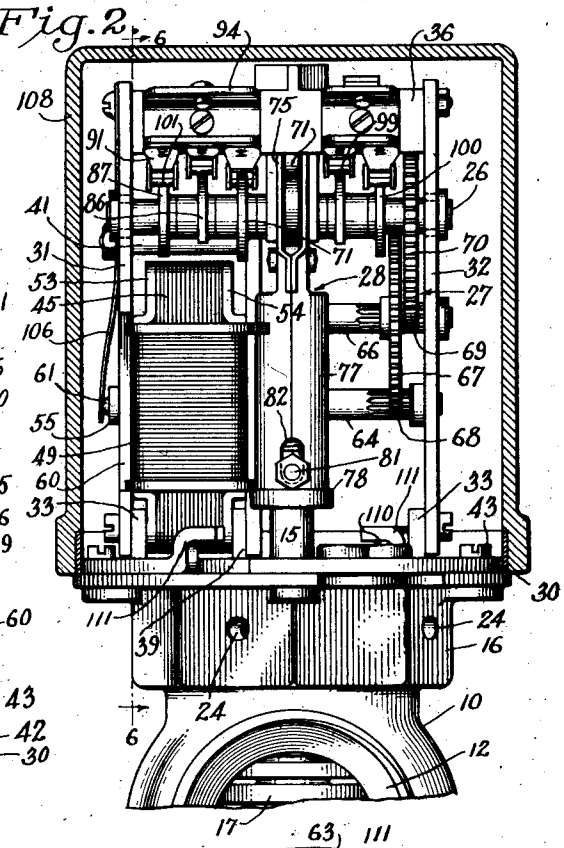


Fig. 3.

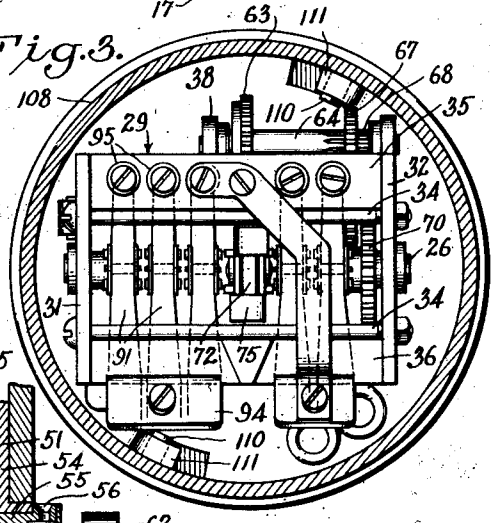


Fig. 4.

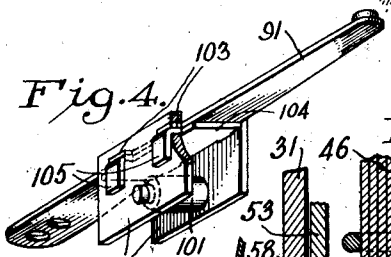
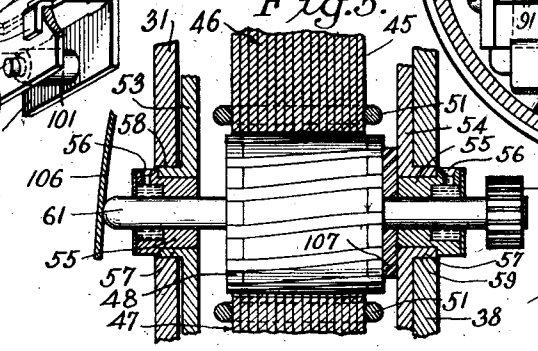


Fig. 5.



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Fig. 6.

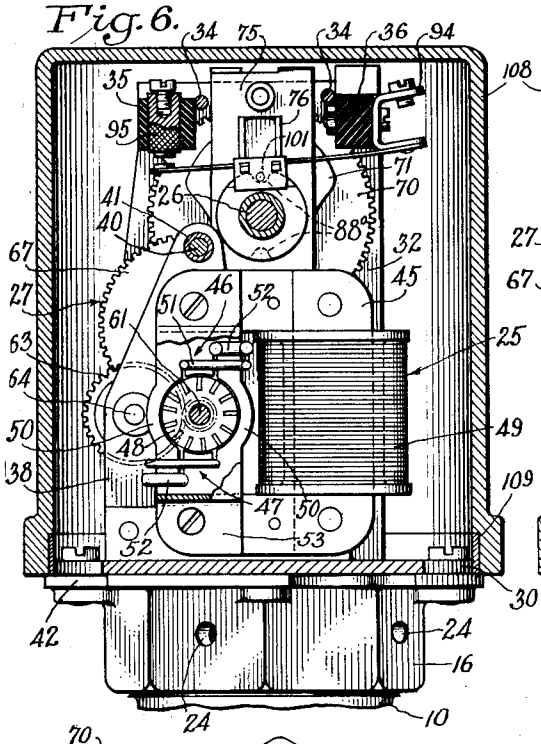


Fig. 7.

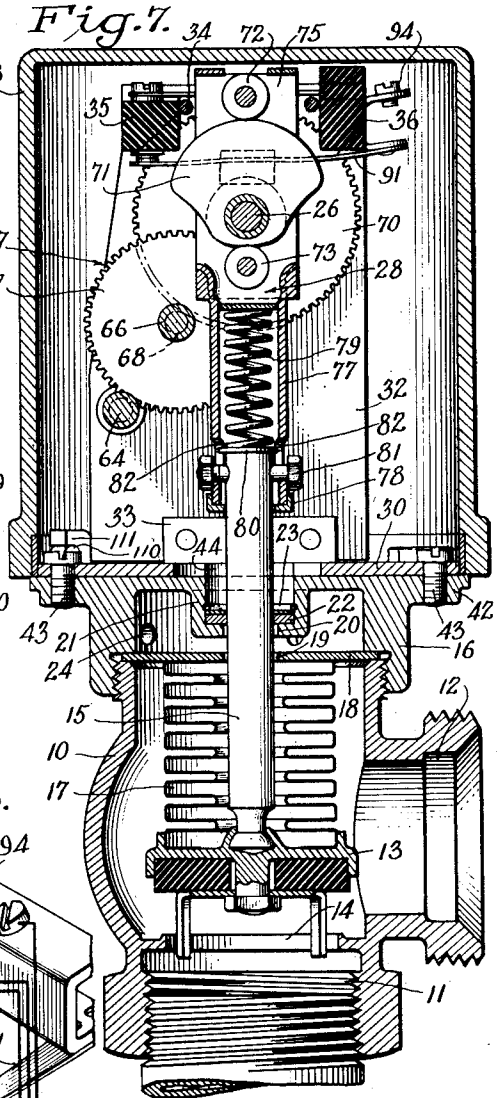
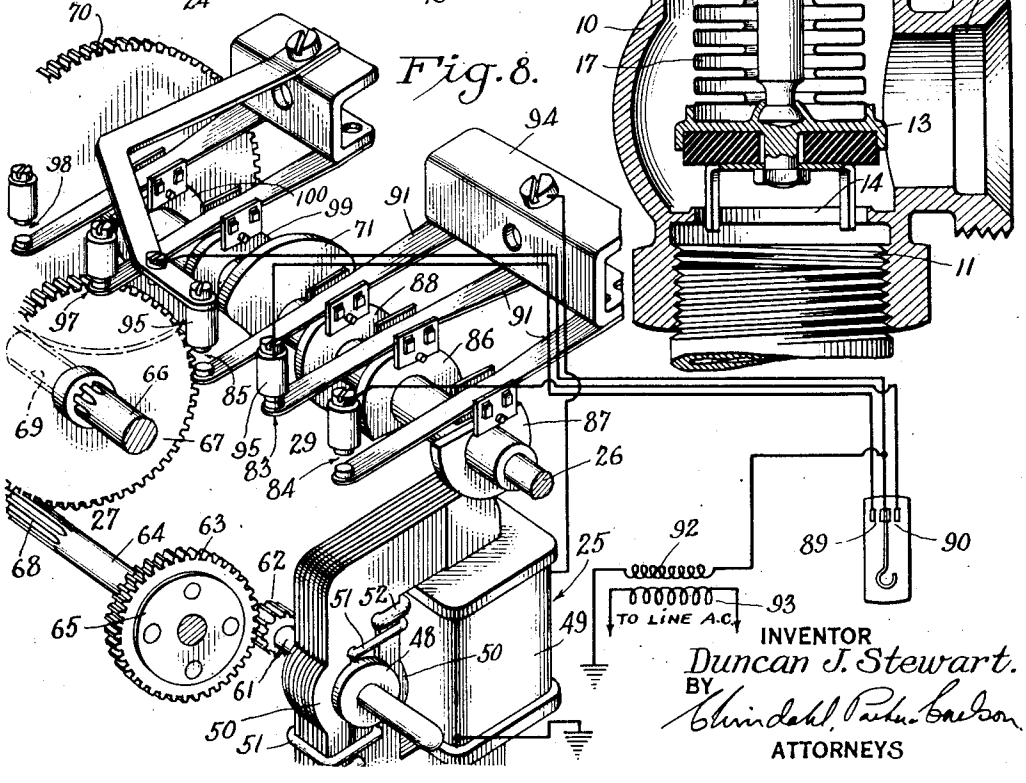


Fig. 8.



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UNITED STATES PATENT OFFICE

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ELECTRIC VALVE OPERATOR

Application filed July 13, 1929. Serial No. 378,118.

The invention relates to an electric valve operator and has more especial reference to an operator driven by a rotary electric motor and adapted for use upon heat control valves of the type employed in controlling the flow of a heating medium to a radiator.

The primary object of the invention is to provide a practical electric valve operator of the character indicated, which by reason of its small size may be mounted in closely restricted spaces directly on the valve to be operated; which is substantially noiseless in its operation; and which is entirely reliable over long periods of time without attention.

I am aware that many attempts have heretofore been made to produce electric valve operators employing rotary motors, but motors of the ordinary type, such as have heretofore been employed, fail to meet the requirements and have not come into commercial usage. Chief among the objections to such prior motors is that they must, if capable of supplying sufficient power, be made so large as to render the operating structure wholly unsuited to application to radiator control valves. Moreover, they commonly use commutators whose brushes are a constant source of difficulty and annoyance.

With these objections in view, I employ in my improved operator an induction motor of the shading ring type having a stator or field member in the form of a flat open frame. A squirrel cage rotor is mounted transversely of one side member of the frame, and the side member remote from the rotor carries the energizing coil. Such a motor may be made of very small dimensions and yet be capable of delivering ample power for the operation of the valve. Also I have found its shape to be advantageous in that it lends itself readily to incorporation in a small compact structure.

In carrying out my invention, I employ a relatively small supporting frame adapted to be secured directly on the valve casing. Centrally disposed within this frame is a reciprocable valve actuator having an operative connection with a transversely disposed actuating shaft. The shaft is driven through a torque multiplying spur gear train from the motor, the latter being positioned at one side of the actuator, with the gear train on the opposite side. A control mechanism for determining the valve opening and closing cycles is operatively associated with the actuating shaft in a conveniently accessible position. Thus the overall longitudinal and lateral dimensions are properly coordinated with reference to the character of the spaces ordinarily provided for radiator control valves, and the entire unit, together with an enclosing cap or cover, requires no greater space than that consumed in many instances by ordinary hand operators.

In the accompanying drawings I have illustrated an operator of the preferred construction and arrangement, although it will be understood that various changes may be made without departing from the spirit and scope of the invention as expressed in the appended claims.

Figure 1 of the drawings is a perspective view of my improved operator with the enclosing cover removed, the operator being shown secured to a radiator control valve.

Fig. 2 is an elevational view of the operator looking from the side opposite that shown in Fig. 1 and showing the removable cover in section.

Fig. 3 is a plan view of the operator, the cover being shown in transverse section.

Fig. 4 is a detail view of a part of the switch mechanism.

Fig. 5 is a fragmentary vertical sectional view on an enlarged scale through the motor.

Fig. 6 is a fragmentary vertical sectional view taken approximately in the plane of line 6—6 of Fig. 2.

Fig. 7 is a central vertical sectional view through the operator and the valve.

Fig. 8 is a schematic view showing the control mechanism with the principal parts of the operator in perspective.

The valve to which the operator is applied comprises as herein shown a casing 10 having an inlet 11 and an outlet 12. A valve member 13 is reciprocable axially toward and from a seat 14 in the casing, the valve member having an operating stem 15 projecting through an

opening in one wall of the casing, which opening is closed by a cap 16. A bellows diaphragm 17 provides a seal to prevent the escape of the heating medium from the casing in a well known manner, the outer end of the diaphragm being secured to a plate 18 which is clamped between the cap 16 and the casing 10.

The plate 18 has a central aperture 19 therein through which the stem 15 projects, and the cap 16 similarly has an aperture 20 formed in a centrally depressed portion 21 adapted to receive a packing ring 22. The latter may be held in position by means of a spring ring 23. A plurality of vent holes 24 are provided in the cap 16 to permit the escape of any steam and vapor which may leak past the diaphragm 17, such steam or vapor being prevented from escaping from the cap around the valve stem by the packing ring 22.

The operator in the preferred embodiment comprises in general an electric motor 25, a main operating shaft 26, a torque multiplying gear train 27 connecting the motor shaft with the main shaft, a reciprocable actuator 28 operatively associated with the main shaft and connected with the valve stem 15, and a controlling switch mechanism 29 for effecting successive valve opening and closing movements in alternate cycles. Of these several elements, the reciprocable actuator 28 constitutes a central axis relative to which the other elements are symmetrically arranged to form a small compact operating unit of proper longitudinal and transverse dimensions.

Referring now to the preferred arrangement employed, the reciprocable actuator 28 is connected at one end to the axial valve stem 15 so as to form an extension thereof; and the main operating shaft 26, which is operatively associated with the opposite end of the actuator, is disposed in perpendicular relation thereto.

The motor 25 is positioned adjacent one side of the actuator and has its shaft extending in a direction parallel with the main operating shaft so that the gearing connection 27 may be in the form of a spur gear train located on the opposite side of the actuator. Preferably the shaft 26 is disposed above the motor, and the switch mechanism 29 is associated with this main shaft, above it, so as to occupy a conveniently accessible position.

To support the various parts in the relation set forth, a frame is provided consisting of a circular base plate 30 and a pair of upstanding side plates 31 and 32. The latter are secured at their lower ends to lugs 33 struck up from the base plate, and are connected at their upper ends by tie rods 34, with blocks 35 and 36 of suitable insulating material interposed between the plates and constituting spacers.

The two side plates 31 and 32 provide bearings for the opposite ends of the main operating shaft 26, and an additional bearing member is provided in the form of a smaller intermediate plate 38 which is preferably made of non-magnetic material. This plate 38 is secured at its lower end to a struck up lug 39 on the circular base plate, and is connected at its upper end to the main side plate 31 as by means of a bolt 40 with a spacer sleeve 41 interposed between the plates 30 and 31. The plate is spaced only a short distance from the side plate 31 so as to receive between it and said side plate a portion of the motor 25. Also the plate 38 coacts with the opposite side plate 32 to provide bearings for supporting the gear train 27.

The base plate 30 is adapted to be secured upon the upper flat face of the valve cap 16, which has a peripheral flange 42. Fastening screws 43 are entered through the base plate and threaded into the flange of the valve cap. When the operator is secured in position upon the valve, the stem 15 projects centrally into the lower portion of the supporting frame, a central aperture 44 being provided in the base plate 30.

The motor 25 comprises a relatively flat field member or stator 45 of laminated construction. It is in the form of an open substantially rectangular frame, one side member of which is constructed to provide two opposed poles 46 and 47 (Fig. 6) between which is mounted a rotor 48 of the squirrel cage type. The opposite side portion of the stator frame carries an energizing field coil 49 which is therefore positioned in laterally offset relation to the rotor. The poles 46 and 47 are in the preferred embodiment connected by integral bridging members 50, and each of the poles is equipped with two shading coils 51 and 52.

The motor as thus constructed may, by analogy to so-called core type transformers, be said to be of the core type, and while the motor structure forms no part, per se, of the present invention, it is peculiarly adaptable in its general characteristics to incorporation in the improved operator. Thus, whereas electric rotary motors of the more common variety must, in order to develop sufficient power to effect the desired operation, be made large and cumbersome in size, the present motor has relatively high starting and stall torques, and is capable of developing ample power for purposes of valve operation even when made of very small dimensions. The flat type of field member, with its laterally offset energizing coil, and with relatively small shading coils, gives to the motor a shape such that it may be incorporated advantageously directly within a small symmetrical operating unit. Moreover, the motor is practically noiseless in operation, and due to the absence of a commutator and brushes it is reliable, even after long periods

of idleness, and presents no difficulties from the standpoint of radio interference.

Preferably the rotor 48 is mounted in bearing members carried directly by the stator frame, thus avoiding the use of a long shaft and insuring accurate centering of the rotor between the poles. As best shown in Figs. 1 and 5, the rotor bearings are provided by two plates 53 and 54 of suitable non-magnetic material. The opposite ends of the plates are rigidly secured on opposite sides of the stator frame and the central portions of the plates are offset in a direction away from said frame and centrally apertured to receive bearing bushings 55. The latter may be of any preferred character, those herein shown being equipped with oil pockets 56 which need be filled only initially to cover the wearing-in period.

The motor is supported between the side plate 31 and the intermediate bearing plate 38, and for this purpose the rotor bearing members 53 and 54 are provided with outwardly projecting annular flanges 57 which bear in apertures 58 and 59 formed respectively in the plates 31 and 38. Said flanges further serve to provide elongated apertures in the plates 53 and 54 for the bushings 55. The motor is held against turning by the engagement of a portion of the spool of the main field coil 49 in a notch 60 formed in the side plate 31.

The rotor shaft 61 extends through the bushings 55, and one projecting end thereof carries a spur pinion 62 forming part of the gear train 27. The spur pinion 62 thus meshes with a spur gear 63 fast on a shaft 64 the opposite ends of which are respectively journaled in the bearing plate 38 and the side plate 32 (Fig. 1). Preferably the spur gear 63 is made of non-metallic material and is made fast upon the shaft 64 by means of a metallic disk 65.

Also journaled in the side plate 32 and the intermediate bearing plate 38 is a shaft 66 having rigid therewith adjacent the plate 32 a spur gear 67 meshing with a pinion 68 formed integral with the shaft 64. The shaft 66 in turn has a pinion 69 meshing with a spur gear 70 fast on the main operating shaft 26 at the end thereof adjacent the plate 32.

The gear train 27 thus constitutes a three step gear reduction between the motor shaft and the main operating shaft, and between the latter shaft and the valve actuator is interposed an operative connection such that in successive half revolutions of this shaft 26 the valve is alternately opened and closed, the rotary motion in the shaft being converted into reciprocatory motion in the actuator 28 and the valve stem 15. The use of spur gearing for connecting said two shafts is advantageous especially in an operator employed for heat control purposes where lubrication difficulties are encountered. Thus the spur type gearing avoids end thrusts and similar wearing actions incident to other types of gearing.

The means for reciprocating the actuator 28 to impart positive opening and closing movements to the valve member 13, comprises in the preferred construction a cam 71 (Fig. 7) secured centrally on the operating shaft 26 and coacting with two follower rollers 72 and 73. The latter are mounted in the actuator on diametrically opposite sides of the cam, and are supported between two plates 75 spaced a short distance apart and longitudinally slotted to form guides coacting with the shaft 26 in the lengthwise movement of the actuator.

A yielding lost motion connection is provided between the actuator and the valve stem 15, of a character such that at the end of the valve closing cycle the valve member is held to its seat with a predetermined yielding pressure. To this end the lower end of the actuator is constructed to form a tubular stem 77. Thus it is made in two segments respectively integral with the plates 75 at the upper end of the actuator. The lower end of the stem 77 is closed by a fixed cap 78 which serves to hold the two segments together, and within the tubular stem is a coiled expansion spring 79 bearing at its lower end upon a washer 80. In the assembled relation of the parts the washer 80 bears upon the upper end of the valve stem 15, and the latter is transversely apertured to receive a bolt 81 the ends of which pass through slots 82 in opposite side walls of the stem. The slots 82 are of a length such that after the valve member, in the closing cycle engages its seat 14, the actuator is permitted to continue its movement as the spring 79 is compressed.

It will be observed that the operator as a whole may be removed from the valve by removing the screws 43 and disconnecting the actuator 28 from the valve stem 15, the latter being accomplished by removing the bolt 81. When the operator is removed the washer 80 engages with the inturned flange of the cap 78 and retains the spring 79 within the tubular stem 77. Moreover, such removal of the operator may be accomplished without opening the valve 10 to the atmosphere, the seal being maintained inasmuch as the cap 16 remains in position.

The switch mechanism 29 for governing the valve opening and closing cycles forms per se no part of the present invention. Briefly it comprises (Fig. 8) three switches 83, 84 and 85 respectively operable by cams 86, 87 and 88 on the shaft 26. The cams 86 and 87 have oppositely disposed flat sides, while the cam 88 for the running switch has two diametrically disposed notches 88^a as shown in Fig. 6.

The switches 83 and 84 constitute starting

switches coacting with two switches 89 and 90 of a suitable thermostat to initiate valve opening or closing cycles respectively. The switch 85 constitutes a running switch and is operable independently of the thermostat after the cycle has been initiated by one of the starting switches.

The movable contact of each of the switches 83, 84 and 85 is carried on the free end of a resilient arm 91 and the three arms are anchored on a metallic channel member 94 secured to the insulated block 36 (Fig. 6). Each of the stationary contacts of said switches 83, 84 and 85 is mounted in a plug 95, and the several plugs are embedded in the fibre block 35 and respectively connected electrically to the three switch contacts of the thermostat. The intermediate or common contact of the thermostat is also connected to the grounded secondary 92 of a transformer having its primary 93 connected to a source of alternating current. The three movable switch arms 91, made electrically common through the metallic channel member 94, are connected with the main field coil 49, the latter being grounded.

With the parts in the relation shown in Fig. 8, the starting switch 83 is closed and when the thermostat switch 89 is closed, the coil 49 is energized and the motor operated. In the initial portion of the movement of the shaft 26, the running switch 85 is closed, and the cycle is terminated by the opening of the running switch 85 after one-half revolution of the shaft 26. At this time the starting switch 83 is also opened, and the starting switch 84 is closed ready for the next operating cycle subject to the control of the thermostat switch 90.

In addition to the switches 83, 84 and 85, two switches 97 and 98 respectively controlled by cams 99 and 100 are shown, so that in all five switches are controlled by as many cams all on the operating shaft 26. The two switches 97 and 98 may be employed in the control of another valve operator without the use of a separate thermostat, as fully set forth in the application of Howard D. Colman, Serial No. 361,302, filed May 8, 1929.

The movable switch arms for the switches 83, 84, 85, 97 and 98 are operated by their respective cams through the medium of follower rollers 101 (Fig. 4). The construction shown comprises two plates 102 of insulating material between which the roller 101 is mounted, the upper ends of the plates being slotted to receive laterally extending lugs 103 formed integrally with the contact arm. Said arm being made of hardened spring steel, does not permit of convenient bending, and the plates 102 are therefore clamped in position by means of a separate plate 104 of relatively softer material. Said plate 104 underlies the contact arm and has at opposite edges lugs 105 passing through slots in the plates and bent downwardly into engagement therewith.

It is desirable that the operation of the motor be stopped quickly at the end of each operating cycle, at which time the running switch is in open position with the roller follower 101 seated in one of the notches 88a of of the cam 88. These notches are made relatively short so as to reduce to a minimum the time during which the current flows through the thermostat contacts, and it is essential that the motor be stopped after the running switch has been opened. Also it is desirable that the actuating cam 71 for the valve be shaped to provide only a short dwell at the end of the closing cycle, and if the operator is not stopped upon this dwell the spring 79, being under substantial tension, would have a tendency to rotate the operating shaft in one direction or the other sufficient to permit leakage of steam past the valve or to close the running switch 85.

I therefore provide an electric brake which is operable as an incident to the energization and de-energization of the field coil 49, and in order to avoid the use of a separate especially constructed alternating current brake magnet, which would consume a substantial amount of space in the operator and which would add substantially to the cost thereof, I utilize a solenoidal action of the motor field upon the rotor. Thus referring to Figs. 1 and 5, the rotor of the motor is mounted so as to be capable of a limited axial movement, the spur gear pinion 62 being made of sufficient length to permit such movement while maintaining the driving connection. A leaf spring 106 is secured to the outer side of the side plate 31 with its free end bearing on the outer end of the rotor shaft 61 in a direction to force the rotor toward its bearing plate 54. Preferably a fibre washer 107 is interposed between the rotor and said plate 54 to provide better frictional surfaces.

When the motor is energized at the beginning of a cycle, the rotor moves axially toward its magnetic center in the stator under a solenoidal action of sufficient strength to overcome the tension of the spring 106. Upon the de-energization of the motor, the spring acts to return the rotor, exerting a braking pressure on the bearing plate 54 through the medium of the washer 107. Since the brake utilizes the same electromagnetic means as the motor, it consumes little or no additional space and does not add appreciably to the cost of the construction.

The entire operating unit is conveniently enclosed by a cylindrical cap or cover 108 which is seated at its lower end upon the flange 42 of the cap 16, said flange being of a diameter slightly larger than the frame base plate 30. Within the lower end of the cap is a metallic band 109 carrying at spaced intervals pins 110 (Fig. 7) adapted to inter-

lock with bent lugs 111 struck up from the base plate 30, the interlocking action being obtained by a slight twisting of the cap relative to the base plate.

It will be observed that by the construction and arrangement provided the motor consumes only a relatively small portion of the space within the frame, being disposed on the one hand between the central reciprocatory actuator and the adjacent side plate, and on the other hand between the operating shaft and the base plate. Thus ample space is provided upon the opposite side of the actuator for the multiplying gear train, and for the switch mechanism advantageously located in the space above the motor between the two side plates of the frame. Moreover, the gear-supporting shafts 64 and 66 are of substantial length with bearings at each end. Thus slight irregularities in the mounting of these shafts does not affect materially the proper intermeshing of the gears, and there is no tendency to wear out of alinement with a resultant chatter of the gears as where the shafts are supported at one end only.

I claim as my invention:

1. An electric valve operator comprising, in combination with a valve having a reciprocable operating stem projecting axially from the casing, a main frame comprising a base plate adapted to be secured to said casing and having a central aperture through which said valve operating stem projects, said frame further comprising a pair of laterally spaced substantially parallel side plates secured at their lower ends to said base plate, a main operating shaft having its opposite ends mounted in said plates in parallel relation to the base plate but spaced a substantial distance therefrom, a reciprocable actuator connected to and axially alined with said valve stem, said actuator having an operative connection with said main operating shaft so as to be reciprocable in the rotation of said shaft, an electric motor comprising a stator in the form of a substantially flat open frame with a rotor mounted transversely of one side member of the frame and an energizing coil mounted on an opposite side member, said motor being disposed within said main frame between said actuator and one of said side plates, a multiplying gear connection between the rotor and said operating shaft, and a controlling switch mechanism supported between the upper ends of the side plates and above the motor, said operating shaft having means for actuating said switch mechanism.

2. An electrically driven operator for radiator valves and the like comprising, in combination, a frame having a base plate, a pair of laterally spaced side plates and a relatively smaller intermediate plate spaced a short distance from one of said side plates, an electric induction motor having a stator in the form of a relatively flat frame mounted between said intermediate plate and the adjacent side plate, a central longitudinal valve actuator disposed between said intermediate plate and the opposite side plate, said motor having a rotor mounted transversely of the stator frame with a driving shaft projecting through said intermediate plate, a main operating shaft mounted in said side plates above the motor and operatively connected with said actuating member, and a spur gear train connecting said rotor shaft with said operating shaft.

3. An electrically driven operator for radiator valves and the like comprising, in combination, a frame having a base plate, a pair of laterally spaced side plates and a relatively smaller intermediate plate spaced from one of said side plates, an electric induction motor having a stator in the form of a relatively flat frame mounted between said intermediate plate and the adjacent side plate, a central longitudinal valve actuator disposed between said intermediate plate and the opposite side plate, said motor having a rotor mounted transversely of the stator frame with a driving shaft projecting through said intermediate plate, a main operating shaft mounted in said side plates above the motor and operatively connected with said actuating member, and a spur gear train connecting said rotor shaft with said operating shaft, said spur gear train having a plurality of operating shafts mounted between said intermediate frame member and the side plate remote from the motor.

4. An electrically driven operator for radiator valves and the like comprising, in combination with a reciprocable valve operating stem, a reciprocable actuating member alined with and having a yieldable lost motion connection with said stem, a main operating shaft having a cam thereon, a pair of cam followers on said actuator disposed on opposite sides of the cam, a rotary electric motor having an energizing field coil, means providing a driving connection between said motor and said main operating shaft, and means operatively associated with said operating shaft and adapted in the unidirectional rotation of the cam to effect successive valve opening and closing cycles, said cam having a relatively short dwell acting through said yieldable lost motion connection to hold the valve member in closed position with a predetermined yielding pressure, and a brake operable as an incident to the energization and de-energization of the field coil and adapted to stop said cam with its dwell engaging one of said followers in the closed position of the valve.

5. An electrically driven operator for radiator valves and the like comprising a valve actuator, a main operating shaft operatively connected with said actuator, an electric induction motor having a stator in the form of

a flat frame and an axially movable rotor having a shaft rotatable unidirectionally in the operation of the motor, a torque multiplying connection between said shafts, a controlling switch mechanism operable to define successive valve opening and closing cycles, and an electric brake comprising a stationary friction surface, and spring means tending to move said rotor into frictional engagement with said surface, said rotor being movable in the opposite direction to release the brake as an incident to the energization of the motor winding.

6. An electrically driven valve operator comprising a supporting frame, valve actuating means including a rotary element mounted in said frame, and a combined electric motor and brake unit also mounted in said frame and including an axially movable rotor, a brake and a single electromagnetic means adapted when energized to produce a magnetic field which causes rotation of said rotor and moves it axially in a direction to release said brake, said rotor having a gearing connection with said rotary element adapted to permit of such axial movement of the rotor.

7. An electric motor-driven operator for radiator control valves and the like comprising, in combination, a base plate, an operating shaft mounted parallel to said plate in spaced relation thereto, an electric motor comprising a flat and relatively thin stator frame disposed perpendicular to said plate and offset to one side of the center of the plate, said frame providing spaced vertical legs, an energizing coil on one of said legs, a rotor extending transversely of the other one of said legs and having a drive shaft parallel with the operating shaft, a torque multiplying driving connection between said two shafts, and a controlling switch mechanism for the motor operable in the rotation of said operating shaft to define successive operating cycles.

8. An electrically driven valve operator comprising, in combination, a frame having a base plate and two side plates rigidly supported in spaced relation at opposite sides of the base plate, an operating shaft mounted at opposite ends in said side plates and disposed parallel to but spaced from the base plate, an electric shading ring motor having a flat core type stator vertically disposed in said frame between the base plate and the operating shaft and having two spaced legs with an energizing coil on one leg and a rotor in the other, said rotor being disposed parallel to said operating shaft, a spur gear train mounted in the frame and providing a torque multiplying gearing connection between said rotor and said shaft, and a switch mechanism operatively associated with said shaft for controlling said motor.

9. An electrically driven valve operator comprising, in combination, a frame having a base plate and two side plates rigidly supported in spaced relation at opposite sides of the base plate, a shaft mounted in said frame parallel to but spaced from the base plate, an electric shading ring motor having a flat core type stator vertically disposed in said frame in offset relation to the center of the base plate and adjacent to one of the side plates, said stator being in the form of a thin flat frame having spaced legs with an energizing coil on one leg and a rotor in the other disposed parallel to said shaft, a spur gear train mounted in the frame adjacent the other side plate and providing a torque multiplying gearing connection between said rotor and said shaft, a cam fast on said shaft centrally thereof, and a reciprocatory valve actuator operatively associated with said cam and disposed between said motor and said gear train.

10. An electrically driven operator for valves of the type comprising a body and a valve member reciprocable axially toward and from a seat in said body, said operator comprising a supporting frame adapted to be mounted upon the valve body in projecting relation to one side thereof, a reciprocatory valve actuating stem disposed centrally within said frame in axial alinement with the valve member to be operated and adapted for connection therewith, an operating shaft mounted in said frame transversely of said stem, means operatively connecting said shaft with the stem adapted to impart a reciprocatory movement to the stem in the rotation of the shaft, an electric shading ring motor having a core type stator in the form of a thin flat frame mounted in said supporting frame and disposed adjacent one side of said stem in parallel relation thereto, a rotor rotatably supported on said stator frame, and a torque multiplying gear train between the rotor and the operating shaft and disposed on the side of the actuating stem opposite the motor.

In testimony whereof, I have hereunto affixed my signature.

DUNCAN J. STEWART.