July 18, 1939. L. A. TROFIMOV 2,166,671

METHOD AND MEANS FOR TREATING ELECTRICALLY CONDUCTING LIQUIDS

Filed Jan. 8, 1937

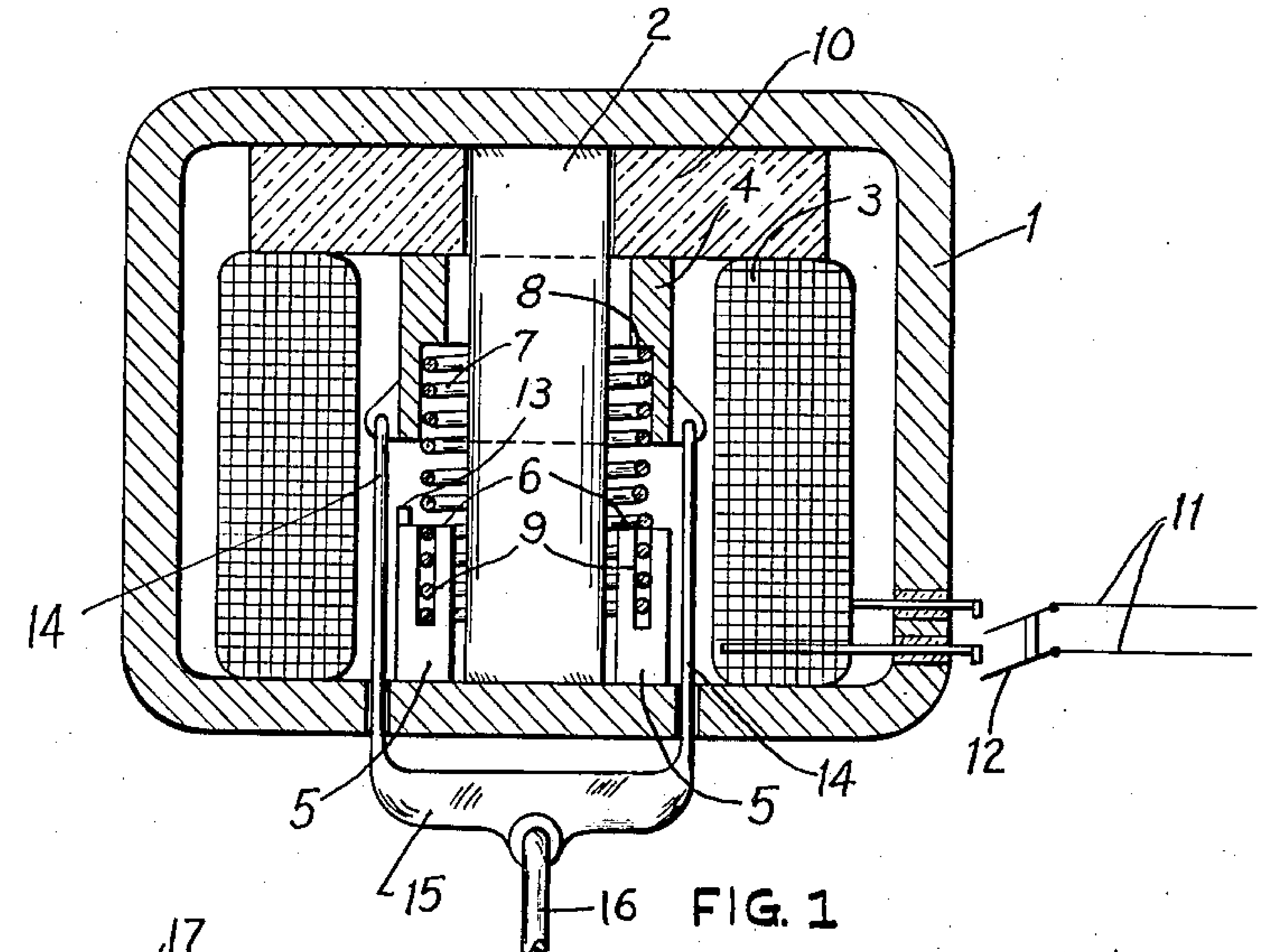


FIG. 1

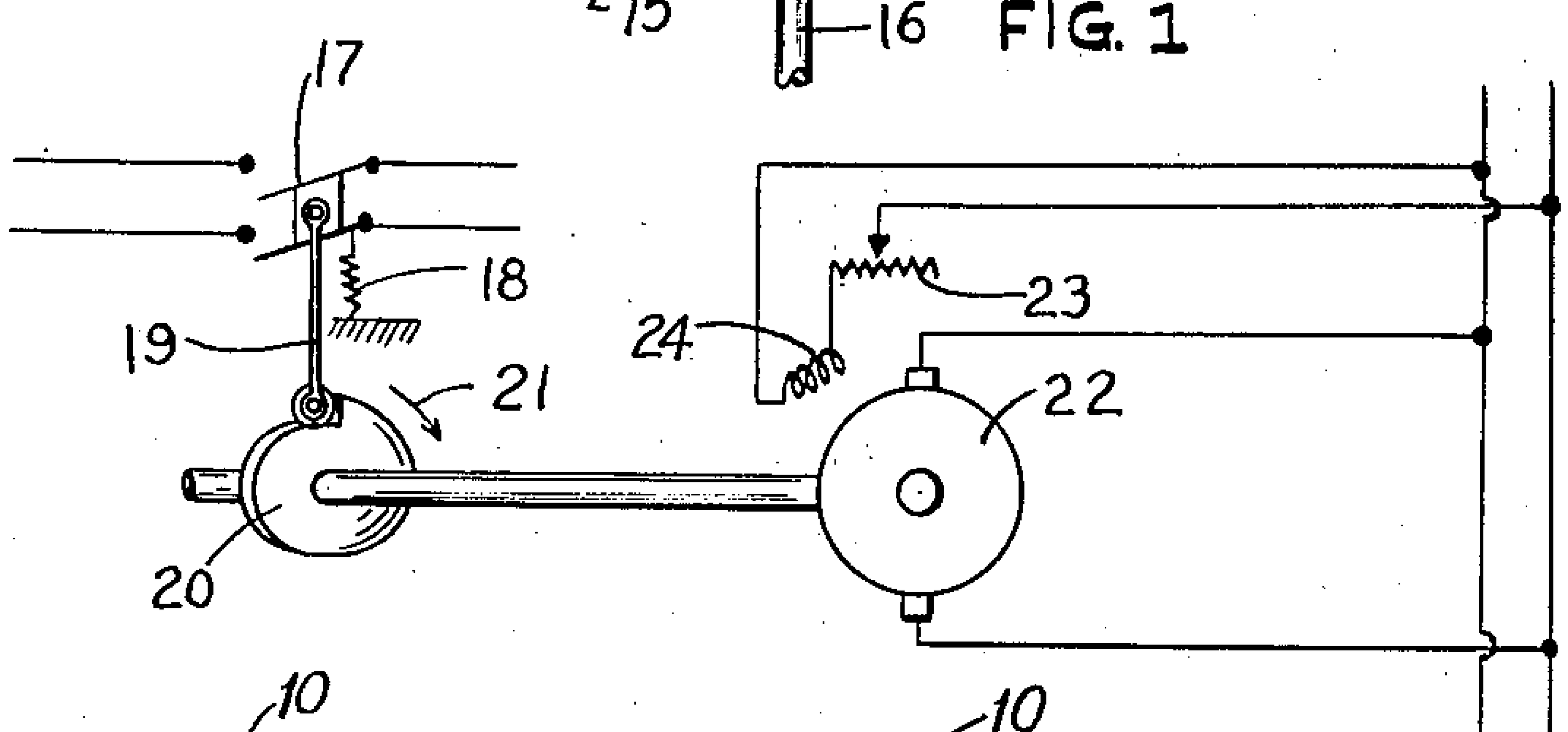
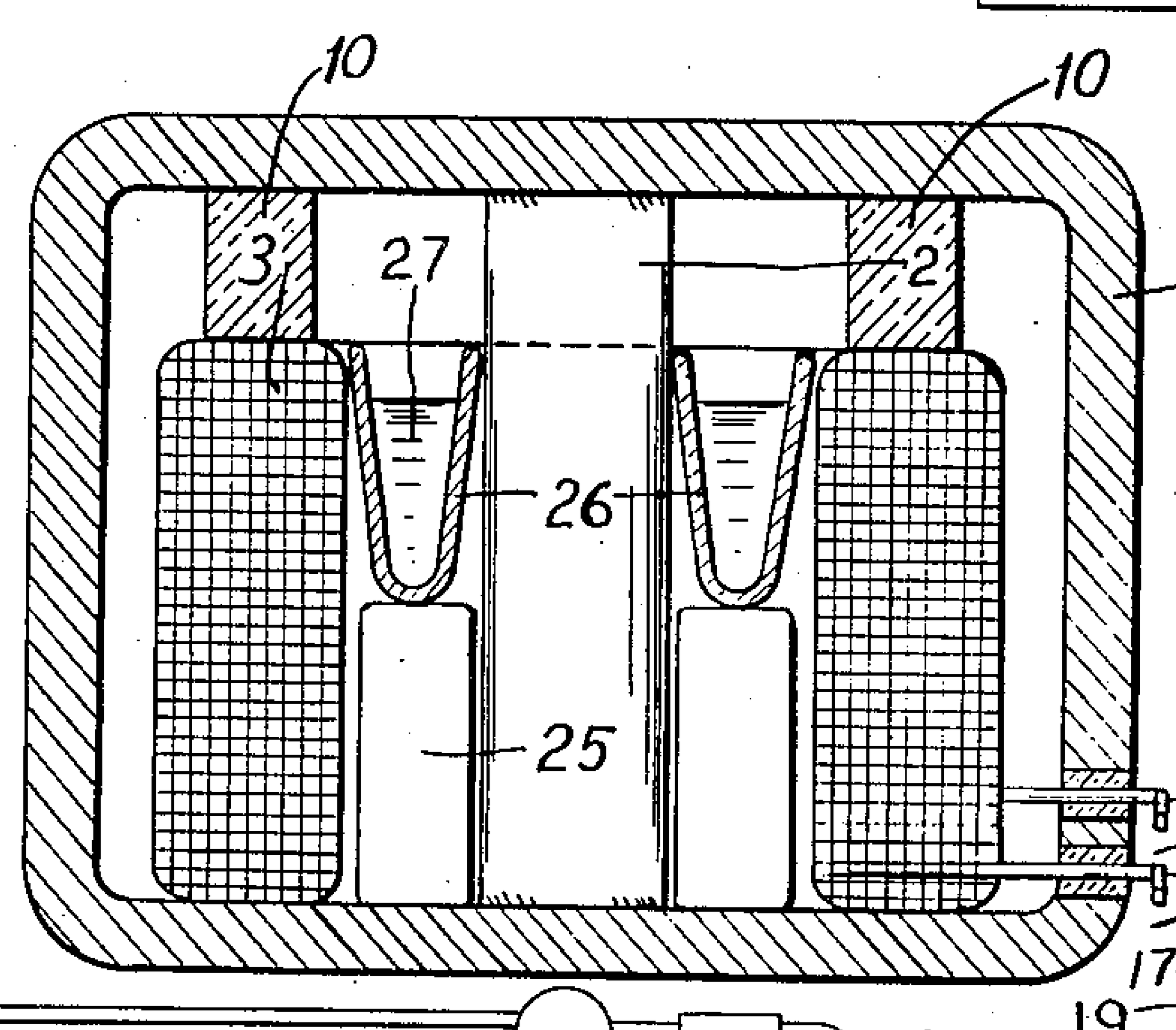


FIG. 2.

FIG. 3.



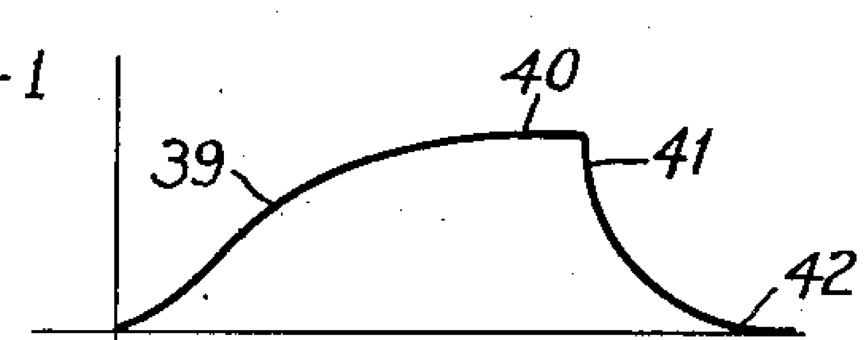


FIG. 5.

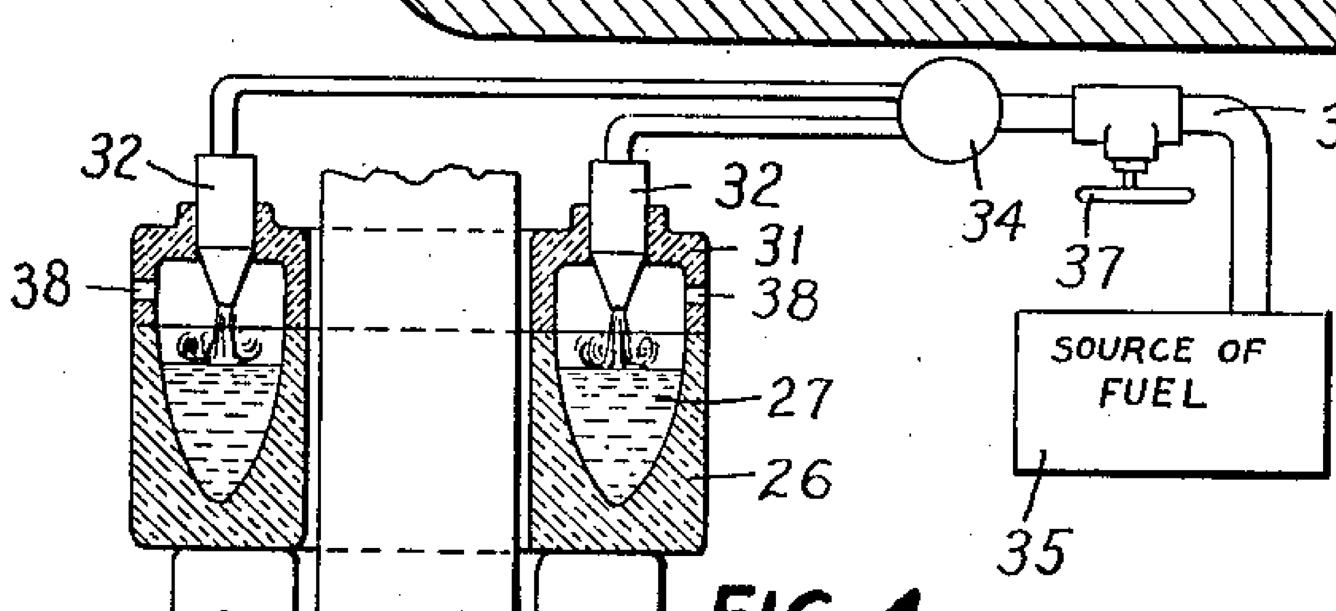


FIG. 4.

INVENTOR.
Lev A. Trofimov.
BY Slough and Canfield
ATTORNEYS

Patented July 18, 1939 2,166,671

UNITED STATES PATENT OFFICE

2,166,671

METHOD AND MEANS FOR TREATING ELECTRICALLY CONDUCTING LIQUIDS

Lev A. Trofimov, Cleveland, Ohio, assignor, by mesne assignments, to Product Development and Engineering Corporation, Cleveland, Ohio, a corporation of Ohio

Application January 8, 1937, Serial No. 119,618

4 Claims. (Cl. 75—93)

This invention relates to methods and means for treating electrically conducting liquids.

The primary object of the invention is to provide an improved method and means for producing electric current impulses and for converting them into mechanical force impulses and for applying the force impulses as pressure impulses in a body of electrically conducting fluid material in a manner to effect the expulsion of gases and other impurities from the liquid material.

Other objects will be apparent to those skilled in the art to which my invention appertains.

My invention is fully disclosed in the following description taken in connection with the accompanying drawing in which:

Fig. 1 is a view in some respects diagrammatic illustrating one means of practicing my invention;

Fig. 2 is a fragmentary view generally similar to Fig. 1 but illustrating a modification;

Fig. 3 is a view illustrating the application of my invention to the expulsion of air and other impurities from molten metal.

Fig. 4 is a view similar to Fig. 3 illustrating a modification, and

Fig. 5 is a diagram of certain electric current characteristics utilized in the practice of my invention.

Referring to the drawing, Fig. 1, I have shown at 1 a closed frame of ferrous metal and at 2 a magnetic core bridging the frame, and at 3 an electric winding encircling the core 2 and spaced therefrom a substantial distance. As is well known, current in the winding 3 will cause magnetic flux to "flow" axially through the core 2 in one direction and then around through the frame 1 and back into the core.

At 4 is a metal ring, preferably of low electrical resistance, surrounding the core 2 and disposed within the winding 3 or adjacent to its upper end. Below the ring 4 is a support comprising one or more blocks 5—5 having upper faces 6—6 preferably parallel to the lower edge of the ring 4. The blocks 5—5 are preferably disposed symmetrically around the core 2, but if made from non-electrical conducting material may be combined in a single annulus. In any case, the blocks 5 are secured against movement to the frame 1 on which they rest.

A spring 7, preferably non-magnetic and of high electrical resistance is telescoped within the ring 4, at one end abutting on a shoulder 8 thereof and at the other end seated in recesses 9—9 in the blocks 5—5.

The spring 7 normally holds the ring 4 in an upper position, as illustrated, determined by a preferably non-electrically conducting ring 10 provided around the core 2 and secured in any suitable manner either to the ring or to the frame 1 at the upper end of the core. The ring 10 is preferably also fitted between the frame 1 and coil 3, to hold the coil down.

The winding 3 may be energized from mains 11 through a make-and-break switch 12, the switch 12 being illustrated diagrammatically, but preferably being any well known switch by which the current flowing therethrough may be abruptly broken.

Such switches are well known in the art and it is believed unnecessary to illustrate or describe them.

Upon closing the switch 12, current flows from the mains 11 through the winding 3, causing magnetic flux to build up in the core 2 and frame 1.

Now I have found, by experiment, that if the switch 12 be suddenly opened to abruptly interrupt the current from the mains 11 there will be developed in the ring an electric current which produces an electro-magnetic force of attraction on the ring 4, and the ring will tend to move downwardly.

The more rapidly the current is broken the greater will this force be on the ring 4, and if the switch 12 be opened to break the current very quickly, the force will be very great and the ring 4 will be projected downwardly and will strike a blow on the blocks 5—5. After the blow has been struck, that is to say, after the impulse has been effected, the force on the ring dies out and the ring will then be again raised by the spring 7, and the cycle is complete. The current cycle above described is illustrated in Fig. 5. The current builds up along the line 39 to a constant maximum value at 40 and then, when abruptly broken, drops as at 41 and finally dies out as at 42.

As a practical use for such a blow, the ring 4, shown diagrammatically in Fig. 1, may be utilized as a hammer and the blocks 5—5 as an anvil and a forging operation may be performed on a workpiece 13 by the repeated blows of the ring 4.

Or for other purposes, a pair of rods 14—14 may be connected to the ring 4 at their inner ends and at their outer ends connected to a head 15. As the ring 4 reciprocates, as above described, reciprocatory motion will be transmitted to an element 16 for any useful purpose, particularly one in which the down stroke is the working stroke.

With the arrangement illustrated in Fig. 1, the switch 12 may be used to produce single down strokes of the ring 4. Another arrangement is shown in Fig. 2. Here the main switch 17 is normally forced open by a powerful spring 18 and may be closed by a cam follower 19 operated by a cam 20 which is continuously rotated in the direction of the arrow 21 by an electric motor 22, the speed of which may be adjustably varied by a rheostat 23 in the field circuit 24 of the motor. There will be a natural periodicity for the ring 4, and if the motor 22 is adjusted to the correct speed, the switch 17 will open each time at the same periodicity, whereby a rapid succession of powerful blows of the ring 4 or reciprocations of the element 16 may be effected.

In Fig. 3, I have illustrated the application of my invention to another use. Here the frame 1, core 2 and winding 3 may be as in the form of Fig. 1. At 25 is a spacer either in the form of separate blocks or in the form of an annulus as described for the first form. Upon the spacer 25 and within the winding 3 or adjacent to its upper end is an annular upwardly open vessel 26 which may be V-form or U-form in cross section, as shown, surrounding the core 2.

The winding 3 may be energized with current by the circuit shown in Fig. 1 but preferably by that shown in Fig. 2.

With the arrangement as illustrated in Fig. 3, and as described above, it will be noted that the medial transverse plane of the winding 3, at which its field is at maximum density, is below at least the greater part of the vessel 26 or of the contents therein.

This application of the invention illustrates its use to force out of liquid metal air and other impurities. As is well known, these impurities are customarily worked out of steel or iron by processes well known in steel mill practice.

To remove such impurities by the practice of my invention, the liquid molten metal 27 is poured into the vessel 26 (the vessel therefore being made of heat-resisting material). While the metal is still molten, the winding 3 is energized, as above described. When the flux in the core 2 is building up, current may be generated in the molten metal. If desired, this current may be kept down to any desired low value by retarding the building up of the flux in the core 2, since, as is well known, the amount of current induced in the metal will be proportional to the rate of change of the flux. To accomplish slow building up of the flux, an induction unit 28 may be placed in the circuit of the winding 3, when the switch 17 is in its upper or closed position as shown in dotted lines in Fig. 3.

The circuit to the winding 3 is then broken by opening the switch 17 and thereupon the induction unit 28 is short circuited by a contact 29, a wire 30 and the upper switch arm; and if the switch is opened quickly the current will be quickly broken. Current is thereby generated in the metal 27 and a downward force is exerted on all the current conducting particles of the metal, pressing every such particle downward toward the bottom of the container and therefore squeezing out upwardly all gas bubbles that may be present, and causing all impurities, especially those which are not of electrical conduction material, to rise.

By utilizing the arrangement shown in Fig. 2, and timing the periodic closing and opening of the switch 17 to the rate of building up and dying out of flux in the core 2, a rapid succession of force impulses on the molten metal may be effected, causing the said impurities and gas bubbles to move rapidly toward the surface of the metal.

The metal may be allowed to cool in its purified condition or the purified metal in the lower part of the vessel may be drained off out of the bottom thereof, by means not shown but well known in the art.

In some cases it may be desired to maintain the molten metal 27 in molten condition for a period of time during which it is being purified as above described. In such cases, the arrangement illustrated diagrammatically in Fig. 4 may be employed. A cover 31 of refractory or heat-resisting material and of annular downwardly concave form is placed over the the annular vessel 26 and preferably fitted thereto. In the upper side or bottom of the cover 31, a plurality of spaced burners 32—32 are provided projecting into the cover and arranged to project a flame upon the molten metal. By this means, the upper portions of the metal through which the gas bubbles and impurities are moving will be kept fluid to facilitate the movements thereof through the metal until the process has been completed.

The burners 32—32 may be supplied with liquid or gaseous fuel by pipes 33—33 fed from a header 34 which is supplied from a source 35 by a conduit 36 and a valve 37 is provided to regulate the supply of the fuel to a rate at which the metal will be suitably heated. Lateral outlets 38—38 may be provided in the side wall of the cover 31 for the escape of gases of combustion.

As will now be apparent, from the foregoing description, the force impulses which are created in the electrically conducting annulus, may be utilized as static forces, as blows, or as reciprocations.

Also, as will be clear, the annulus in which the force is developed may be made from solid material or may be liquid or gaseous, it being only necessary that it be of electrically conducting material.

Furthermore, the magnitude of the mechanical impulses developed in the annulus may be varied as desired to suit any particular case by varying in a well known manner the strength of the magnetic flux in the core and the rate at which it is caused to die out when the current is broken and the electrical resistance of the annulus itself.

In the foregoing I have illustrated a number of practical uses for mechanical force impulses produced by the method and means embodying my invention. These are merely illustrative. My invention is applicable to numerous other uses and is not limited to the exact means shown but is inclusive of all applications of my invention and to the numerous modifications and changes which may be made and which are not illustrated nor described herein and which come within the scope of the appended claims.

I claim:

1. The method of purifying molten metal which includes disposing the metal in annular form in a supporting vessel, repeatedly building up a magnetic field within and embraced by the annular metal to develop current in the metal to effect a reaction on the field in the direction to exert an upward repulsion force on the metal and causing the field to abruptly cease to develop current in the annular metal to thereby effect a reaction on the field in the direction to cause downward force to be developed in the molten mass to force upwardly therefrom gases and

other impurities, and while said action is repeatedly going on, applying heat from an external source to the metal to maintain it in molten condition the rate of decrease of the field and the downward force on the metal effected thereby being greater than the rate of building up of the flux and the upward force on the metal respectively.

2. The method of treating electrically conducting liquid supported in a vessel in the form of a closed loop, which includes gradually building up an electro-magnetic field within the loop the magnetic field having a transverse plane of maximum density below at least the greater portion of the liquid, and the building up of the field occurring at a sufficiently low rate to cause the concurrent upward force exerted on the liquid to be negligible, then abruptly causing the field to decay at a sufficiently rapid rate to cause the current thereby produced in the liquid to react on the decaying field to exert a powerful impulse of force on the liquid in the downward direction.

3. In an apparatus for treating electrically conducting liquid, a liquid containing vessel of closed loop form, a magnetic circuit comprising a field element encircled by the loop, a winding to supply magnetic flux to the field element and having a transverse medial plane below at least the greater portion of the liquid, a source of electric current and a circuit for energizing the winding, and circuit controlling means to repeatedly effect building up of flux in the winding and then decay thereof and to cause the decay of the flux to occur at a much more rapid rate than the building up of the flux.

4. In an apparatus for treating electrically conducting liquid, a liquid containing vessel of closed loop form, a magnetic circuit comprising a field element encircled by the loop, a winding to supply magnetic flux to the field element and having a transverse medial plane below at least the greater portion of the liquid, a source of electric current and a circuit for energizing the winding, and circuit controlling means to repeatedly close the circuit for a period of time and then to break the circuit in a shorter period of time to repeatedly effect building up of the flux in the winding and then decay thereof at a much more rapid rate than the building up thereof.

LEV A. TROFIMOV.