CLEARANCE CONTROL

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Fig. 1.

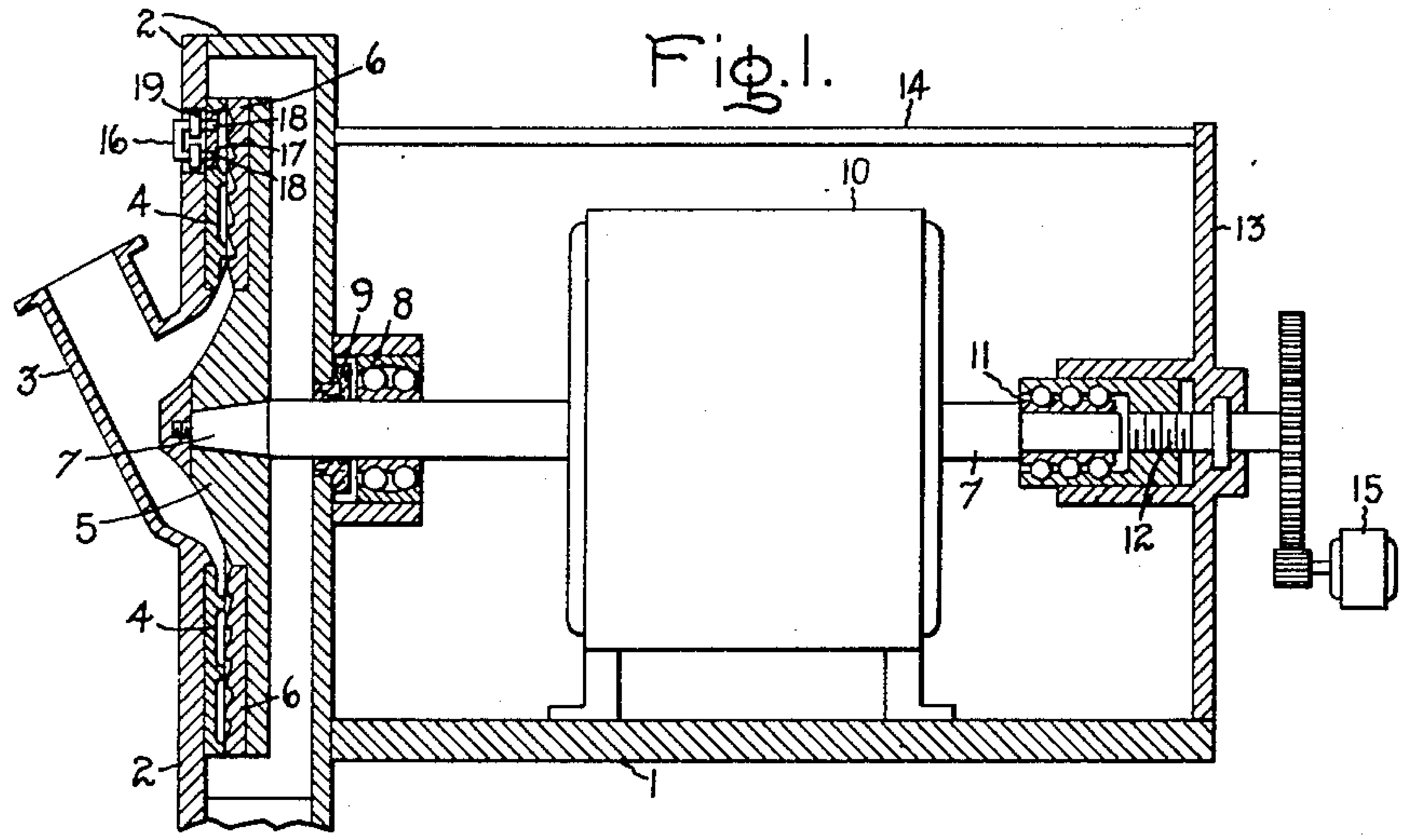

Fig. 2.

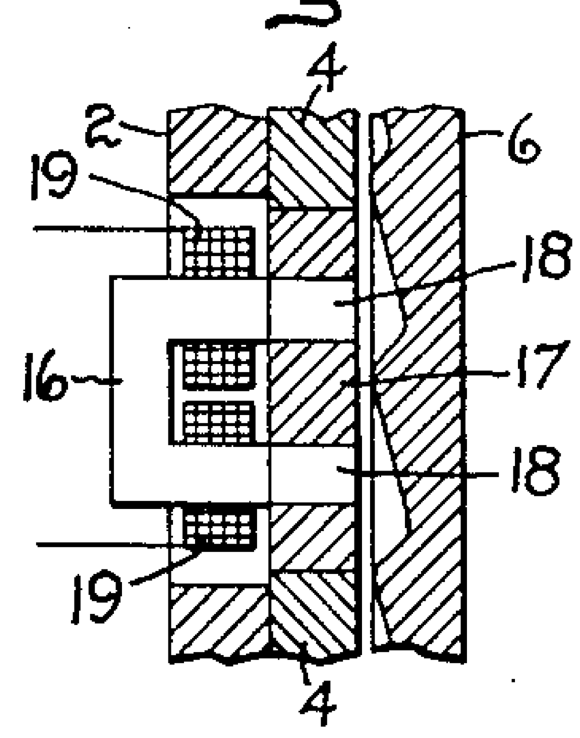

Fig. 3.

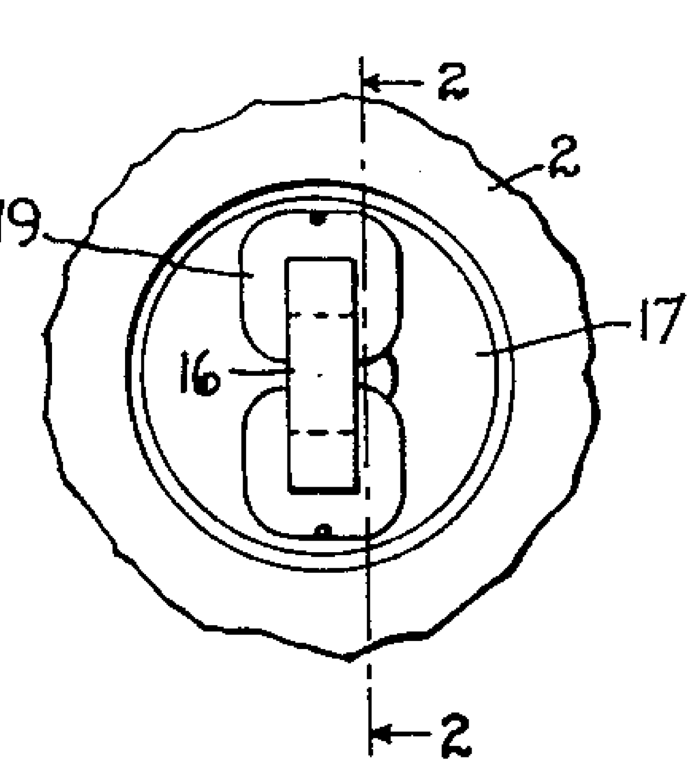

Fig. 4.

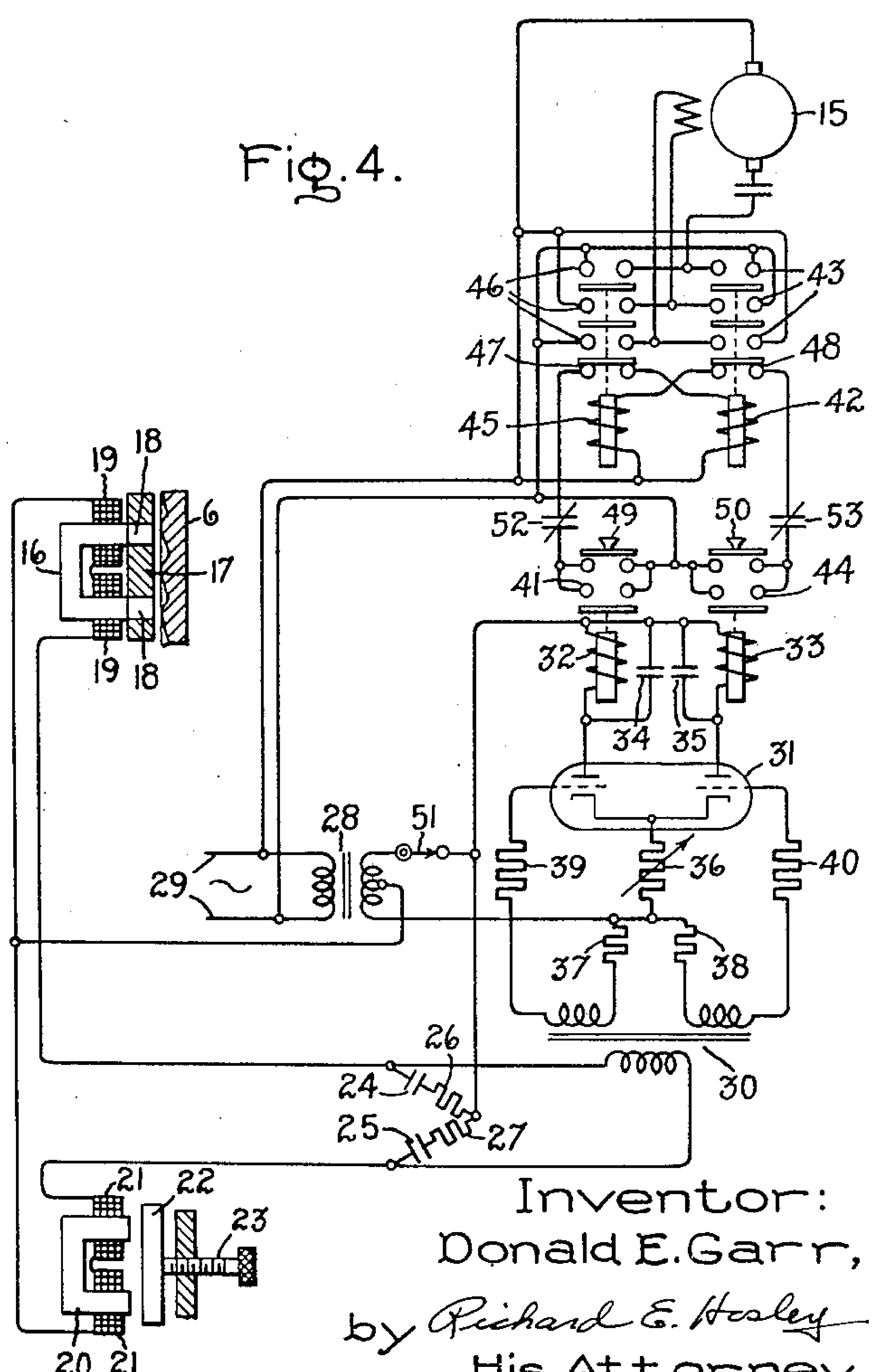

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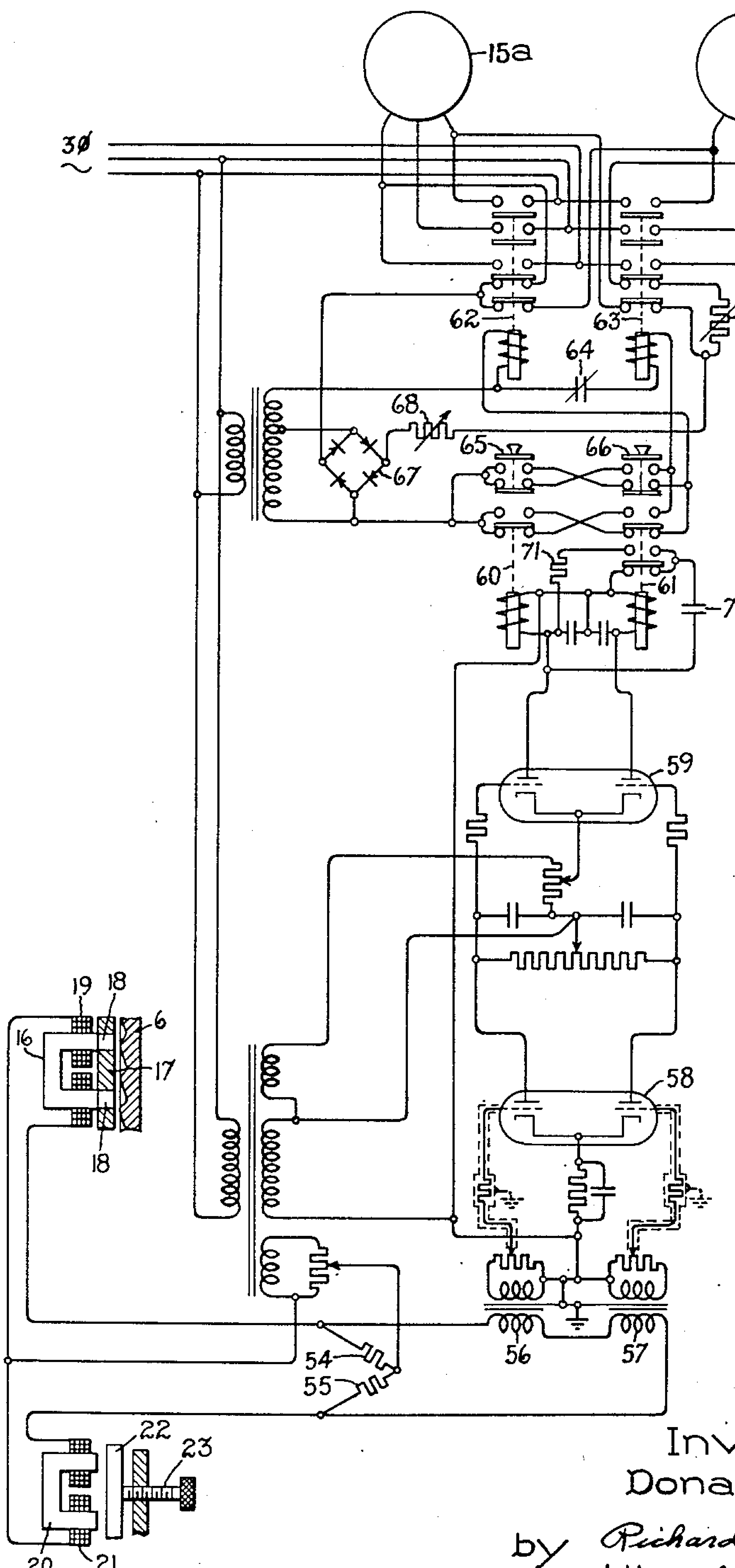
Fig. 5.



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UNITED STATES PATENT OFFICE

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CLEARANCE CONTROL

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Application November 2, 1948, Serial No. 57,925

1 Claim. (Cl. 241—37)

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This invention relates to a clearance control, and in particular to apparatus for controlling the clearance between two refining plates of a rotary disk pulp refiner.

The principal object of this invention is to provide an improved automatic clearance control of the type described. Other objects and advantages will appear as the description proceeds.

The features of the invention which are believed to be novel and patentable are pointed out in the claim forming a part of this specification. For a better understanding of the invention, reference is made in the following description to the accompanying drawings in which Fig. 1 is a schematic diagram, partly in cross section, showing attachment of the clearance control to a rotary disk pulp refiner; Fig. 2 is a cross sectional view drawn to a larger scale showing the relation between the refining disks and a reactor used in the control system; Fig. 3 is a view perpendicular to the plane of Fig. 2; Fig. 4 is a circuit diagram of one form of the control system; and Fig. 5 is a circuit diagram of another form of the control system. Where the same part appears in more than one figure of the drawing, it is always represented by the same reference numeral.

Refer now to Fig. 1, which shows the attachment of control system elements to a rotary disk pulp refiner. The pulp refiner includes a steel base **1**, feed end shell **2**, feed spout **3**, stationary refining plate **4**, runner head **5**, rotating refining plate **6**, shaft **7**, feed end bearing **8**, packing rings **9**, electric motor **10**, thrust bearing **11**, thrust bearing screw **12**, tail end pedestal **13**, and tension bar **14**.

Water and pulp to be refined are fed in through feed spout **3**. The pulp passes between refining plates **4** and **6**, and the refined pulp escapes at the bottom of feed end shell **2**. The fineness of the refined pulp is determined by the clearance between the refining plates **4** and **6**. This clearance is regulated by thrust bearing **11** under the control of thrust bearing screw **12**.

According to a prior art method of operating such refiners, the clearance is adjusted manually as follows: Without any material passing through the refiner, the operator adjusts the thrust bearing until a noise is heard, which indicates that the plates are touching. Micrometer dials, not shown, are then set, and the bearing is retracted a distance of a few thousandths of an inch which the operator feels to be correct for the particular pulp to be refined. After the adjustment is made, any change in motor temperature, or

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any change in refiner load, will cause the axial dimension of the shaft and other parts to change. Therefore, adjustments must continually be made, which if done manually necessitates considerable delay with a consequent reduction in refiner output, in addition to requiring frequent attention by a skilled operator. Refiners have also been used with other types of control: for example, some have the clearance adjusted by a function of load current of the main driving motor. However, such systems do not control the clearance with the desired degree of accuracy.

In one form of my improved apparatus to control the clearance between plates **4** and **6** automatically, a reversible motor **15** is connected through suitable gearing to turn thrust bearing screw **12**; and a first reactor having a U-shaped magnetic core **16** is attached adjacent to plate **4** as shown in Figs. 1, 2, and 3. Plates 4 and 6 are usually made of hard steel, which is a magnetic material. A hole is cut in plate **4** and filled with an insert **17** of relatively soft, non-magnetic and preferably non-conducting material such as wear-resistant plastics. In tests which have been conducted, it has been found that wear of such a soft insert proceeds at substantially the same rate as wear of the harder refining plates. U-shaped core **16** is positioned with its open end adjacent to insert **17**, as shown. Legs **18** of magnetic material, such as soft iron, extend from the ends of reactor core **16** through the insert, so that the magnetic flux path of the reactor includes core **16**, legs **18**, the space between refining plates, and a portion of plate **6**. The reluctance of this magnetic path is determined almost entirely by the clearance between plates **4** and **6**, since all other parts of the path are of magnetic material having relatively small values of reluctance. Windings **19** connected in series are provided about core **16** in the conventional manner.

Refer now to Fig. 4, which is a circuit diagram of the control system. A second reactor has a U-shaped core **20** and series-connected windings **21**. Preferably, the first and second reactors are substantially identical. A magnetic member **22** is adjustably spaced from the open end of core **20**. The magnetic path of the second reactor thus includes core **20**, member **22**, and the space therebetween; and its reluctance is almost entirely determined by the space. Thus it is evident that if clearance between plates **4** and **6** is equal to the space between core **20** and member **22**, both reactors will have magnetic paths of substantially the same reluctance, and accordingly the alternating current impedance of the two reactors will be substantially the same. In operation of the system, the space between core 20 and member 22 is adjusted to the desired clearance between refiner plates by a micrometer screw 23, which may be provided with a suitable calibrated dial, not shown.

The two reactors are connected in respective legs of an alternating-current bridge circuit. The other two legs of the bridge circuit comprise capacitors 24 and 25 and resistors 26 and 27. The bridge is energized by voltage from one-half the secondary of a transformer 28, the primary of which is supplied with alternating current from a suitable source through connections 29. Capacitors 24 and 25 resonate with the reactors, and thus accentuate any difference between the two air gaps. This gives the bridge circuit greater sensitivity. It is evident that other bridge circuits may be used to give equivalent results, and that other impedances may be substituted for the second reactor. However, the form shown is preferred because of its simplicity and convenience of operation.

A transformer 30 has a primary connected across the output of the A.-C. bridge, and a divided secondary connected in the grid circuit of a dual triode vacuum tube 31, as shown. Since the two grids are connected to the opposite sides of the transformer secondary, the grid voltages are in phase opposition. The plates of tube 31 receive alternating voltage from the secondary of transformer 28. Relays 32 and 33 are respectively connected in series with the vacuum tube plates. Capacitors 34 and 35 are connected in parallel with the two relays in a conventional manner to "smooth" the currents through the relays and thus improve their operation. Resistors 36, 37, 38, 39, and 40 perform conventional cathode bias and grid leak duties in the vacuum tube circuit.

Vacuum tube 31 and its associated circuit, together with relays 32 and 33, functions as a phase-sensitive relay which responds to unbalance of the alternating current bridge circuit. When the bridge circuit is balanced, cathode bias resistor 36 is adjusted so that each half of vacuum tube 31 conducts a value of current just below that required to operate relays 32 and 33. Thus both relays are de-energized at balance, but any increase in current through either half of tube 31 will energize the corresponding relay. Other forms of phase-sensitive relays are known in the art which may be substituted for the relay shown without departing from the principle of the invention.

When relay 32 is energized, it closes normally open contacts 41, thus energizing relay 42. This closes normally open contacts 43, which causes motor 15 to rotate to the right and turn the thrust bearing screw to increase the clearance between plates 4 and 6. When relay 33 is energized, normally open contacts 44 are closed. This energizes relay 45 which closes normally open contacts 46 and causes motor 15 to rotate to the left and reduce the clearance between plates 4 and 6. Normally closed contacts 47 and 48 prevent simultaneous energization of relays 42 and 45, which would short-circuit the alternating current supply.

In the operation of the system, when for any reason the clearance between plates 4 and 6 becomes less than the standard clearance established by reactor core 20 and member 22, the alternating current bridge circuit is unbalanced in such a direction that an alternating voltage is

applied to the left-hand grid of tube 31 which is in phase with the voltage applied to the plates. Thus the left-hand grid of tube 31 is driven positive at the same time that positive voltage is applied to the plates, and consequently the conduction of current through the left-hand side of tube 31 is increased. This energizes relay 32 and causes motor 15 to rotate to the right, as has been explained, which increases the clearance between plates 4 and 6 until the bridge circuit is returned to balance. The alternating voltage applied to the right-hand grid of tube 31 is in phase opposition to the voltage applied to the plates, so that the right-hand grid is driven negative when the plates are positive, and conduction through the right-hand side of the tube is reduced. Thus relay 33 remains unenergized. Conversely, if for any reason the clearance between plates 4 and 6 becomes greater than the standard, the voltage applied to the right-hand grid of tube 31 is in phase with the voltage applied to the plates, relay 33 is energized and motor 15 rotates to the left to decrease the clearance between plates 4 and 6 until the bridge circuit is returned to balance.

Push buttons 49 and 50 are provided as a means for manually operating motor 15 to increase or decrease the clearance between refiner plates independent of the operation of the automatic control system, when it is desired to do so. Switch 51 may be opened to shut off the automatic control without affecting the push button control. Normally closed limit switches 52 and 53 may be provided to prevent over-travel of the thrust bearing in either direction.

Refer now to Fig. 5, which is a circuit diagram of another form of the invention. In this modification two drive motors 15*a* and 15*b* are respectively connected through suitable gearing to the thrust bearing screw of the refiner. These two motors may be three-phase induction motors, as shown. Motor 15*a* turns the thrust bearing screw in a direction to close the gap between the refiner plates. This motor is connected to the thrust bearing screw through gears having a large speed-reduction ratio, so that the gap between the refiner plates is closed relatively slowly, which makes for more accurate positioning of the plates. Motor 15*b* is geared to retract the feed screw, and thus separate the refiner plates, at a very rapid speed. This prevents the refiner plates from coming together when the water supply and pulp feed is lost.

The two reactor assemblies in the apparatus of Fig. 5 may be identical with those in the apparatus of Fig. 4. The reactors plus resistors 54 and 55 comprise a bridge circuit across which an error voltage appears responsive to any deviation of the refiner plates from their pre-selected clearance. This error voltage is applied to the primaries of transformers 56 and 57, which are connected in such a way that voltages of opposite polarities are applied to the left-hand and right-hand control grids respectively of vacuum tube 58. Depending upon the direction of unbalance of the bridge circuit, the voltage applied to one of the control grids will be in phase with the plate voltage, while the voltage applied to the other control grid is in phase opposition to the plate voltage. The in-phase voltage is amplified and applied to the corresponding control grid of vacuum tube 59, where it is again in phase with the plate to cathode voltage, and causes its section of tube 59 to conduct heavily. The out-of-phase voltage is suppressed, and has a negligible effect upon the conduction of its side of vacuum tube 59. Tubes 58 and 59 with their associated circuits thus constitute a phase-sensitive relay.

Relays 60 and 61 are connected in respective plate circuits of the two sections of vacuum tube 59. These relays are normally de-energized and in the position shown in the drawing. When an error signal causes one section of vacuum tube 59 to conduct more heavily, the associated relay is energized. When relay 60 is in its energized position, connections are completed to energize relay 62, which operates motor 15*a* to decrease the gap between refiner plates. When relay 61 is energized connections are completed to energize relay 63, which operates motor 15*b* to retract the thrust bearing screw and increase the gap between refiner plates. A limit switch 64 is provided to prevent over-travel on retraction of the thrust bearing screw. Push buttons 65 and 66 are connected in the circuit to energize relays 62 and 63 respectively for manual operation of motors 15*a* and 15*b*.

When no motion is required, and consequently both relay 62 and relay 63 are de-energized, a small amount of direct current from rectifier 67 is passed through the motor windings, thereby causing a braking action which tends to halt any motion of the thrust bearing screw. This makes it practical to have a much more sensitive control without over-shoot or instability troubles. The amount of D.-C. fed to the motor windings is controlled by adjustable resistor 68. Adjustable resistor 69 is provided to control the ratio of direct currents fed to motors 15*a* and 15*b* respectively.

Capacitor 70 and resistor 71 provide a time delay which prevents immediate energization of relay 60 after operation of relay 61. This arrangement reduces hunting which might be caused by rapid alternate operation of the two relays.

Having described the principle of this invention and the best mode in which I have contemplated applying that principle, I wish it to be understood that the apparatus described is illustrative only, and that other means can be employed without departing from the true scope of the invention defined by the following claim.

What I claim as new and desire to secure by Letters Patent of the United States is:

Apparatus for controlling the clearance between two refining plates of a rotary disk pulp refiner having a thrust bearing screw for adjusting such clearance, comprising a non-magnetic insert extending through one of the refining plates, an alternating-current bridge circuit including first and second reactors each having U-shaped cores, the first reactor core being positioned with its open end adjacent to said insert on the side opposite the other refiner plate, magnetic legs extending from the ends of the first reactor core through said insert, a magnetic member adjustably spaced from the open end of the second reactor core, a phase-sensitive relay connected to respond to unbalance of the bridge circuit, and a motor controlled by said relay and connected to turn the thrust bearing screw.

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