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RECTIFIER REGULATING SYSTEM

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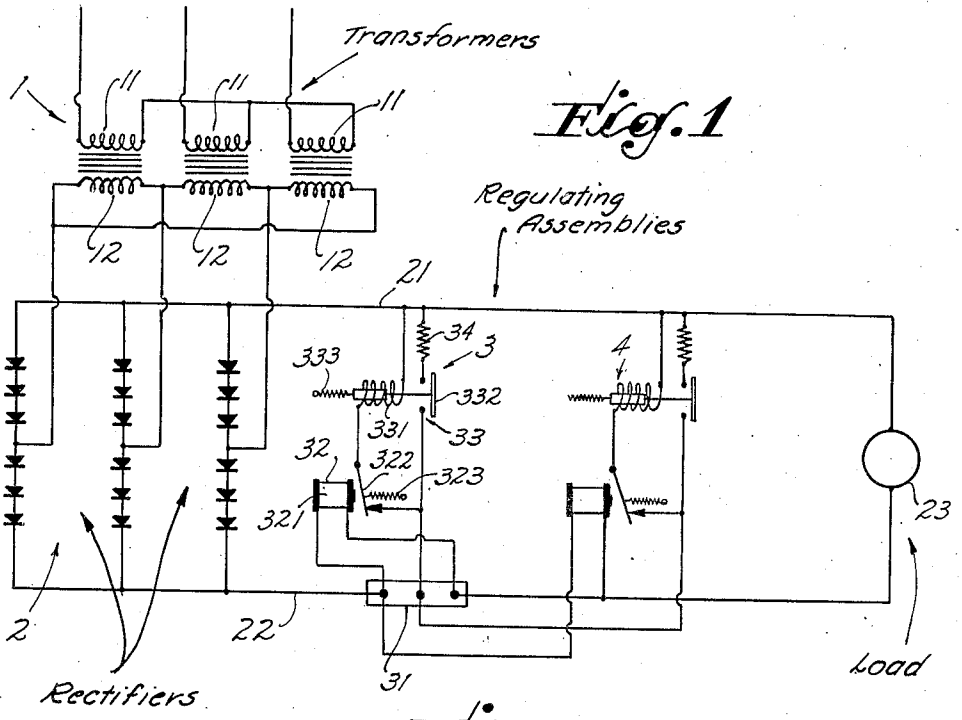
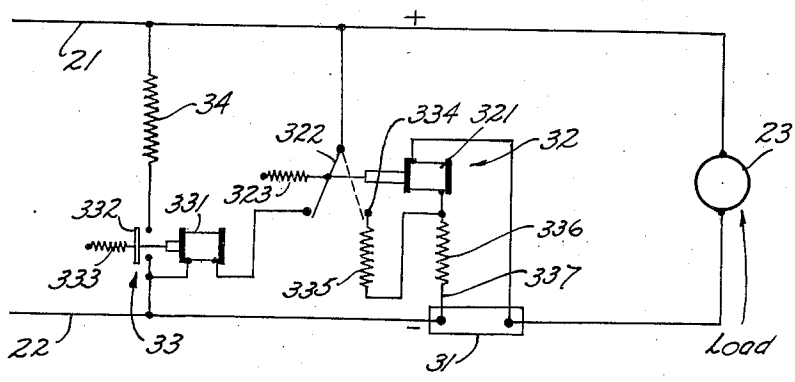



Fig. 1

Fig. 2




INVENTOR:
SOREN L. CHRISTIE
BY HARRIS, KIECH, FOSTER & HARRIS,

FOR THE FIRM
ATTORNEYS

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## RECTIFIER REGULATING SYSTEM

Soren L. Christie, Los Angeles, Calif.

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3 Claims. (Cl. 171—229)

1

My invention relates to rectifiers, that is, devices by which a supply of direct current may be obtained from an alternating source of electrical supply. A common form of such rectifiers is the metallic disc type, and my invention is especially adapted for use with rectifiers of this type. If such rectifiers are operated on a source of alternating current of uniform voltage, such as is commonly available, the voltage of the direct current supplied therefrom may vary as much as 30%, that is, the voltage at full load on the rectifier may be only 70% of the no-load voltage.

This large variation in direct current voltage is objectionable when the rectifiers are used to supply electric current for some purposes, and it is an object of my invention to reduce the variation in potential between full load and no load on the direct current supply lines leading from the rectifier, or to improve the voltage regulation of the system.

Fig. 1 of the drawing shows a circuit diagram of an installation embodying my invention; and

Fig. 2 shows an alternative relay circuit.

The apparatus which I use to accomplish the purpose of my invention may be readily supplied by a man skilled in the art with the information supplied by the accompanying specification and the drawing, which shows simple diagrams of connections. In the drawing 1 designates transformers, 2 rectifier columns, and 3 and 4 regulating assemblies. Three transformers may be used, each having a primary 11 connected to an alternating current supply source. The transformers are shown Y-connected to a three-phase source. The secondary 12 of each transformer is connected, as shown in Fig. 1, to the center of one of the rectifiers 2. One end of each of the rectifiers 2, which are preferably of the metallic disc type, is connected to one wire 21 of a direct-current load line, the other side being connected to the other wire 22 of that line. Various loads 23 may be connected across these lines, as shown.

I have found that, using metallic disc rectifiers of the form now in common use, the voltage between the wires 21 and 22, with the load 23 drawing 100% of the full load rated capacity of the rectifiers, may be only 70% of the voltage at no load. The load 23 may be variable, and it is highly desirable that the voltage between the wires or direct current busses 21 and 22 be kept more uniform.

I render this voltage more uniform or constant in potential by one or more regulating assemblies, each of such assemblies consisting of a shunt 31

2

through which the current flowing in the load 23 passes. Connected to the ends of the shunt 31 is the coil of a pilot relay 32. The voltage impressed on this coil is the potential drop in the shunt 31 caused by the currents flowing through it. The coil 321 of the relay 32 attracts a pivoted armature 322, but this armature is held in its closed position, as shown in the drawing, by a tension spring 323. In this closed position the armature 322 closes the circuit through the coil 331 of a contactor 33. The coil 331 attracts an armature 332, which is held away from the coil 331 by a spring 333. As long as the current flows in the coil 331, the armature 332 holds contacts closed through which current flows through a ballast resistor 34. This ballast resistor 34 is in parallel with the load 23 and is, in effect, an artificial load.

The voltage drop in the rectifiers 2 is not a direct straight line function of the current flowing therethrough, but about 50% of the total variation of 30% voltage drop between full load and no load occurs in the first one-third of the increase in load. If we consider no load voltage as 100%, the voltage at one-third load will have dropped to 85%. Using only one regulating assembly, I therefore may make the ballasting resistance take one-third full load current so that initially with no load 23 I still have an artificial load equal to one-third full load, this artificial load or ballast being imposed by the ballasting resistor 34. The voltage between the wires 21 and 22 cannot rise above 85% of no load voltage as long as the ballast resistor 34 is in circuit.

The pilot relay is, however, so adjusted that whenever the current taken by the load 23 is more than two-thirds full load current, the relay 32 actuates the contactor 33 and cuts the resistor 34 out of circuit. In other words, the pilot relay acts to cut the resistor 34 out of circuit whenever two-thirds load is taken by the load 23. Before the relay 32 so operates, the voltage between the wires 21 and 22 will have fallen to full load voltage, or 70% of no load voltage. Using a regulating assembly, the voltage can never exceed 85% of no load voltage and will fall to 70%. With no regulating assembly, the voltage may fluctuate from 100% to 70%.

If two regulating assemblies are used, each ballast resistance takes about one-third full load current, or a total of two-thirds full load current. The voltage between the wires 21 and 22 may then be about 78% of no load voltage. As the load 23 draws more current up to one-third load, the voltage decreases to, say, 70%. The pilot relay of the regulating assembly 3 then op-

erates, and the resistor **34** is cut out, and the voltage again rises to 78%. As the load **23** increases to two-thirds full load, the voltage drops to 70%, the pilot relay of the assembly **4** cuts out the ballast resistance, and the voltage again rises to 78%, falling gradually to 70% as the load imposed by the load **23** increases to full load. Using two assemblies, the voltage then fluctuates from 70% to 78% of no load voltage; that is, when no load **23** is imposed, the voltage is 78% of no load voltage without the regulating assemblies, and it never falls below 70% of this value. It is to be noted in Fig. 1 that the current feeding the resistor **34** passes through part of the shunt **31**, which also carries the current to the load **23**, and that the relay **32** is so adjusted that after it opens and the ballast resistor **34** is disconnected, the relay will not close if the load current persists at its previous value. This current will increase slightly due to the rise in voltage due to the disconnection of the ballast resistor **34**, and the relay can be, and should be, so set that it will again close if the load current falls substantially below the value it had at the time the relay opened. Practically all commercial relays will remain closed on a considerably lower current in their coil than is needed to cause them to close. It is, however, easy to make a relay which will close with 100 millivolts at the terminal of its coils and will open when this value falls to 45 millivolts. Assuming that, using a single regulator **4**, the relay **32** opens when the load is one-third of maximum rated load and that the voltage across the shunt is 100 millivolts with the resistor connected, when the resistor is disconnected, the potential across the shunt will be slightly more than 50 millivolts. If, now, the load decreases a little more than 10%, the potential across the shunt will be about 45 millivolts, and the relay **32** will then close. This provides a very sensitive control using a conventional and easily obtained pilot relay.

An even more sensitive relay circuit is shown in Fig. 2. In this arrangement I supply the relay **32** with a contact **334** which is connected to a primary resistor **335** and a secondary resistor **336**, one terminal of the coil **321** being connected between the resistors **335** and **336**, as shown in the drawing, and one terminal **337** of the resistor **336** being connected to the shunt **31**, as shown. When the armature **322** is pulled out of its closed or primary position shown in full lines in the drawing into its open or secondary position, as shown in dotted lines, it completes a circuit from the wire **21** to the wire **22** through the resistors **335** and **336**. Prior to this, the circuit through the resistor **335** is open, but the coil **321** is at all times energized by current flowing through the resistor **336**. With no current flowing in the resistor **335**, the voltage drop across the resistor **336** is merely that produced by the current flowing to the coil **321**. Nearly every relay of the type I prefer to use as the relay **32** will hold in its secondary position on less current than it will need to pull into that position, so that with the armature **322** in the position shown in dotted lines in the drawing, or in its secondary position, this armature will not be pulled back to its primary position shown in full lines until the current falls considerably below that needed to pull the armature from its full line or primary position to its dotted line or secondary position. When, however, the circuit is established through the resistors **335** and **336**, the current in the resistor **336** is increased, being the sum of the currents in the resistor **335** and the coil **321**. This results in a voltage drop in the resistor **336** greater than existed when only the coil **321** was in circuit. The voltage across the shunt **31** being unchanged, this reduces the voltage on the terminals of the coil **321** and reduces the current flowing through the coil **321**. The resistor **335** is so proportioned that with the voltage across the shunt **31** just sufficient to cause the coil **321** to pull the armature **322** from its full line or primary position to its dotted line or secondary position, the voltage across the coil **321**, after the circuit is established through the resistors **335** and **336**, is only very slightly more than that necessary to cause enough current to flow in the coil **321** to hold the armature **322** in its dotted line or secondary position. A slight decrease in the current taken by the load **23** will cause a slight decrease in the voltage across the shunt **31**, and the current in the coil **321** will decrease to a sufficient degree to allow the spring **323** to pull the armature **322** back into its full line or primary position, which will cut the ballast resistor **34** back into circuit.

One important feature common to both the alternatives illustrated is the method of accomplishing the immediate change in relay coil voltage upon operation of the relay. Usually such a change is accomplished by a switching arrangement within the relay coil circuit, changing the resistance of that circuit. Because in a low voltage circuit any switch contact resistance may greatly affect the current flow, such a method will sometimes result in erratic and unreliable operation. In my system, the resistance in the low voltage relay coil circuit remains substantially constant, and no switching is performed in series or parallel with this low voltage circuit.

To accomplish the desired immediate change in relay coil voltage, I utilize a potential external to the relay coil circuit and in the order of 100 times its magnitude. This follows from the fact that, while the potential operating the relay is derived from a shunt connected in series with the load, the circuit which causes the immediate change in relay coil voltage is connected in parallel with the load.

In other words, by employing the methods shown I utilize an external potential source of a magnitude of at least ten times the potential which feeds the relay coil circuit, which causes, upon operation of the relay, an immediate change in the relay magnetic flux. Due to the relatively high voltage, the effect of variations in contact resistance in the circuit is practically eliminated.

Furthermore, by arranging the external potential to cause a flux subtractive to the flux caused by the shunt potential, a small percentage increment in the shunt potential will cause a larger percentage increment in the resultant coil potential. This is seen from the fact that the external potential can be considered as substantially constant for small variations of the shunt potential.

I claim as my invention:

1. In an electrical system, the combination of: two supply conductors; a load connected directly to the first of said supply conductors; a shunt through which current passes to said load from the second of said supply conductors; a relay having an actuating coil connected at its first end to one terminal of said shunt; a secondary resistor connected at one end to the other terminal of said shunt and at its other end to the second end of said actuating coil; a primary re-

sistor connected at one end to the junction of said secondary resistor and said coil and connected at its other end to a secondary contact of said relay; a primary contact; means by which said relay connects said first conductor to said primary contact whenever the coil in said relay is actuated by a current below a predetermined value and connects said first conductor to said secondary contact whenever said current exceeds this value; a ballast resistor connected at one end to said first conductor; and means for connecting the other end of said ballast resistor to said second conductor whenever said first conductor is connected by said relay to said primary contact.

2. In an electrical system, the combination of: a first and a second supply conductor; a load connected at one end directly to said first conductor; a shunt, one terminal of which is connected to said second conductor and the other terminal of which is connected to the other end of said load; a relay coil, one end of which is connected to one terminal of said shunt and the other end of which is connected to the other terminal of said shunt; a ballast resistor, one end of which is connected to said first conductor; a pair of ballast contacts, one of which is connected to the other end of said ballast resistor and the other of which is connected to an intermediate point in said shunt; and means for closing the circuit between said ballast contacts whenever the current in said coil exceeds a predetermined value, and opening said circuit when the current in said coil falls below a predetermined value.



3. In an electrical system, the combination of: two supply conductors; a load connected to the first of said supply conductors; a shunt through which current passes to said load from the second of said supply conductors; a relay having an actuating coil connected at its first end to one terminal of said shunt; a secondary resistor connected at one end to the other terminal of said shunt and at its other end to the second end of said actuating coil; a primary resistor; means by which said relay causes current to flow from said first conductor through said primary and said secondary resistors to said second conductor whenever the current in said shunt rises above a predetermined value, and causes a reduction in said current through said primary and said secondary resistors whenever the current in said shunt falls below said predetermined value; a ballast resistor connected at one end to one of said conductors; and means actuated by said relay for connecting the other end of said ballast resistor to the other conductor whenever the current through said shunt falls below said predetermined value, and for reducing said current through said ballast resistor when said current through said shunt exceeds said value.

SOREN L. CHRISTIE.