

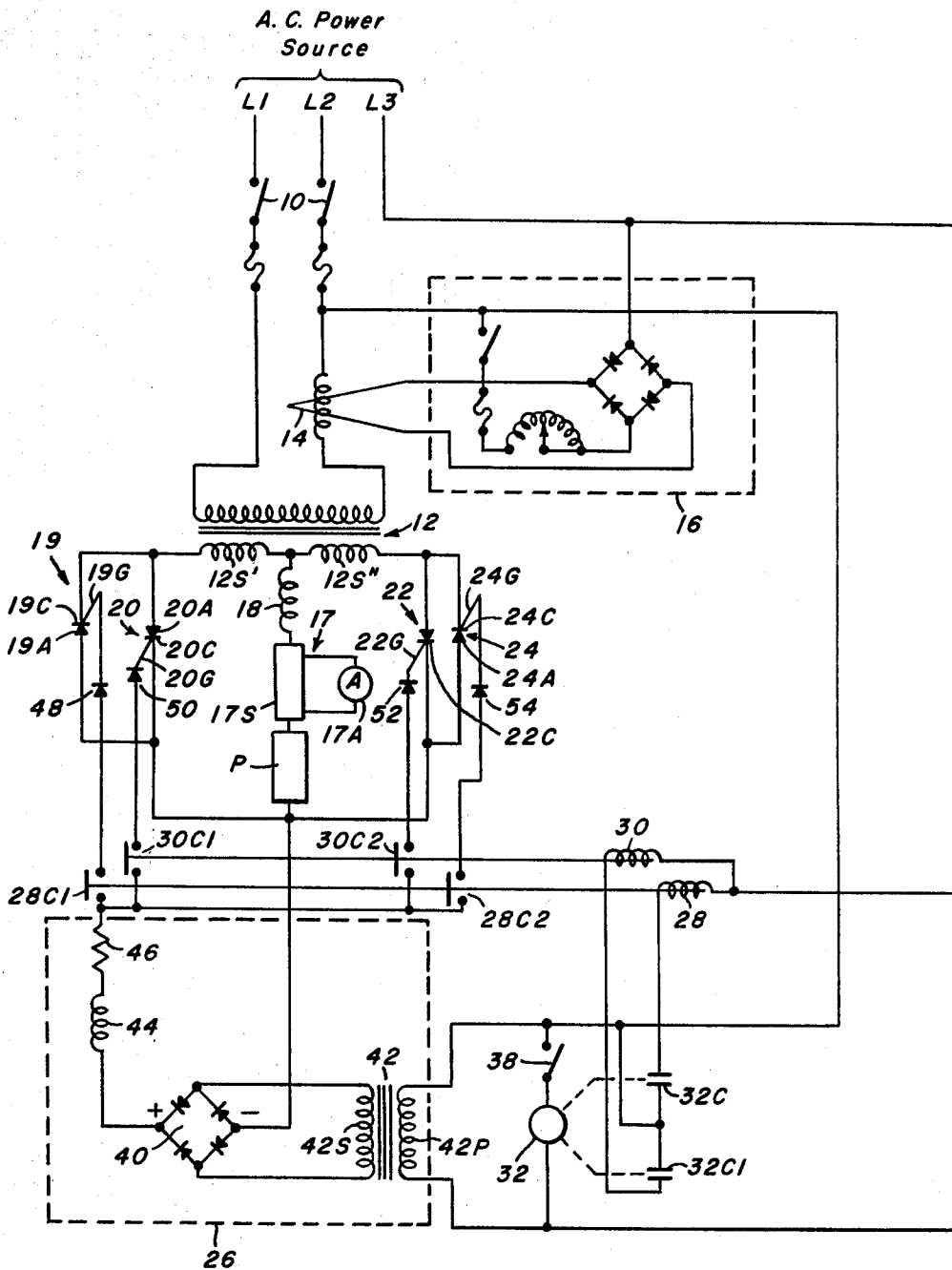
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SYSTEM FOR PERIODICALLY REVERSING LARGE DIRECT CURRENTS

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SYSTEM FOR PERIODICALLY REVERSING LARGE DIRECT CURRENTS

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ABSTRACT OF THE DISCLOSURE

Apparatus for periodic reverse plating and anodic-cathodic pickling of metal sheets or the like includes an A.C.-D.C. power supply circuit composed of a bridge of silicon controlled rectifiers center tapped to a transformer through the plating and pickling equipment, the gate circuits of the rectifiers are selectively energized in pairs so as to provide the plating and pickling equipment full wave rectified D.C. which is reversible upon alternate energizing of the silicon controlled rectifier gate circuits.

This invention relates to the reversing of direct current in a load, specifically, apparatus for the periodic reverse plating an anodic-cathodic pickling of metal sheets, i.e. steel. Present methods of reverse plating and anodic-cathodic pickling use large reversing contactors to change the direction of the large current flowing from a D.C. source. Such contactors are subjected to severe duty and thus have a limited service life under the heavy service loads imposed. The maintenance cost of these mechanical contactors is high and the noise generated by their frequent operation is undesirable.

Our invention relates to the reversing of a large direct current in a load, here specifically in apparatus for the periodic reverse plating and anodic-cathodic pickling of metal (sheets/strip). Present apparatus for reverse plating and anodic-cathodic pickling utilizes an outside D.C. source (purchased power) and large reversing contactors (relays) to change the direction of the large currents involved. Such contactors are subjected to severe duty and thus have a limited service life under these severe heavy service loads. Further, the maintenance and replacement costs of these mechanical contactors is high. The apparatus in requiring rapid, frequent reversal of these contactors contributes to a significant increase in the ambient noise level of the work area around the contactors as there is a significant report when these actuate. It is also recognized that there is significant strain upon the electrical components of any circuit for carrying large currents when these currents are interrupted.

It is therefore an object of our invention to provide a reliable current reversing device for heavy duty operation.

A further object of our invention is to provide a current reversing device producing no audible sounds during operation.

A still further object of our invention is to provide an inexpensive, reliable source of direct current.

Another object of our invention is to provide a current reversing device which will reverse only when a minimum value of load current is flowing.

These and other objects will be more apparent after referring to the following specification and attached drawing, in which:

The single figure is a schematic diagram of the apparatus of our invention.

Referring more particularly to the drawing, reference

characters L1, L2 and L3 indicate an A.C. power source. Primary A.C. power is supplied through line switch 10 to the primary winding of main transformer 12. A saturable core reactor 14 in the previously described circuit employs a separate power supply 16. The elements so far described are conventional.

Connected between secondaries 12S' and 12S'' of the center tapped secondary winding of the transformer 12 are pickling tank P, a current measuring device 17, including a shunt 17S and ammeter 17A and a current smoothing coil 18. In the loop of secondary 12S' are silicon controlled rectifiers 19 and 20, having anodes A, cathodes C and gates G. The rectifiers 19 and 20 are connected in parallel, anode to cathode, with each other and in series with secondary 12S' and pickling tank P. In series with secondary 12S'' and pickling tank P are silicon controlled rectifiers 22 and 24, having anodes A, cathodes C and gates G, connected in parallel with each other, anode to cathode.

Gate power supply 26 is connected to the gates of rectifiers 19, 20, 22 and 24 through relay contacts 28C1, 28C2, 30C1, and 30C2 which are sequenced by control coils 28 and 30. The coils 28 and 30 are connected in parallel to power lines L2, L3. An automatic repeat cycle timer 32 alternately closes its contacts 32C and 32C1 while opening the other contact. The contacts are connected in parallel with each other and in series with relay coils 28 and 30, respectively. Thus, coils 28 and 30 are alternately actuated. An actuating switch 38 is connected in series with the timer 36 to power lines L3, L2.

The gate power supply 26 includes a bridge of rectifiers 40 connected across the secondary 42S of a step down transformer 42 having its primary 42P connected to A.C. power lines L2 and L3. The bridge 40 is connected in series with the gate circuit relay contacts 28C1, 28C2, 30C1 and 30C2 through current smoothing coil 44 and current limiting resistor 46.

Blocking diodes 48, 50, 52 and 54 are connected in the gate circuits of silicon controlled rectifiers 19, 20, 22 and 24 between the silicon controlled rectifiers and contacts 28C1, 30C1, 30C2 and 28C2.

Switches 10 and 38 are closed to initiate operation. Closing of main power switch 10 induces an A.C. voltage in secondaries 12S' and 12S'', and in secondary 42S. The 2.5 volt A.C. voltage induced in secondary 42S is rectified to a full wave D.C. voltage in bridge 40. The coil 44 and resistor 46 serve to smooth out the ripple in the D.C. voltage providing a reliable signal to the controlling contacts 28C1, 28C2, 30C1 and 30C2.

Depending upon which of the silicon controlled rectifiers 19, 20, 22 or 24 have the necessary voltage applied to their gates 19G, 20G, 22G and 24G, a direct current will flow in pickling tank P, current measuring device 17 and coil 18, according to the direction of flow permitted by the conducting rectifiers. In this embodiment, rectifiers 19 and 24 work as a pair, and rectifiers 20 and 22 work as a pair.

Closing of switch 38 starts timer 32 in operation which, for example, closes its contact 32C so as to energize relay 28 closing normally open contacts 28C1 and 28C2. This permits a signal voltage to be applied from power supply 26 to the gates of rectifiers 19 and 24. This gate signal induces conduction in alternate half cycles of the active rectifiers according to their orientation, thus passing a direct current through the pickling tank P. The timer 32 then opens contact 32C to deenergize relay 28 and open contacts 28C1 and 28C2. This removes the signal voltage from the gates of rectifiers 19 and 24, but they continue to conduct until the induced current in secondaries 12S' and 12S'' reaches the minimum hold-

ing value for the rectifiers 19 and 24, at which time they assume their non-conductive characteristic. The timer 32 then closes its contact 32C1 to energize relay 30 and close its normally open contacts 30C1 and 30C2 to apply a voltage to the gates of rectifiers 20 and 22 and permit conduction in alternate half cycles resulting in a direct current through the pickling tank P opposite in direction to that when relay 28 was energized. In its cycling function timer 32 must control contacts 32C and 32C1 such that relay 30 is not activated until rectifiers 19 and 24 have assumed their non-conductive characteristics, and relay 28 is not activated until rectifiers 20 and 22 have assumed non-conductive characteristics.

Blocking diodes 48, 50, 52 and 54 are placed in the gate circuits of silicon controlled rectifiers 19, 20, 22 and 24 as precautionary devices. Due to the heavy load currents involved and the relatively low trigger voltage for the silicon controlled rectifiers, inductive feedback sufficient to trigger a silicon controlled rectifier is possible. Further, additional circuit protection is desired to isolate the gates from accidental trigger voltages in event of failure or malfunction of the sequencing contacts 28C1, 30C1, 30C2 and 28C2.

Through the selective application of small trigger voltages to the gates of special bridges of silicon controlled rectifiers, the rapid, silent switching of a heavy D.C. current is accomplished. Further, the combination of the silicon controlled rectifier with the center tapped transformer and standard industrial A.C. source eliminates the need of a separate, expensive D.C. power source.

We claim:

1. Apparatus for periodically reversing the direction of full wave rectified direct current to a load comprising an alternating current source; a transformer having a primary connected to the alternating current source and a center tapped secondary; two pairs of silicon controlled rectifiers, each of the rectifiers having an anode, a cathode, and a gate; means connecting the rectifiers of the first pair in parallel relation, anode to cathode; means connecting the rectifiers of the second pair in parallel relation, anode to cathode; means connecting the first pair of rectifiers in series with the load and one half the secondary of the transformer through the center tap; means connecting the second pair of rectifiers in series with the load and the second half of the secondary of the transformer through the center tap, whereby the first pair of rectifiers and the first half of the secondary are in parallel with the second pair of rectifiers and the second half of the transformer and in series with the load; means generating a voltage of predetermined character; and means selectively and alternately applying said generated voltage to the gates of like direction rectifiers of opposite pairs to trigger them into conduction whereby a direct current will flow in the load in one direction and then alternately in the other direction.

2. Apparatus according to claim 1 wherein the load comprises pickling tanks for the reverse plating and anodic-cathodic pickling of metal sheets.

3. Apparatus according to claim 2 including a current measuring device connected in series with the load.

4. Apparatus according to claim 3 including a current smoothing coil in series with the load to smooth out ripple.

5. Apparatus according to claim 4 in which said means for alternately applying voltage to the gates includes an automatic repeat cycle timer having two contacts which alternately close, two relay coils connected in parallel with each other and each connected in series with one of said timer contacts, and a normally open contact in the connection between said voltage generating means and each of said rectifiers, the contacts in the connections to one pair of like direction rectifiers being operable by one relay coil and the contacts in the connections to the other pair of like direction rectifiers being operable by the other relay coil.

6. Apparatus according to claim 1 wherein the means for generating the bias voltage of predetermined character includes a rectifier bridge circuit generating a D.C. voltage, and means connecting said last named rectifier to said alternating current source.

7. Apparatus according to claim 6 characterized by a current measuring device connected in series with the load.

8. Apparatus according to claim 7 characterized by a current smoothing device in series with the load to smooth out ripple.

9. Apparatus according to claim 8 in which said means for alternately applying voltage to the gates includes an automatic repeat cycle timer having two contacts which alternately close, two relay coils connected in parallel with each other and each connected in series with one of said timer contacts, and a normally open contact in the connection between said voltage generating means and each of said rectifiers, the contacts in the connections to one pair of like direction rectifiers being operable by one relay coil and the contacts in the connections to the other pair of like direction rectifiers being operable by the other relay coil.

10. Apparatus according to claim 9 including diodes having a cathode and anode in series with the gate circuits oriented with the cathode adjacent the gate whereby trigger voltages will be passed through to the gates but reverse induced voltages will be blocked.

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