

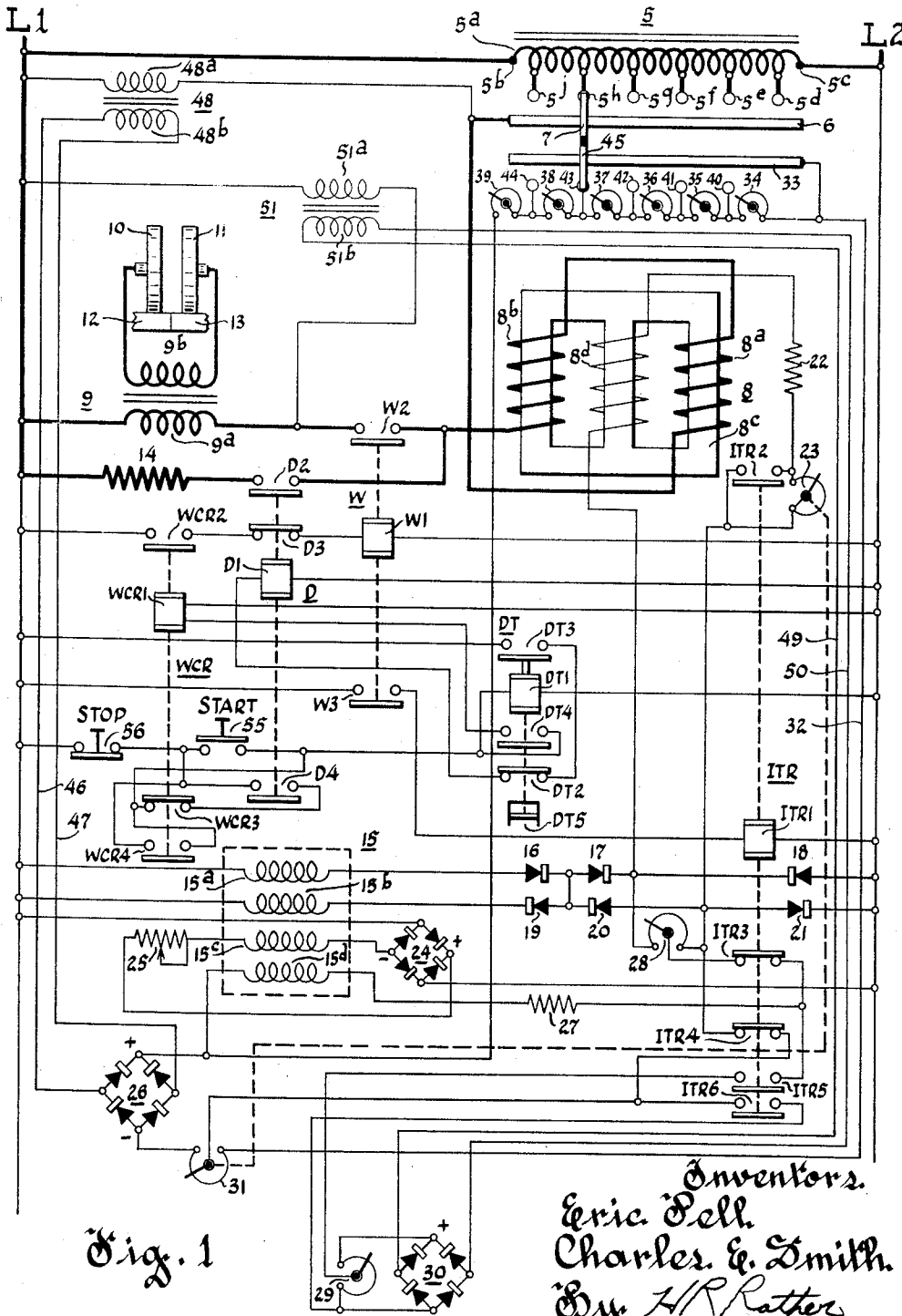
May 5, 1959

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SATURABLE REACTOR FOR REGULATION

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Filed Feb. 6, 1956

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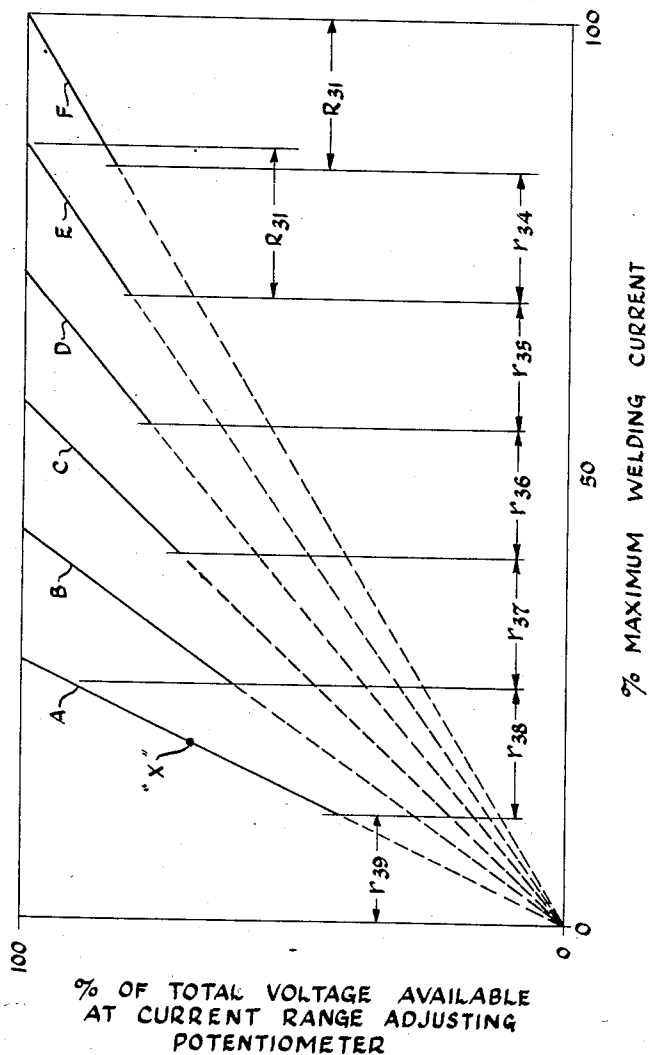
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Fig. 2



Inventors
Eric Pell
Charles E. Smith
By A/R Ratter
Attorney

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ALTERNATING CURRENT CONTROL SYSTEM UTILIZING SATURABLE REACTOR FOR REGULATION

Eric Pell, Wauwatosa, and Charles E. Smith, Milwaukee, Wis., assignors to Cutler-Hammer, Inc., Milwaukee, Wis., a corporation of Delaware

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19 Claims. (Cl. 323-66)

This invention pertains to an improved alternating current control system utilizing saturable reactors for regulation.

More particularly the invention pertains to a type of control system disclosed and claimed in the Ball and Pell Patent No. 2,697,200, granted December 14, 1954, and is an improvement.

It is a primary object of the invention to provide an alternating current control system of the aforementioned type which is characterized by effecting closer control of alternating current supplied to a load device through use of automatic regulating means.

Another object of the invention is to reduce the drift of weld voltage due to line voltage changes.

A further object is to improve linearity between desired values of alternating current output and settings of a current selecting device.

A still further object is to provide regulation of control current for the saturable reactor, while the system is idle, to a value which will result in minimization of transient current peaks when the current control system is connected to the load, and

A more specific object is to provide an improved resistance welder incorporating the aforementioned improved alternating current control system.

Other objects and advantages of the invention will hereinafter appear.

The accompanying drawings illustrate a preferred embodiment of the invention which will now be described in detail, it being understood that the invention is susceptible of modifications in respect of details without departing from the scope of the appended claims.

In the drawings:

Figure 1 is a diagrammatic showing of the improved alternating current control system constructed in accordance with the invention as applied to a resistance seam welder, and

Fig. 2 is a graph depicting certain operating characteristics obtainable with the system in Fig. 1.

The present system, as compared with the system of the aforementioned Ball and Pell patent, utilizes a self-saturating type of magnetic amplifier to regulate the energization of the saturating control winding of the saturable reactor. During working operation of the improved system a signal control winding of the amplifier is subjected to a unidirectional voltage proportional to the difference between a preselected position of the alternating voltage of the load supplying tap of an autotransformer and an opposing voltage proportional, at any instant to a preselected portion of the load current. The preselected portion of the load voltage determines the regulated maximum value of the load voltage for any preselected autotransformer tap voltage. The latter voltage portions are selectable by a current adjusting potentiometer. The regulated value of load current for the minimum position of the current adjusting potentiometer is adjustable for each voltage tap of the autotransformer by means of rheostats included in series

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circuit with the current adjusting potentiometer as the autotransformer tap changer is moved from a lower to a higher voltage tap and successively excluded as the tap changer is moved from higher to lower voltage taps.

5 This enables preselection of the overlap between the maximum and minimum position of the current adjusting potentiometer on the various voltage taps of the autotransformer. Assuming a given alternating voltage tap selection, and a given setting of the current range adjusting potentiometer, the amplifier output varies with change in load current to correspondingly regulate the energization of the saturating control winding of the saturable reactor so that the load current is maintained at substantially the desired value at all times.

15 When the saturable reactor is disconnected from the load, the control winding of the magnetic amplifier is reconnected to a source of "self-feed-back" voltage derived from the rectified output of the amplifier. Such reconnection, together with modification in connections and resistance in circuit with the saturating control winding of the saturable reactor, affords an "idle" excitation of the latter control winding which minimizes transient current peaks immediately following connection of the A.C. windings of the saturable reactor to the load circuit.

25 Referring to Fig. 1, it discloses a preferred embodiment of the improved alternating current control system as applied to the control of welding current in a resistance seam welder. More particularly, a source of alternating current is afforded by supply lines L1 and L2. 30 A tapped winding 5a of an autotransformer 5 has its left-hand end terminal 5b connected to line L1 and its right-hand end terminal 5c connected to line L2. Winding 5a is provided with intermediate voltage tap contacts 5d, 5e, 5f, 5g, 5h and 5i. Associated with the voltage tap contacts is a tap changer comprising a stationary contact member 6 and a slidable contactor 7.

35 Contact member 6 is electrically connected to one end of A.C. winding 8a of a saturable reactor 8 which is illustrated as wound on an outer leg of a three-legged core 8c of such reactor. The other end of winding 8a is connected to one end of a second A.C. winding 8b which is wound on the other outer leg of core 8c. The other end of winding 8b is connected to the right-hand contacts W2 and D2 of electro-responsive switches W and D, respectively. The left-hand contact of contacts W2 is connected in series with the primary winding 9a of a welding transformer 9 to line L1. Transformer 9 is provided with a secondary winding 9b which is connected to the welding electrodes 10 and 11 of a resistance seam welder operating on work pieces 12 and 13. 40 A resistor 14, constituting a dummy load, is connected between line L1 and the left-hand contact of contacts D2.

Reactor 8 is provided with a D.C. saturation control coil 8d which is wound on the center leg of the core 8c. 45 Control coil 8d is supplied with rectified A.C. current from a self-saturating magnetic amplifier, consisting of a reactor 15 and rectifiers 16, 17, 18, 19, 20 and 21. Reactor 15 has A.C. power winding 15a and 15b, a bias winding 15c and a signal winding 15d. Winding 15a is connected at one end to line L1 and at its other end in series with rectifiers 16 and 17, to the lower end of control coil 8d of reactor 8. Rectifier 18 is connected, in opposed conducting relation to rectifiers 16 and 17, between the lower end of control coil 8d and line L2. The upper end of control coil 8a is connected in series with a resistor 22, and through a rheostat 23, or through normally open contacts ITR2 of an electroresponsive switch ITR when the latter contacts are closed, to a point common between rectifiers 20 and 21, and thence from such common point in series with rectifiers 19 and 20 and A.C. power winding 15b of reactor 15 to line L1, and also from such common point

in series with rectifier 21 to line L2. The point common between rectifiers 16 and 17 is connected to the point common between rectifiers 19 and 20. It will be observed that with the aforescribed connections of windings 15^a and 15^b and rectifiers 16 to 21, that rectified current will be supplied to control coil 8^d of reactor 8, and that the direction of current flow will be from the lower end to the upper end of such coil.

A full wave rectifier bridge 24 has its A.C. terminals connected to lines L1 and L2. The positive D.C. terminal of bridge 24 is connected in series with an adjustable resistor 25 and bias winding 15^c of reactor 15 to the negative D.C. terminal of bridge 24. With signal winding 15^d deenergized it may be assumed resistor 25 is adjusted so that the ampere turns developed by bias winding 15^c will bias reactor 15 to minimum output.

One end of signal winding 15^d of reactor 15 is connected to the positive D.C. terminal of a full wave rectifier bridge 26 and its other end is connected in series with a resistor 27 to a point common between the right-hand contacts of normally closed contacts ITR3 and normally open contacts ITR5 of electroresponsive switch ITR. The left-hand contacts of contacts ITR3 are connected to the slider of an "idle" excitation adjusting potentiometer 28, which has its resistance element connected at one end to the point common between rectifiers 17 and 18 and other end thereof connected to the point common between rectifiers 20 and 21. The left-hand contacts of contacts ITR5 is connected to the slider of a potentiometer 29 which has its resistance element connected across the D.C. terminals of a full wave rectifier bridge 30. The negative D.C. terminal of rectifier bridge 26 is connected in series with the resistance element of a welding current adjusting potentiometer 31 and a conductor 32 to a stationary contact member 33, and also in series with the resistance elements of a plurality of rheostats 34 to 39, to the positive D.C. terminal of rectifier bridge 26. The slider of potentiometer 31 is connected in series with normally closed contacts ITR4 of electroresponsive switch ITR to the point common between rectifiers 20 and 21, and is also connected in series with normally open contacts ITR6 of switch ITR to the negative D.C. terminal of rectifier bridge 30. The latter slider is mechanically connected with the slider of rheostat 23 for concurrent adjustment as will hereinafter be more fully explained.

The points common between rheostats 34 and 35, 35 and 36, 36 and 37, 37 and 38, 38 and 39 are connected to commutating contacts 40, 41, 42, 43, and 44, respectively. Associated with the contacts 40 to 44 and contact member 33 is a slidable contactor 45 mechanically coupled to, but electrically insulated from contactor 7. It will be noted that the voltage tap contacts 5^a to 5^j of autotransformer 5 are aligned respectively with the commutating contacts of the series connected rheostats 34 to 39, and that contactors 7 and 45 are slidable on their respective contact members 6 and 33 to simultaneously engage respective aligned pairs of voltage tap contacts and commutating contacts. Thus, whenever a voltage provided by a particular voltage tap of autotransformer 5 is selected, a certain preselected value of resistance will be effectively connected in series with the resistance element of potentiometer 31 for a purpose that will be later explained.

The A.C. terminals of rectifier bridge 26 are connected through conductors 46 and 47 to the end terminals of a secondary winding 48^b of a transformer 48 which has a primary winding 48^a. Winding 48^a is connected at one end to line L1 and at its other end to contact member 6. Accordingly, the alternating voltage impressed across winding 48^a will be in accordance with the alternating voltage selected on autotransformer 5. Thus, the rectified voltage across the D.C. terminals of rectifier bridge 26 will bear a similar relation to the alternating voltage selected on autotransformer 5. Consequently, signal winding 15^d of reactor 15 will be subjected to a unidirectional

reference voltage which is in accordance with the alternating voltage selected on autotransformer 5.

The A.C. terminals of rectifier bridge 30 are connected through conductors 49 and 50 to secondary winding 51^b of a transformer 51 which has a primary winding 51^a. Winding 51^a is connected at one end to line L1 and at its other end to the point common between primary winding 9^a of welding transformer 9 and the left-hand contact of contact W2 of switch W. Whenever contacts W2 are closed to complete the A.C. energizing connections to winding 9^a from the A.C. windings of reactor 8, winding 51^a of transformer 51 will have an alternating voltage impressed thereacross which will vary as a function of the welding load current. Thus, through its aforementioned connections with secondary winding 51^b, rectifier bridge 30 will afford supply at its D.C. terminals of a unidirectional "feed-back" voltage which varies in magnitude as a function of the welding current load. The aforescribed connections of potentiometer 29 to the D.C. terminals of rectifier bridge 30 permits selection of any desired position of such "feed-back" voltage, and it will be seen that whenever contacts ITR5 of switch ITR are closed the right-hand end of signal winding 15^d of reactor 15 will be subjected to such selected portion of the "feed-back" voltage.

From the foregoing, it will be observed that whenever contacts ITR5 and ITR6 of switch ITR are closed, and contacts ITR3 and ITR4 of the switch are open, signal winding 15^d will be subjected to the difference between unidirectional "reference voltage," in accordance with the alternating voltage selected on autotransformer 5, the adjustments of rheostats 34 to 39 and the adjustments of the slider of potentiometer 31 and an opposing unidirectional voltage which is the resultant of a selected portion of a variable "feed-back" voltage as determined by adjustment of rheostat 29. Thus during a welding operation the control ampere turns developed by signal winding 15^d will at any instant depend upon the resultant of the aforementioned voltages to which it is subjected. It may be assumed that the relationship of signal winding 15^d to bias winding 15^c is such that with a decrease in the aforementioned "feed-back" voltage the net ampere turns will increase the output of the magnetic amplifier and thereby increase the energization of saturation control winding 8^d of reactor 8. Conversely with an increase in such "feed-back" voltage, it may be assumed that the output of the magnetic amplifier is decreased to afford a corresponding decrease in energization of control winding 8^d of reactor 8. It will be observed that under the aforementioned assumed operating condition of switch ITR, contacts ITR2 will also be closed, thereby effectively shunting rheostat 23 out of circuit with control winding 8^d of reactor 8.

Referring to Fig. 2, the straight line curves A through F depict the range of welding current control afforded by the control system when the voltage tap changer is operated to the voltage tap contacts 5^j through 5^a, respectively. Considering curve A, this depicts the range of welding current control afforded when contactor 7 engages voltage tap contact 5^j of autotransformer 5. Depending upon the adjustment of the slider of potentiometer 31, the system will function during welding operation to maintain the welding current substantially constant at a selected value, such as for example, the point "X" on curve A. The lowest value of current obtainable on tap contact 5^j is determined by the resistance of rheostat 39 and the effective portion of such resistance selected by the adjustment of the slider of rheostat 39. In welding current systems of this type the total current range is usually selected on the basis of a ratio of 6 to 1 between maximum and minimum. Thus with the slider of potentiometer 31 in its counterclockwise extreme position, the slider of rheostat 39 is adjusted to provide a minimum current which is not less than one-sixth that of the maximum obtainable. When the slider of potentiometer 31 is

adjusted to its clockwise extreme position, the value of welding current which the system regulates to maintain is depicted by the upper end of curve A. Intermediate values of current are obtained by intermediate adjustments of the slider of potentiometer 31 between its aforementioned extreme positions.

Curve B, of course, depicts the range of welding current control afforded when contactor 7 engages voltage tap contact 5^h of autotransformer 5. It will be observed that rheostat 38 will then be included in series with rheostat 39, and minimum value of current obtainable is determined by the total effective resistance of rheostats 38 and 39. Inasmuch as the slider of rheostat 39 was adjusted to obtain a desired minimum value for tap 5ⁱ, its adjustment is maintained, and any adjustment is made with the slider of rheostat 38. Preferably the later adjustment is made so the minimum value of welding current obtainable, as depicted by the lower end of curve B, is somewhat less than the maximum value obtainable when contactor 7 engages voltage tap 5ⁱ, as depicted by the upper end of curve A, thereby affording a certain degree of "overlap." Such adjustment of the slider of rheostat 38 is, of course, made with the slider of potentiometer 31 in its counterclockwise extreme position. Any desired value of welding current between minimum and maximum depicted by curve B is then selected by adjustment of the slider of potentiometer 31 to different points between its extreme positions.

As will be understood, the minimum welding current values obtainable with the contactor 7 on any of the other voltage taps 5^g, 5^f, 5^e and 5^d is determined by the adjustments of rheostats 37, 36, 35 and 34, the latter being successively included in series circuit with rheostats 39 and 38 in accordance with the engagement of contactor 45 with commutating contacts 42, 41 and 40. With contactor 7 engaging voltage tap contact 5^d, all of the rheostats 34 through 39 will be connected in series with the resistance element of potentiometer 31, and the minimum welding current obtainable, depicted by curve F, will depend upon the sum of all the effective resistance of rheostats 34 through 39. The range of current adjustment at any voltage tap position on autotransformer 5 is, of course, determined by the range of adjustment of the slider of potentiometer 31.

As depicted in Fig. 2, the range of welding current adjustment, in percent of maximum welding current is equal at all voltage tap positions on autotransformer 5, indicating an equal overlap between maximum current obtainable on any tap position and the next higher voltage tap position. Of course, such overlaps need not be equal and can be adjusted as desired.

Whenever energizing winding ITR1 of switch ITR is deenergized its associated contacts will assume their operating conditions depicted in Fig. 1. Thus the right-hand end of signal winding 15^a will then be connected in series with the resistor 27, the then closed contacts ITR3 to the slider of potentiometer 28, and the slider of potentiometer 31 will then be connected in series with the then closed contacts ITR4 to one end of the resistance element of potentiometer 28 and the point common between rectifiers 20 and 21. With the last described connections the right-hand end of signal winding 15^a of the amplifier is subjected to a "self-feed-back" voltage from the rectified output of the magnetic amplifier. Accordingly, control winding 8^a of reactor 8 is subjected to an "idle" excitation current proportional to the welding current adjusting potentiometer adjustment and voltage tap changer position. However, as contacts ITR2 will then be open, rheostat 23 will be effectively in circuit with control winding 8^a of reactor 8, to further modify the "idle" excitation of control winding 8^a. By virtue of the mechanical connection between the sliders of potentiometer 31 and rheostats 23, the effective resistance of rheostat 23 included in circuit with control winding 8^a

will be in accordance with the value of welding current selected on potentiometer 31.

The last mentioned "idle" excitation connections reduce the D.C. excitation of saturable reactor 8 below the steady state regulating value. This minimizes transient welding current peaks to tolerable limits immediately following closure of contacts W2 of switch W. We also provide for initially connecting the winding 8^a and 8^b of saturable reactor 8 to the dummy load resistor 14 to insure magnetic stabilization of reactor 8 before connecting it to winding 9^a of the welding transformer. The use of the dummy load resistor is optional and may not be necessary when the aforesaid "idle" excitation connections are used, and a proper relationship between the resistance elements of potentiometer 31 and rheostat 23 is obtained and a suitable taper for the resistance element of rheostat 23 is used.

The system also includes initiating and stopping control instrumentalities associated with switches D, W and ITR which will now be described. Switch W has an operating coil W1 which is connected at one end in series with normally closed contacts D3 of switch D and normally open contacts WCR2 of an electroresponsive relay WCR to line L1, and its other end to line L2. Switch D has its operating coil D1 connected at one end in series with normally closed, time delay opening contacts DT2 and normally open contacts DT3 of a timing relay DT, to line L1, and at its other end to line L2. Relay DT has its operating coil DT1 connected at one end in series with a normally open, momentary close type of "start" switch 55, and a normally closed momentary open type of "stop" switch 56 to line L1, and at its other end to line L2. Normally open, time delay close contacts DT4 of relay DT when closed complete an energizing circuit for the operating coil WCR1 of relay WCR from "start" switch 55 through coil WCR1 to line L2. Relay DT is provided with a time delay device DT5 which may be assumed to provide time delay in closure of contacts DT4 and opening of contacts DT2, following energization of coil DT1, and inoperative upon deenergization of coil DT1. It may also be assumed that under the time delay action of device DT5 the contacts DT4 close slightly in advance of the opening of contacts DT2.

Relay WCR is provided with normally closed contacts WCR3 which provide a "temporary" maintaining connection around "start" switch 55, through the then closed contacts D4 of the switch D prior to energization of coil WCR1. The latter relay is also provided with normally open contacts WCR4 which provide for a "permanent" maintaining circuit around "start" switch 55 following energization of coil WCR1. The operating coil ITR1 of switch ITR is connected across lines L1 and L2 for energization thereof whenever normally open contacts W3 of switch W close.

Upon momentary closure of switch 55 current flows from line L1 through switches 56 and 55 and coil DT1 to line L2. Contacts DT3 of relay DT immediately close to provide an energizing circuit for coil D1 of switch D from line L1 through contacts DT3, the then closed contacts DT2, and coil D1 to line L2. Energization of coil D1 results in closure of contacts D2 and D4 and opening of contacts D3. Closure of contacts D2 complete the connection of A.C. winding of reactor 8 to dummy load resistor 14, closure of contacts D4 completes the "temporary" maintaining connection around switch 55, and opening of contacts D3 prevents establishment of energizing connections to coil W1 as a result of following closure of contacts WCR2 of relay WCR.

After a selected period of time delay, contacts DT4 of relay DT close to complete the energizing connections for coil WCR1. Energization of coil WCR1 results in closure of contacts WCR2 and WCR4 and opening of contacts WCR3. Due to contacts D3 then being open, closure of contacts WCR2 does not result in immediate completion of energizing connections to coil W1 of

switch W. Closure of contacts WCR4 results in completion of the "permanent" maintaining circuit around switch 55. Shortly after contacts DT4 close, contacts DT2 open to interrupt the energizing connection for coil D1 of switch D. Consequently contacts D2 open, disconnecting A.C. windings of reactor 8 from dummy load resistor 14, contacts D3 close, completing the energizing connection for coil W1 of switch W through the then closed contacts WCR2 of relay WCR, and contacts D4 reopen. Energization of coil W1 results in closure of contacts W2, thereby connecting the A.C. windings of reactor 8 in circuit with winding 9^a of the welding transformer, and in closure of contacts W3, thereby completing the energizing connections for coil ITR1 of switch ITR. Energization of coil ITR1 results in closure of contacts ITR2, ITR5 and ITR6 and in opening of contacts ITR3 and ITR4 for the purposes hereinbefore described in connection with amplifier 15 and D.C. control winding 8^d of reactor 8.

Momentary opening of "stop" switch 56 results in de-energization of coils WCR1, W1 and ITR1 of relay WCR, switch W and switch ITR, respectively, to effect the "at rest" condition of the system depicted in Fig. 1. It should be noted that all contacts of relay DT return immediately to their operating position depicted in Fig. 1 when operating coil DT1 is deenergized.

As will be understood, adjustment of contactors 7 and 45 to their various associated voltage tap contacts and commutating contacts is done with the A.C. windings of reactor 8 disconnected from the load. While in the form depicted adjustment of contactors 7 and 45 on their contact members 6 and 33 would be accomplished manually, it is apparent that motor driven tap changers of various forms can be employed if desired.

We claim:

1. The combination with an electrical load device, of a system for supplying said load device with regulated alternating current comprising means affording a source of a plurality of different alternating voltage values, a saturable reactor having its A.C. windings in circuit with said load device, means for selectively connecting said A.C. windings to different values of alternating voltage of said source, means affording a unidirectional voltage proportional to the alternating voltage selected for said A.C. windings, means affording a unidirectional voltage varying as a function of the current flowing in said load device, and regulating means having a D.C. output in circuit with the saturating winding of said reactor and subjected to said unidirectional voltages to vary its output in accordance with the difference between said unidirectional voltages to maintain the current supplied to said load device substantially constant.

2. The combination according to claim 1 wherein the means affording a unidirectional voltage proportional to the alternating voltage selected for said A.C. windings includes means for preselecting minimum portions of the unidirectional voltage varying as a function of the alternating voltage selected for said A.C. windings and means for selectively adjusting said portions of such unidirectional voltage to higher values above said minimum values through predetermined ranges, and wherein said regulating means is subjected to the resulting portions of such unidirectional voltage.

3. The combination according to claim 1 wherein said means affording a unidirectional voltage varying as a function of the current flow in said load device includes means for adjusting the proportion of variation of said unidirectional voltage for a given variation in current flow in said load device.

4. The combinations according to claim 1 together with means affording a unidirectional voltage proportional to the output of said regulating means and means for selectively subjecting said regulating means to the last mentioned unidirectional voltage or the unidirectional voltage varying as a function of the current flow in said load

device together with the first mentioned unidirectional voltage in either case.

5. The combination according to claim 4 wherein the last mentioned means also changes the resistance in circuit with the saturating winding of said reactor according to whether said regulating means is subjected to said last mentioned unidirectional voltage or said unidirectional voltage varying as a function of the current flow in said load device.

6. The combination according to claim 4 wherein said means affording a unidirectional voltage proportional to the output of said regulations includes means for providing an adjustable portion of such unidirectional voltage to which said regulating means is selectively subjected.

7. The combination with an electrical load service, of a system for supplying said load device with regulated alternating current comprising means affording a source of a plurality of different alternating voltage values, a saturable reactor having its A.C. windings in circuit with said load device, means for selectively connecting said A.C. windings to different values of alternating voltage of said source, means affording a unidirectional voltage proportional to the alternating voltage selected for said A.C. windings, means affording a unidirectional voltage varying as a function of the current flowing in said load device, magnetic amplifying means supplying said saturating winding with a rectified current and having a control winding subjected to said unidirectional voltages to vary the output of said rectified current in accordance with the difference between said unidirectional voltages.

8. The combination according to claim 7 wherein said magnetic amplifying means includes a bias winding subjected to a constant adjustable unidirectional voltage.

9. The combination with a translating device, a saturable reactor having its A.C. winding in circuit with said translating device, means including a tapped autotransformer providing a plurality of different alternating voltages and means for selectively connecting the A.C. windings of said reactor to the different taps of said autotransformer, of means for regulating the saturating current supplied to the saturating winding of said reactor comprising magnetic amplifying means having its output connected in circuit with the saturating winding of said reactor for supply of the latter winding with rectified current and having a control winding, means in circuit with said control winding, affording a supply of unidirectional voltage proportional to the alternating voltage selected for the A.C. windings of said reactor, and means in circuit with said control winding and affording a supply of unidirectional voltage varying as a function of the current flowing in said translating device and in opposition to the first mentioned unidirectional voltage.

10. The combination according to claim 9 wherein the means supplying said first mentioned unidirectional voltage comprises, in circuit with said control winding a potentiometer, a plurality of adjustable resistance elements corresponding in number to the taps of said autotransformer connected in series with the resistance element of said potentiometer and means adjustable with the first mentioned means to commutate said resistance elements into and out of circuit with said resistance element of said potentiometer in accordance with the alternating voltage selected for the A.C. windings of said reactor.

11. The combination according to claim 10 wherein said means supplying the last mentioned unidirectional voltage comprises a potentiometer in circuit with said control winding for subjecting the latter to a selected portion of said last mentioned unidirectional voltage.

12. The combination according to claim 11 together with means in circuit with the output of said amplifying means and including a potentiometer to provide a selected portion of the rectified output of said amplifying means, and means for selectively connecting said control winding to the last mentioned potentiometer or to the poten-

tiometer affording a selected portion of said last mentioned unidirectional voltage.

13. The combination according to claim 12 together with an adjustable resistance element in circuit with the saturating winding of said reactor and having its adjusting element mechanically connected to the slider of the first mentioned potentiometer for concurrent adjustment therewith, and wherein the last mentioned means includes means for shunting the last mentioned resistance element out of circuit when said saturating winding is connected to the potentiometer affording a selected portion of said last mentioned unidirectional voltage.

14. In combination, a welding transformer, a saturable reactor, means for connecting the A.C. windings of said reactor in circuit with the primary winding of said welding transformer, means including a tapped autotransformer providing a plurality of different alternating voltages, means for selectively connecting the A.C. windings of said reactor to the different taps of said autotransformer, means for regulating the saturating current supplied to the saturating winding of said reactor comprising magnetic amplifying means having its output connected in circuit with the saturating winding of said reactor for supply of the latter winding with rectified current and having a control winding, means in circuit with said control winding affording a supply of unidirectional voltage proportional to the alternating voltage selected for the A.C. winding of said reactor, and means in circuit with said control winding and affording a supply of unidirectional voltage varying as a function of the current flowing in said translating device and in opposition to the first mentioned unidirectional voltage.

15. The combination according to claim 14 wherein the means supplying said first mentioned unidirectional voltage comprises, in circuit with said control winding a potentiometer, a plurality of adjustable resistance elements corresponding in number to the taps of said autotransformer connected in series with the resistance element of said potentiometer and means adjustable with the first mentioned means to commutate said resistance elements into and out of circuit with said resistance element of said potentiometer in accordance with the alternating voltage selected for the A.C. windings of said reactor.

16. The combination according to claim 14 wherein said means supplying the last mentioned unidirectional

voltage comprises a potentiometer in circuit with said control winding for subjecting the latter to a selected portion of said last mentioned unidirectional voltage.

17. The combination according to claim 16 together with means in circuit with the output of said amplifying means and including a potentiometer to provide a selected portion of the rectified output of said amplifying means, and means for selectively connecting said control winding to the last mentioned potentiometer or to the potentiometer affording a selected portion of said last mentioned unidirectional voltage.

18. The combination according to claim 17 together with an adjustable resistance element in circuit with the saturating winding of said reactor and having its adjusting element mechanically connected to the slider of the first mentioned potentiometer for concurrent adjustment therewith, and wherein the last mentioned means includes means for shunting the last mentioned resistance element out of circuit when said saturating winding is connected to the potentiometer affording a selected portion of said last mentioned unidirectional voltage.

19. The combination according to claim 18 together with control means operable to connect and disconnect said A.C. windings of said reactor from circuit with the primary windings of said welding transformer and effect operation of said means affording selective connections of said control winding to said last mentioned potentiometer or to the potentiometer affording a selected portion of said last mentioned unidirectional voltage, so that said control winding is connected to said last mentioned potentiometer when said A. C. windings of said reactor are connected in circuit with the primary winding of said welding transformer and is connected to the potentiometer affording a selected portion of said last mentioned unidirectional voltage when said A.C. windings of said reactor are disconnected from said primary winding of said welding transformer.

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