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VOLTAGE REGULATORS

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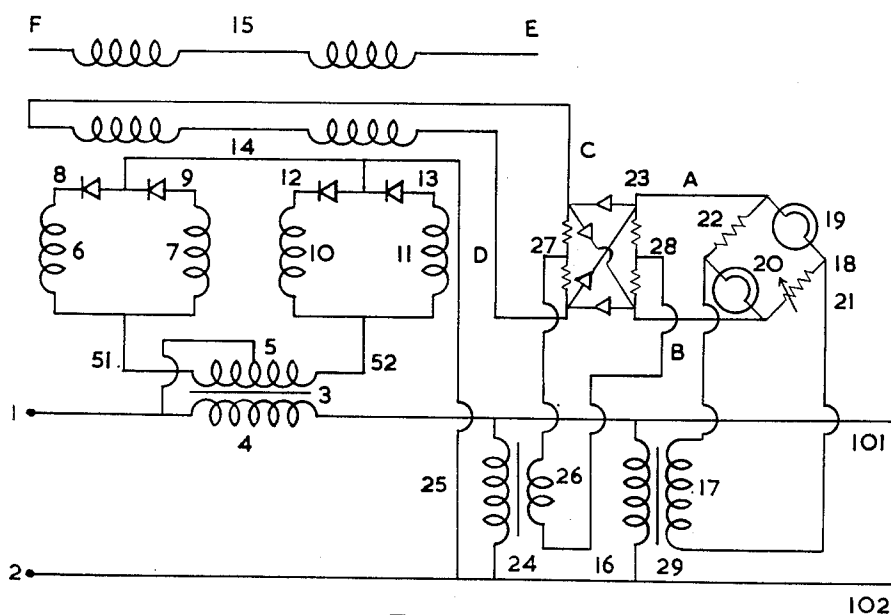


FIG. 1

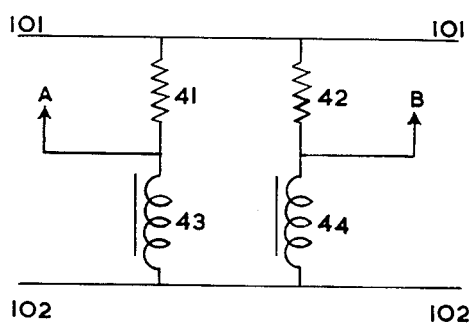


FIG. 2.

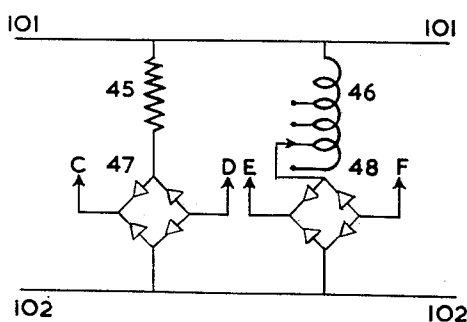


FIG. 3

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VOLTAGE REGULATOR

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The present invention relates to the provision of voltage regulators for alternating current supplies. Previously proposed regulators have had disadvantages in that comparatively simple types of regulators tend to produce a wave-form with a high harmonic content, necessitating the provision of filter circuits to remove a substantial proportion of the harmonic content if the output is to be used in apparatus where the wave-form is at all critical and also the regulation may not be as good as is desirable, while the types of regulator which produce an output of good wave-form and have good regulation tend to be inherently complicated. Furthermore the voltage output of such regulators is usually frequency dependent.

It is therefore the object of the present invention to provide a comparatively simple voltage regulator for an alternating current supply producing an output wave-form of low harmonic content and with good regulation, and in which the output voltage is substantially unaffected by normal frequency variations.

According to the present invention a voltage regulator supplying at a pair of output terminals a voltage of a substantially constant datum amplitude derived from a voltage of variable amplitude at a pair of input terminals comprises means connected across the output terminals to give a D. C. magnetic flux whose magnitude and sign are in accordance with the variation of the voltage across the output terminals from its datum amplitude, a transformer whose secondary winding is connected between the first input terminal and the first output terminal, said transformer having a centre-tapped primary, the centre tap of the said primary being connected to one of the input terminals, two similar variable impedance elements of the saturable reactor type connected respectively between the other input terminal and the remaining terminals of the transformer primary and means to vary the impedance of the variable impedance elements differentially in accordance with the aforementioned D. C. magnetic flux, the variation being such that the voltage across the transformer secondary is such as to reduce the variation of the voltage between the output terminals from its datum amplitude.

The means for deriving the D. C. flux may conveniently comprise a bridge the impedance of at least one of whose arms depends upon the voltage across it, one pair of terminals of the said bridge being connected across the output terminals of the regulator and the voltage across the remain-

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ing (output) pair of terminals being utilised to generate the requisite flux. The voltage across the output terminals of the bridge may be applied to the input terminals of a phase sensitive demodulator, the output from which is applied to control the impedances of the saturable reactors. Two opposite arms of the bridge may conveniently be constituted by elements, such as metal filament lamps, whose resistance depends upon the current flowing therein, while the remaining arms constituted by resistive elements whose resistance is largely independent of the current flowing therein. Alternatively, one pair of adjacent arms may consist of resistive elements while the other adjacent arms consist respectively of an inductor whose inductance is substantially independent of the voltage across it and an inductor whose impedance changes relatively suddenly at a critical value of the voltage across it. Whatever form of bridge is used, it is preferably substantially balanced when the output voltage from the regulator has its datum amplitude.

Alternatively the means for deriving the D. C. flux may comprise a first impedance element whose impedance is substantially independent of the voltage across it in series with a first rectifier connected across the output terminals in parallel with a second impedance element whose impedance varies substantially with the voltage across it in series with a second rectifier also connected across the output terminals together with first and second windings respectively connected across the outputs of said rectifiers and arranged to generate the requisite flux.

Whatever form is used, the means generating the D. C. magnetic flux may be connected across the output terminals either directly or through a transformer; and the saturable reactors are conveniently arranged and controlled as described in British specification No. 633,375.

Voltage regulators constructed in accordance with the present invention will now be described with reference to the accompanying drawings of which:

Figure 1 shows one embodiment of the invention.

Figure 2 shows one alternative form of the means connected across the output terminals responsive to variations in the voltage between them.

Figure 3 shows a second alternative form of these means.

Referring to Figure 1, an unstabilised A. C. input voltage is applied to terminals 1, 2 while a

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stabilised output voltage is obtained between output terminals 101 and 102. Terminals 1 and 101 are connected to the secondary winding 4 of a transformer 3. The primary winding 5 of transformer 3 is centre-tapped and the centre-tap connected to input terminal 1. One of the remaining terminals 51 of winding 5 is connected to the common terminal of two similar saturable reactors 6, 7 the other terminals of the reactors being joined through two similar dry plate rectifiers 8, 9. The other remaining terminal 52 is connected to two further similar reactors 10, 11 associated with similar dry plate rectifiers 12, 13. The junctions of rectifiers 8, 9 and 12, 13 are both connected to terminal 2. The effective impedances of windings 6, 7, 10, 11 are controlled by direct current flowing in control windings 14 and 15, the impedance between terminal 51 and terminal 2 being increased and that between terminal 52 and terminal 2 being decreased for one direction of resultant flux produced by 15, 15, and vice versa for the other. The precise arrangement and operation of windings 6, 7, 10, 11, 14, 15 and their associated iron cores is fully described in British specification No. 633,375 and will not be further discussed here.

The primary winding 16 of a transformer 29 is connected between the output terminals 101 and 102, while the secondary 17 is connected to one pair of opposite terminals of a bridge 18 having in one pair of opposite arms metal filament lamps 19, 20 and in the other pair resistors 21, 22, resistor 21 being variable. The other pair of opposite terminals is connected to the input terminals A, B, of a phase-sensitive demodulator 23, consisting of resistors and dry plate rectifier elements arranged in a conventional manner. The "carrier" input to the demodulator (at terminals 27, 28) is obtained from the secondary 26 of a transformer 24 whose primary 25 is connected between terminals 101, 102. The output from demodulator 23 is connected to terminals C, D, of control winding 14. As is well known the resistance of metal filament lamps such as 19, 20 varies rapidly with temperature and hence with the current flowing through them. The bridge 23 is so arranged that when the voltage between terminals 101, 102 is that desired, the bridge 18 is balanced. When the voltage deviates from the desired datum a voltage is applied to terminals A, B, of magnitude and sign depending upon the deviation. This is rectified, in demodulator 23, to give a D. C. voltage whose magnitude and sign is dependent upon the magnitude and sense of the deviation. The D. C. when applied to winding 14, produces differential variation of the impedances between terminals 51 and 52 respectively and terminal 2, so that a voltage is developed across the secondary winding 4 of transformer 3. The connections are so arranged that this voltage is in such a sense as to oppose variation in the voltage between terminals 101, 102.

It will be seen that by adjustment of resistor 21 the level of the output voltage can be adjusted; and it will be appreciated that in certain circumstances it may be convenient to connect bridge 18 directly across terminals 101, 102. When however a transformer such as 16 is used it will usually be convenient to obtain the "carrier" input to demodulator 23 from a further secondary winding on transformer 29.

In Figure 2 is shown a modification for part of the circuit which may be connected between lines 101, 102 in place of transformer 29 and the bridge 18 shown in Figure 1, terminals A, B, in

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Figure 2 being connected to the input terminals A, B of demodulator 23.

The circuit in Figure 2 comprises a bridge consisting of resistors 41, 42 and inductors 43, 44. Inductor 43 has an inductance substantially independent of the voltage to be applied to it, while that of inductor 44 rapidly decreases as the voltage applied to it is increased through a critical value. This can be arranged by, for example, winding the inductor upon a core of material having a sharp "knee" in the B-H curve. The components are so chosen that when the voltage between terminals 101, 102 has its desired datum value the bridge is balanced and the voltage across inductor 43 is in the neighbourhood of its critical value. Increase of the voltage between terminals 101, 102 above the datum thus produces a voltage between terminals A, B of one phase and a decrease of the voltage between the terminals 101, 102 produces a voltage of the other phase between terminals A, B. This voltage is utilized, as in the embodiment of Figure 1, to produce a voltage across winding 4 to counteract variations in the output voltage.

In Figure 3 is shown a further modification, which may be connected between terminals 101 and 102, replacing transformer 29, bridge 18 and demodulator 23 of Figure 1, and enabling transformer 24 to be omitted.

The circuit of Figure 3 consists of a resistor 45 in series with a bridge-connected dry plate rectifier 47 and a tapped inductor 46 in series with a further dry plate rectifier 48. The inductor is of a similar kind to inductor 44 (Figure 2) but such that the critical voltage (which can be varied by adjusting the tap) is substantially equal to the desired output voltage.

Terminals C, D of rectifier 47 are connected to winding 14 (Figure 1) while terminals E, F are connected to winding 15. The D. C. fluxes produced by the currents in windings 14 and 15 are in opposition, and resistor 45 is such that when the output voltage between terminals 101, 102 is at the desired datum the resultant flux is zero. If the voltage varies from the datum the circuit acts, as described earlier to produce a voltage across winding 4 to counteract the variation.

It will be appreciated that the devices shown in Figure 2 or 3 may be connected across lines 101, 102 through a transformer instead of directly if this is convenient.

I claim:

1. A voltage regulator supplying at a pair of output terminals a voltage of a substantially constant datum amplitude derived from a voltage of variable amplitude at a pair of input terminals comprising means connected across the output terminals to give a D. C. magnetic flux whose magnitude and sign are in accordance with the variation of the voltage across the output terminals from its datum amplitude, a transformer whose secondary winding is connected in series between the first input terminal and the first output terminal, said transformer having a centre-tapped primary, the centre tap of said primary being connected to one of the input terminals, two similar variable impedance elements of the saturable reactor type connected respectively between the other input terminal and the remaining terminals of the transformer primary and means to vary the impedances of the variable impedance elements differentially in accordance with the aforementioned D. C. magnetic flux, the variation being such that the voltage across the transformer secondary is such as to

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reduce the variation of the voltage between the output terminals from its datum amplitude.

2. A voltage regulator as claimed in claim 1 wherein the means for deriving the D. C. flux comprise a bridge the impedance of at least one of whose arms depends upon the voltage across it, one pair of opposite terminals of the said bridge being connected across the output terminals of the regulator and the voltage across the remaining (output) pair of terminals being utilised to generate the requisite flux.

3. A voltage regulator as claimed in claim 2 wherein two opposite arms of the bridge consists of resistive elements whose resistance is largely independent of the current flowing therein while the remaining arms consist of resistive elements whose resistance varies substantially with the current flowing therein.

4. A voltage regulator as claimed in claim 3 wherein the resistive elements of substantially varying resistance are constituted by metal filament lamps.

5. A voltage regulator as claimed in claim 2 wherein the one pair of adjacent arms of the bridge consists of resistive elements while the other adjacent arms consist respectively of an inductor whose impedance is substantially independent of the voltage across it and an inductor whose impedance changes relatively suddenly at a critical value of the voltage across it.

6. A voltage regulator as claimed in claim 2 wherein one of the elements of the bridge is in-

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dependently variable to enable the datum amplitude to be adjusted.

7. A voltage regulator as claimed in claim 1 wherein the means for deriving a D. C. flux comprise a first impedance element whose impedance is substantially independent of the voltage across it in series with a first rectifier connected across the output terminals a second impedance element whose impedance varies substantially with the voltage across it in series with a second rectifier also connected across the output terminals with first and second windings respectively connected to the output of said rectifiers and arranged to generate the requisite flux.

8. A voltage regulator as claimed in claim 7 wherein the second impedance is constituted by an inductor whose impedance changes relatively suddenly at a critical value of the voltage across it.

9. A voltage regulator as claimed in claim 2 comprising also a phase-sensitive demodulator, the input to which is supplied by the output from the bridge and the direct current output from which is applied to control the impedances of the saturable reactors.

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