United States Patent

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[33] **Great Britain**
[31] **7523/69**

[54] **AC VOLTAGE CONTROL APPARATUS**
4 Claims, 2 Drawing Figs.

[52] **U.S. Cl.** **323/6,**
323/43.5 R, 323/45, 323/47
[51] **Int. Cl.** **G05f 3/04**
[50] **Field of Search** 323/43.5,
44, 45, 47, 57, 83, 91, 6

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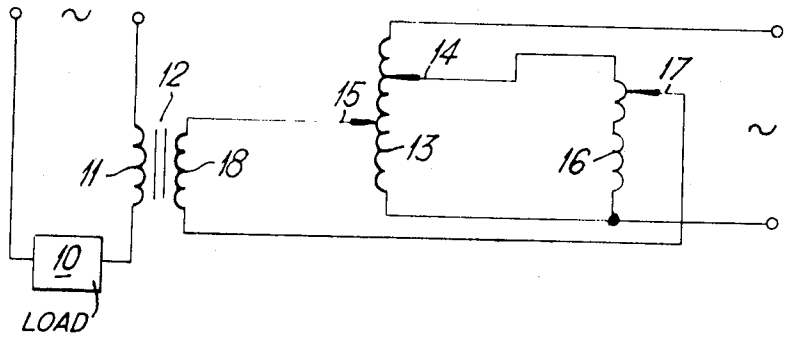
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Primary Examiner—J. D. Miller
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Attorney—Cameron, Kerkam & Sutton

ABSTRACT: Alternating current voltage control apparatus comprises a coarse and a fine voltage regulator feeding the primary winding of a buck/boost transformer the secondary of which is connected in series with a load. The coarse voltage regulator has two movable contacts capable of passing one another, and has the ends of the winding connected to the two poles of an alternating current supply of the same frequency as that connected to the load. The fine regulator is connected between one contact on the coarse regulator and one pole of the supply and itself carries a movable contact. The primary of the buck/boost transformer is connected between the other movable contact on the coarse voltage regulator and the movable contact on the fine regulator.



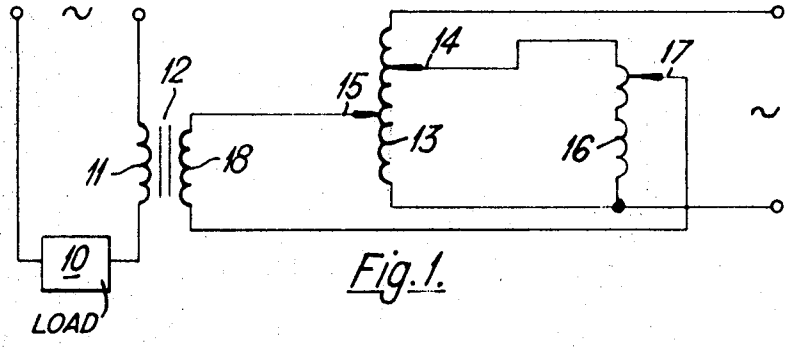

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LOAD

Fig. 1.

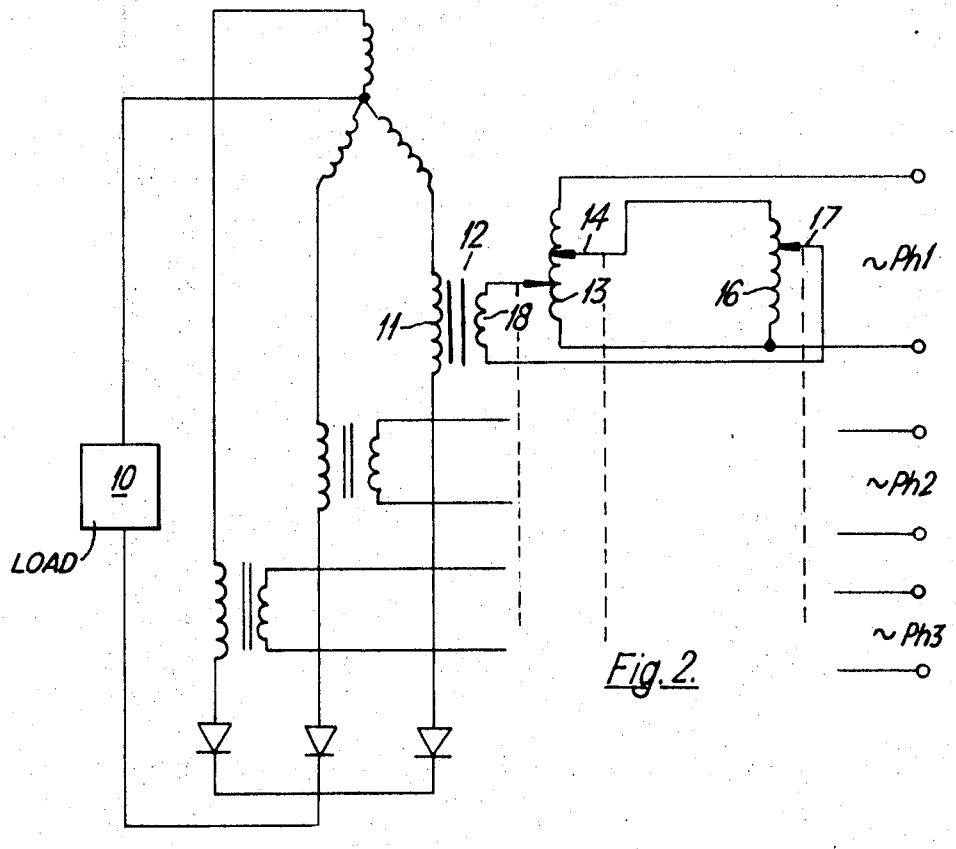

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LOAD
~Ph2
~Ph3

Fig. 2.

AC VOLTAGE CONTROL APPARATUS

This invention relates to voltage control apparatus for use with alternating current systems.

Voltage control apparatus for use with alternating current exists in many forms, a common one being the use of a bucking-and-boosting (buck/boost) transformer having one winding connected in series with the AC supply to the load. The other winding of the buck/boost transformer is fed with an AC voltage which may be varied between required limits, for example, by means of a tapped or continuously variable autotransformer If the autotransformer is provided with two movable contacts to which the two ends of the buck/boost transformer winding are connected, then it is possible to use the apparatus to either increase or decrease the load voltage as required.

The main disadvantage with this relatively simple arrangement is that at low-voltage settings the voltage changes by relatively large steps, and the accuracy of control is lost. The eventual limitation is the finite number of turns on the autotransformer over which the moving contacts operate.

It is an object of the invention to provide voltage control apparatus for an AC system which will provide small and accurate voltage changes at the low-voltage end of the operating range.

According to the present invention there is provided voltage control apparatus for use with alternating current systems which includes a first moving contact autotransformer voltage regulator capable of having the ends of its winding connected directly across an alternating current supply and carrying two movable contacts capable of passing one another along the regulator winding, a second moving contact autotransformer voltage regulator arranged to have one end of its winding connected directly to one side of said alternating current supply and having another point on its winding connected to one movable contact on the first voltage regulator and carrying a movable contact capable of traversing part at least of the regulator winding, and a bucking and boosting transformer having its primary winding connected between the other moving contact on the first voltage regulator and the moving contact on the second voltage regulator and with its secondary winding suitable for connection in series with the load to be across an alternating current supply.

The invention will now be described with reference to the accompanying drawings, in which:

FIG. 1 is a circuit diagram of one form of the apparatus; and

FIG. 2 illustrates the application of the invention to a three phase rectifier system.

Referring now to FIG. 1, a load 10 is connected in series with the secondary winding 11 of a buck/boost transformer 12 across an AC supply. A first or "coarse" moving contact autotransformer voltage regulator has is winding connected across the AC supply which may be the same as that connected to the load, and which must in any event be in phase with the load supply. The coarse regulator comprises a winding 13 connected to the supply, and two movable contacts 14 and 15. Each of the movable contacts is capable of traversing the entire winding 13 of the regulator. Connected between one of the movable contacts 14 and one side of the regulator supply the winding 16 of a second or "fine" regulator of the same type. This has a single movable contact 17 arranged to cover a voltage range which is only a fraction of the voltage of the winding 16, say one-third. The primary winding 18 of the buck/boost transformer is connected between the other movable contact 15 on the coarse regulator and the movable contact 17 on the fine regulator. The movable contacts may move over tappings connected to the winding or over the turns of the actual winding.

Consider first the case when the contact 17 on the fine regulator is at the upper end of winding 16. In this condition contact 17 is electrically connected directly to contact 14 on the coarse regulator, and the voltage regulator operates in the same manner as the known type of regulator described above. Whenever the two contacts 14 and 15 occupy the same position on winding 13 then the voltage is applied to the primary winding 18 of the buck/boost transformer 12 will be zero. This is not affected by the actual position of the contacts on winding 13. Whenever the two contacts move away from one another a voltage is applied to the primary winding 18 of the buck/boost transformer. This voltage has a phase dependent upon the relative positions of the two contacts.

For example, if contact 14 moves "above" contact 15 as shown in FIG. 1, then a voltage of one phase is applied to the winding 18. If however the contact 14 moves below the contact 15, then the voltage applied to the winding 18 is of opposite phase. Hence it is possible to provide, through the buck/boost transformer a voltage which may either be added to the voltage supplied to the load, or be subtracted from the voltage supplied to the load.

Such a simple arrangement is, as has been stated, already known, if one ignores the presence of the fine regulator.

The fine regulator operates to add to the coarse regulator output a small variable fraction of the voltage tapped off the coarse regulator by the contact 14. The position of contact 14 therefore determines the range of voltage covered by the contact 17, and the position of contact 14 may be adjusted to give the required accuracy of control. When working at low voltages the contact 14 will be towards the bottom of the winding 13, and hence travel of contact 17 on winding 16 covers the small voltage tapped off by contact 14.

Suppose, for example, that the load is supplied with a voltage which is only 50 percent of its maximum working voltage. The voltage regulator may be arranged to increase or decrease this by the same amount, thus providing full control from zero to 100 percent of the working voltage. The regulators and buck/boost transformer are connected so that maximum voltage is applied to load when contact 15 is at the bottom end of winding 13 and contact 14 is at the top end of the winding. Contact 17 on the fine regulator then provides for variation of the load voltage from 100 percent with contact 17 at the top end of its travel to approximately 83 percent with contact 17 at the lower end of its travel. The lower value arises since the regulator adds to the 50 percent voltage from the load supply two-thirds of the same voltage. When the voltage applied to the load is to be a minimum, then the positions of contacts 14 and 15 are reversed. If contact 14 is placed at the very bottom end of the winding 13, then the fine regulator exerts no control, but as soon as a small voltage appears across the fine regulator, then this may be varied in very small steps by movement of contact 17.

Thus the complete system operates so that the range of control covered by the fine regulator is always a fixed fraction of the variable output voltage, not of the fixed supply voltage, and the accuracy of control is maintained down to a very low output voltage level.

Although the voltage control apparatus described may be used to vary a voltage over a wide range, it is more commonly used as a voltage stabilizing arrangement which may be motor-driven under the control of a sensing relay. It is then possible to control the coarse regulator contacts so that the fine regulator contact always works about the center of its range, controlled by the sensing relay.

FIG. 2 illustrates one possible application for the voltage control apparatus described above. This shows a three-phase rectifier system with the three rectifiers fed from a star-connected transformer secondary winding. The three-phase primary winding is not shown. Into each connection from the transformer to a rectifier is inserted the secondary winding of a buck/booster transformer. Each of the three voltage regulator arrangements is identical to that shown in FIG. 1. The three AC supplies to the regulators are of different phase, each regulator supply being in-phase with the rectifier to which it is connected via the regulators. Hence the regulator supplies are readily derived from tertiary windings on the rectifier transformer.

The corresponding movable contacts of the regulators in the three separate phases must be kept in step with one another in order to balance the loads on the three phases of

the supply. The various contacts will probably be interconnected mechanically in order to achieve this.

It is possible to modify the connections of the fine regulator by connecting the movable contact 14 to the center of the upper part of winding 16, instead of to the top end of the winding. This will then allow the movable contact 17 to tap off a voltage variable above and below the voltage applied to the winding by contact 14.

I claim:

1. Voltage control apparatus for use with alternating current systems, including a first moving-contact autotransformer voltage regulator including a winding, the ends of said winding adapted to be connected directly across an alternating current supply said regulator further having two movable contacts adapted to pass one another along the regulator winding, a second moving-contact autotransformer voltage regulator including a winding, said second regulator arranged to have one end of its winding directly connected to one side of said alternating current supply and having another point on its winding connected to one movable contact on the first voltage regulator and carrying a movable contact capable of traversing part at least of the regulator winding, and a bucking and boosting transformer having its primary winding connected between the other movable contact on the first voltage regulator and the movable contact on the second voltage regulator and with its secondary winding arranged for connection in series with the load to be controlled across an alternating current supply.

2. Voltage control apparatus as claimed in claim 1 in which

the movable contact carried by the second voltage regulator is adapted to traverse only that part of the regulator winding adjacent to the point on the winding connected to the said one movable contact of the first voltage regulator.

3. Voltage control apparatus for controlling the voltage supplied to a load adapted to be connected across an alternating current supply comprising a first coarse voltage regulator, said coarse voltage regulator including a winding and two movable contacts arranged for passing one another along the winding, means for connecting said coarse voltage regulator across an alternating current supply, a second fine voltage regulator, said fine voltage regulator including a winding and a movable contact, means for connecting said winding between one side of said alternating current supply and said movable contact on the first voltage regulator, said movable contact on said second voltage regulator being arranged to traverse part at least of the associated winding, a bucking and boosting transformer having a primary and a secondary winding, means connecting said primary winding between the other moving contact on the first voltage regulator and the moving contact on the second voltage regulator and means for connecting said secondary winding in series with the load to be controlled.

4. Voltage control apparatus as claimed in claim 3 in which the movable contact carried by the second voltage regulator is adapted to traverse only that part of the associated regulator winding adjacent to the point on the winding connected to the said one movable contact of the first voltage regulator.