March 2, 1965 J. G. SOLA 3,172,031

SATURABLE POWER MODULATOR

Filed June 1, 1961

fig. 1

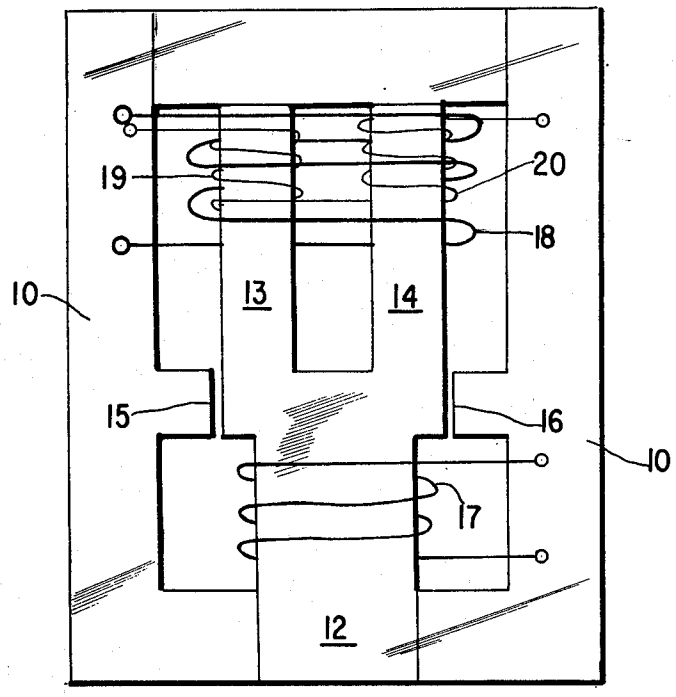


fig.3

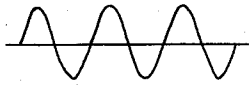


fig.4

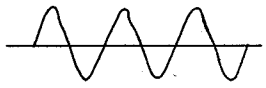
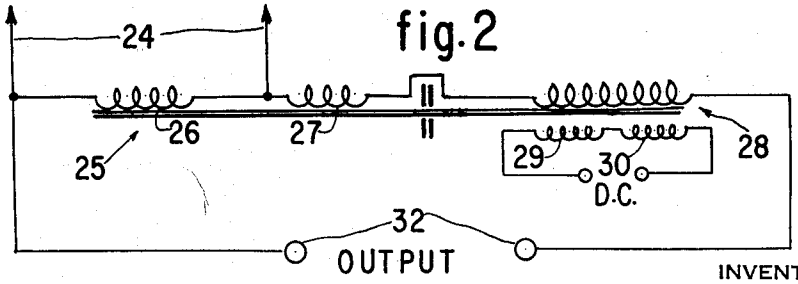


fig.2



INVENTOR
JOSEPH G. SOLA
BY
Robertson and Sweythe
ATTORNEYS

United States Patent Office

3,172,031
Patented Mar. 2, 1965

3,172,031

SATURABLE POWER MODULATOR

Joseph G. Sola, River Forest, Ill., assignor to Basic Products Corporation, Elk Grove Village, Ill., a corporation of Wisconsin

Filed June 1, 1961, Ser. No. 114,079
4 Claims. (Cl. 323—56)

This invention relates to power modulators and particularly to one for use as line voltage or constant current regulators.

In the prior art, devices for regulating voltage or current have been relatively expensive. In some instances moving parts have been employed. Another problem has been that they have not been fast enough in their response and the waveform has been unsatisfactory.

One of the objects of this invention is to provide a relatively inexpensive power modulator.

Another of the objects of the invention is to provide a power modulator which is fast in response and which will have the desired waveform and no moving parts.

In one aspect of the invention, a high leakage reactance transformer is used having a core with a magnetic shunt path, there being an air gap therein. The primary is on one side of the air gap and the secondary on the other side. A D.C. control winding means is positioned on the core so that change of D.C. thereto will shift the flux from the secondary to the shunt path so as only to affect the secondary winding flux. All or only a portion of the primary and secondary windings may be on their respective sides of the air gap. Also, the D.C. control winding means may or may not be on the same leg of the core as the secondary or primary. Preferably, the D.C. control winding is in two parts, each on tongues or separated portions of a bifurcated portion of the core, the winding parts being connected in opposed relation. Further, in one form, the core has a center leg with a bifurcated portion adjacent one end thereof, the D.C. windings being on the tongues thereof and the secondary winding wound around the pair of D.C. windings. The primary winding then is wound adjacent the opposite end of the center leg, the shunt air gap being between the primary and secondary. Thus, without D.C., the flux will flow in the center leg to the outer legs and not through the air gap shunt. When control D.C. is applied to the control windings, increase thereof will cause shifting of flux affecting the secondary to the shunt path so as to control the secondary output.

The arrangement can be used in various circuits, one being shown herein which is especially useful for power or voltage output control. In this system, the primary may be in the form of an auto-transformer or one having an extension so that more than the input voltage is available across the primary. The secondary has one end connected to the load and the other to the primary extension, the opposite ends of both the primary and secondary being connected to the load. When the secondary is in bucking relation, increase in D.C. will result in an output voltage increase and vice versa. It is to be understood, however, that the invention can be applied to other circuits and arrangements. The term "power modulator" means power, voltage and/or current modulation. The arrangement also could be used as a magnetic amplifier, the D.C. windings being the control windings thereof.

These and other objects, features and advantages will become apparent from the following description and drawings which are merely exemplary.

In the drawings:

FIG. 1 illustrates one form of core and high leakage reactance transformer.

FIG. 2 is a wiring diagram showing one form of circuit with which the invention can be used.

FIG. 3 shows an oscillograph picture showing no load wave form.

FIG. 4 is similar to FIG. 3 except it is under full load conditions.

The invention first will be described in conjunction with a line voltage regulator and a shell-type core arrangement. Referring to FIG. 1, the core may comprise outer legs **10**, **11** and a center leg **12**, the center leg in the form shown having a bifurcated end or tongue-like shape with tongues **13**, **14**. Magnetic shunt air gap paths **15**, **16** are provided between the center leg and the two outer legs **10** and **11**. The primary **17** may be wound on one portion of the center core leg, secondary means **18** being wound on the center core leg on the opposite side of magnetic shunt air gaps **15**, **16**. The D.C. control windings **19**, **20** are wound on the tongues **13**, **14** and connected in opposite polarity. In the form illustrated, the secondary winding **18** is wound over the D.C. control windings. The D.C. control windings are wound and connected so that the fundamental frequency will not be introduced therein. When there is no D.C. control current being supplied, the secondary will have flux pass therethrough from the primary, returning through the outer legs to the center core leg. When the D.C. control windings are energized so as to saturate the upper portion of the center leg, the flux from the primary will pass through the magnetic shunts and return along the lower sections of the side legs. In this manner, the D.C. control windings will serve to shift the flux from its path through the secondary to a path through the magnetic shunt located therebetween and thus affect only the voltage induced in the secondary winding. It should be evident that other arrangements of the core can be made, for example, winding the primary on each of the side legs and the secondaries on each of the side legs, the control winding remaining on the center leg. Also, the upper portion of the side legs may be bifurcated (not shown) and D.C. windings placed on each of the bifurcated sections.

Merely as an example, when used as a line voltage regulator to maintain the output voltage constant for varying input line voltage, one circuit is illustrated in FIG. 2 wherein the primary **25** is in the form of an auto-transformer arrangement having main section **26** and a boost or series section **27**, such serving to boost the line voltage by a predetermined percentage. The secondary winding **28** is connected to the primary winding, there being a D.C. control winding arrangement **29** and **30** corresponding to control windings **19** and **20** of FIG. 1. A suitable source of D.C. control power can be applied at **31** as needed.

In a preferred form, the secondary coil **28** is arranged in a bucking relationship so that when there is no control current in the D.C. coils, it will serve to buck the voltage

output of the primary. In such an arrangement, the voltage supplied by the secondary should be made slightly greater than the voltage added by the boost section **27** of the primary. Thus, when there is no control current, the voltage will be less than that available from the primary section. As control current is applied to the D.C. windings, the effect of the secondary will be lowered until with full control current, the sum of the voltages of the primary section **26** and boost coil **27** will be available at the output terminals **32**. In the arrangement illustrated in FIG. 2, the primary is fed from a suitable source of A.C. to the terminals **24**.

Referring to FIG. 1, when direct current is applied to the D.C. windings, then a D.C. component of flux is circulated up one of the fingers of the center section and down the other finger of the center section so as to saturate the same and thus reduce the effectiveness of the secondary bucking windings **28**.

It also is possible to arrange the secondary section **28** in aiding relation and therefore control the amount of voltage added to the primary section **26** and boost coil **27**.

Merely by way of example, a line voltage regulator having a rating of 10 kva. was connected in a circuit similar to FIG. 2. The length of the core was 10", the width 7⅝" and the stack height 3". The primary **26** and 234 turns and the series section **27** had 30 turns. The D.C. windings were 160 turns each and the secondary had 50 turns.

With a line voltage from 220 to 250 volts and a load current variation from 0 to 45 amps. and by suitably regulating the D.C., the output voltage was maintained at 225 volts. The waveform was maintained substantially sinusoidal as can be seen in FIG. 3 showing no load and FIG. 4 showing full load.

It should be apparent that various changes may be made in the details of the circuit without departing from the spirit of the invention except as defined in the appended claims.

What is claimed is:

1. In a power modulator for controlling power delivered from an A.C. source to a load over a predetermined normal continuous range of operation, the combination including a high leakage reactance transformer core having a first loop path therein for magnetic flux and said core having at least one magnetic shunt path with an air gap therein for bypassing a portion of said first loop path in said normal continuous range, primary winding means on said core having a pair of input terminals for connection to the A.C. source for providing primary flux in said first loop path, an extension of said primary winding means on said core connected in circuit in series with said primary winding means, secondary winding means on said core surrounding said portion of said first loop path and being linked by the primary flux in said portion for inducing voltage in said secondary winding means, a pair of output terminals for connection to the load, circuit means for connecting said primary winding means, said extension and said secondary winding means in circuit in series between said pair of output terminals with said secondary winding means and said extension being in voltage opposing relationship, and D.C. control winding means on said core for shifting said primary flux in said normal continuous range from said portion of said first loop path to said air gap magnetic shunt path bypassing said core portion for diverting said primary flux away from said secondary winding means for reducing the amount of primary flux linking said secondary winding means as the direct current in said D.C. winding means is increased within said normal continuous range for reducing the effective amount of voltage opposition between said secondary winding means and said extension.

2. In a power modulator for controlling power delivered from A.C. source to a load over a predetermined normal continuous range of operation, the combination including a high leakage reactance transformer core having a first loop path therein for magnetic flux and said core having at least one magnetic shunt path with an air gap therein for bypassing a portion of said first loop path in said normal continuous range; primary winding means on said core on one side of said shunt path and having a pair of input terminals for connection to the A.C. source for providing primary flux in said first loop path, an extension of said primary winding means on said core connected in circuit in series voltage boosting relationship with said primary winding means, secondary winding means on said core on the other side of said shunt path surrounding said portion of said first loop path and being linked by the primary flux in said portion for inducing voltage in said secondary winding means, a pair of output terminals for connection to the load, circuit means for connecting said primary winding means, said extension and said secondary winding means in circuit in series between said pair of output terminals with said secondary winding means in voltage bucking relationship with said primary winding means and extension, and D.C. control winding means on said core for shifting said primary flux in said normal continuous range from said secondary winding means to said shunt path as the direct current in said control winding means is increased within said normal continuous range for reducing the voltage bucking effect of said secondary winding means.

3. In a power modulator for controling power delivered from an A.C. source to a load over a predetermined normal continuous range of operation, the combination including a high leakage reactance transformer having a first loop path therein for magnetic flux and said core having a magnetic shunt with an air gap therein for bypassing a portion of said first loop path in said normal continuous range, primary winding means on said core on one side of said shunt having a pair of input terminals for connection to the A.C. source for providing primary flux in said first loop path, an extension of said primary winding means on said core on said one side of said shunt connected in circuit in series voltage boosting relationship with said primary winding means for boosting the A.C. voltage of said source by a predetermined percentage, secondary winding means on said core on the other side of said shunt surrounding said portion of said first loop path and being linked by the primary flux in said portion for inducing voltage in said secondary winding means slightly greater than the voltage added by said boosting extension, a pair of output terminals for connection to the load, circuit means for connecting said primary winding means, said extension and said secondary winding means in circuit in series between said pair of output terminals with said secondary winding means in voltage bucking relationship with said primary winding means and extension, and D.C. control winding means on said core for shifting said primary flux in said normal continuous range from said portion of said first loop path to said air gap magnetic shunt bypassing said core portion for diverting said primary flux away from said secondary winding means to said shunt path upon increase in the direct current in said control winding means for reducing the amount of primary flux linking said secondary winding means as the direct current in said control winding means is increased within said normal continuous range for reducing the amount of bucking voltage.

4. In a power modulator for controlling power delivered from an A.C. source to a load, the combination including a high leakage reactance transformer having a magnetic shunt with an air gap, primary winding means on one side of said shunt providing primary flux, secondary winding means on the other side of said shunt, input terminal means for connecting a portion of said primary means to said A.C. source so as to provide an extension thereof in voltage boosting relationship with said primary winding means; first output terminal means for connecting one end of said primary means to said load, second

output terminal means for connecting one portion of said secondary means to said load and another portion of said secondary means with said extension of said primary means, said connection between said secondary means and said primary means being in voltage bucking relation, and D.C. control winding means on said core for shifting said primary flux from said secondary winding means to said shunt path upon increase in D.C., said control winding means affecting the primary flux linking the secondary winding and shunt path flux so that increase of D.C. to said control winding means will reduce output to said load.

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