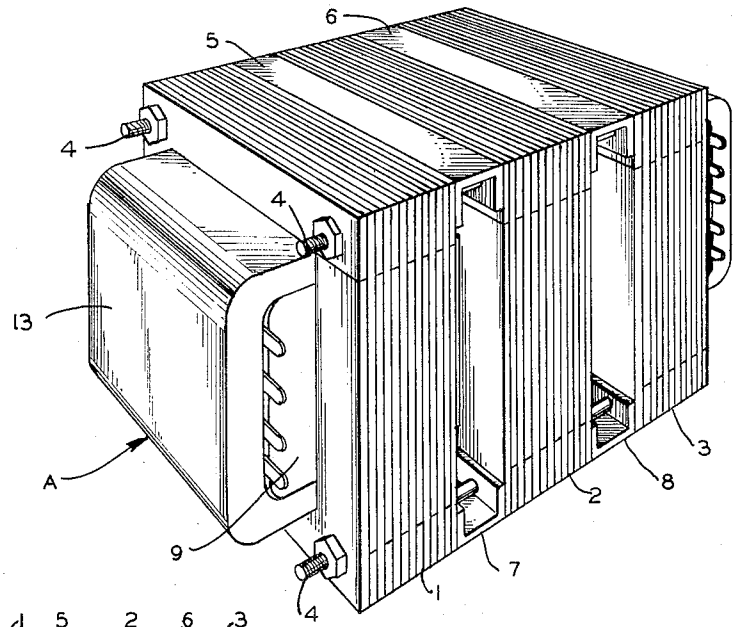
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TRANSFORMER SYSTEM FOR INVERTERS

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FIG. 1



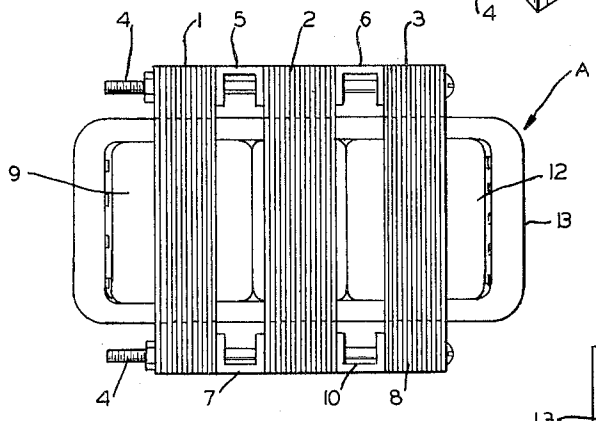


FIG. 2

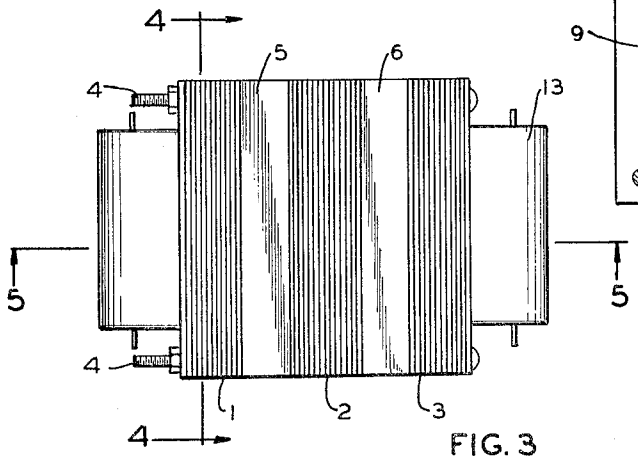


FIG. 3

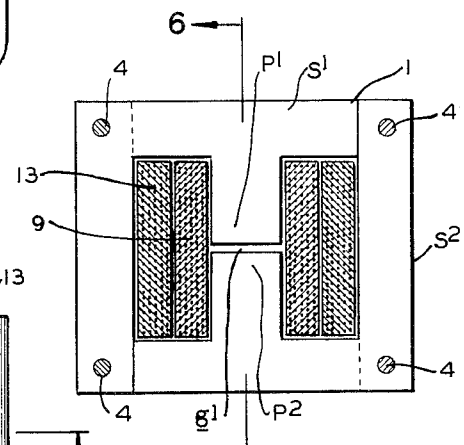


FIG 4

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TRANSFORMER SYSTEM FOR INVERTERS

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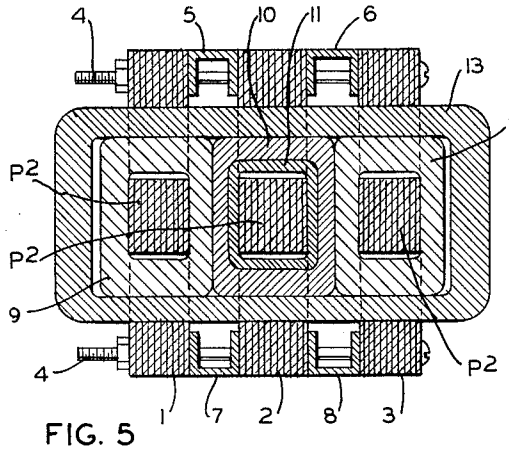


FIG. 5

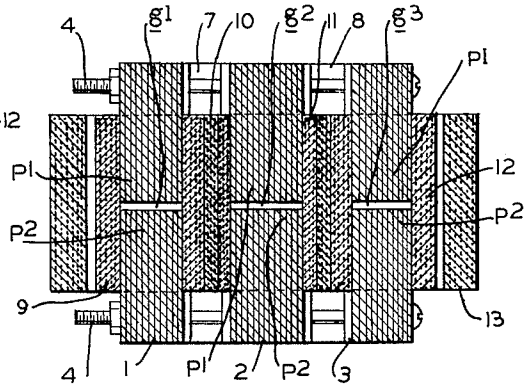


FIG. 6

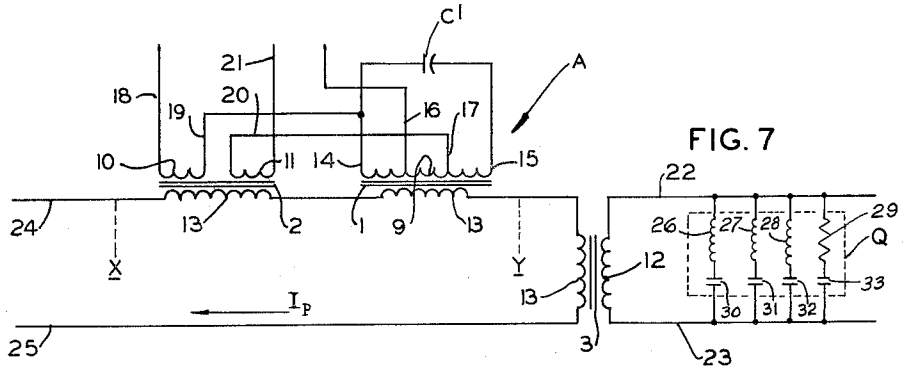


FIG. 7

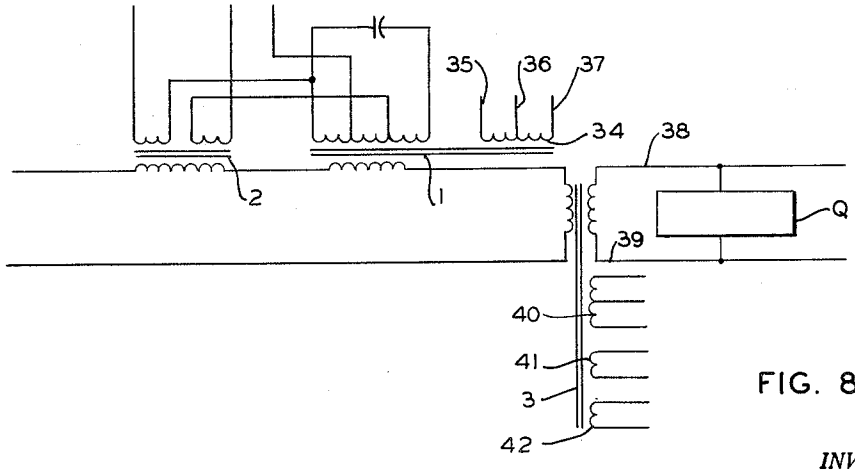


FIG. 8

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United States Patent Office 3,241,048 Patented Mar. 15, 1966

3,241,048

TRANSFORMER SYSTEM FOR INVERTERS

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Filed Dec. 4, 1961, Ser. No. 156,846
6 Claims. (Cl. 323—44)

This invention relates in general to inverters and, more particularly, to an output transformer for transistorized inverters and the like.

It is the primary object of the present invention to provide a simple, relatively compact and comparatively light-weight means for producing a suitable sine wave voltage from the output of a transistor-inverter.

It is also an object of the present invention to provide means for converting the square-wave output of the transistorized inverter to sine wave voltage and filtering out substantially all harmonic voltages.

It is another object of the present invention to provide an output transformer for use with transistorized inverters, which transformed is capable of forming a series resonant circuit, which establishes a low impedance path for current of a selected frequency while establishing a high impedance path for all harmonics of such frequency and thereby filtering out such harmonic voltages.

It is another object of the present invention to provide means for instantaneous cycle-by-cycle limitation of the output current furnished by power transistors, thereby protecting such transistors from destruction which would result from excessive currents.

It is likewise an object of the present invention to provide means for use with transistorized inverter circuitry whereby very precise current and voltage regulations can be achieved.

With the above and other objects in view, my invention resides in the novel features of form, construction, arrangement, and combination of parts presently described and pointed out in the claims.

In the drawings (two sheets)—

FIG. 1 is a perspective view of an output transformer constructed in accordance with an embodying the present invention;

FIG. 2 is a side elevational view of the output transformer;

FIG. 3 is a top plan view of the output transformer;

FIGS. 4 and 5 are transverse and longitudinal sectional views, respectively, taken along lines 4—4 and 5—5 of FIG. 3;

FIG. 6 is a longitudinal sectional view taken along line 6—6 of FIG. 4;

FIG. 7 is a schematic diagram of a voltage converting and filtering circuit embodying the present invention; and

FIG. 8 is a schematic diagram of a modified form of a voltage converting and filtering circuit embodying the present invention.

Referring now in more detail and by reference characters to the drawings, which illustrate practical embodiments of the present invention, A designates an output transformer consisting of three spaced parallel sets of laminations 1, 2, and 3, which are suitably punched and held in stacked relation by means of a plurality of stacking bolts 4 and U-shaped aluminum spacer-channels 5, 6, 7, and 8, all as best seen in FIG. 1.

Each of the sets of laminations 1, 2, 3, is made up of a plurality of identical F-shaped laminate-stampings S^1, S^2, which are inter-leaved, as shown in FIG. 4, and thereby form central leg portions P^1, P^2, which establish narrow core-gaps g^1, g^2, g^3, for the respective sets of laminations 1, 2, 3, as best seen in FIG. 6. The central legs P^1, P^2, of the set of laminations 1 are provided with a single control secondary winding 9. Similarly, the central legs P^1, P^2, of the set of laminations 2 are provided with two concentric auxiliary secondary windings 10, 11, and, finally, the central legs P^1, P^2, of the set of laminations 3 are provided with a single secondary winding 12. The transformer A is also provided with a single large primary winding 13 which extends around and envelopes all of the secondary windings 9, 10, 11, 12, substantially as shown in FIG. 5. Actually, this single primary winding 13 is electrically equivalent to three series-connected separate primary windings and, for convenience of illustration, has been so shown in FIGS. 7 and 8.

The secondary winding 9 is provided with two end-taps 14, 15, and two intermediate taps 16, 17. Similarly, the secondaries 10, 11, are respectively provided with end-taps 18, 19, and 20, 21. The secondary 12 is similarly provided with output leads 22, 23. Finally, the primary 13 is provided with end-taps or so-called input terminals 24, 25.

The transformer A may be connected as shown in the schematic diagram of FIG. 7 in which a large value capacitor C^1 is connected across the end-taps 14, 15, of the secondary 9. The intermediate tap 17 is connected to the end-tap 20 of the secondary 11 and the end-tap 14 is connected to the end-tap 19 of the secondary 10. The circuit accomplishes the various objects above stated in a highly efficient manner. For instance, a series resonant circuit consisting of an inductance formed by the turns of the primary winding 13 encircling the set of laminations or so-called "core" 2 and by a capacitance which appears in the primary circuit due to transformer action between the windings 13 and 9 provides a low impedance path between points x and y in the circuit before a voltage of some selected frequency (e.g., 400 cycles), but a high impedance path for the harmonics which are present at the input terminals 24, 25, for such selected frequency. Connected across the output leads 22, 23, is a so-called "trap" Q of series tuned circuits consisting of a plurality of reactors 26, 27, 28, a resistance 29, capacitors 30, 31, 32, 33, for attenuating the harmonic frequencies and passing the fundamental frequency as a substantially pure sine wave. It has been found in a manner of actual practice that for an input voltage having approximately thirty percent harmonic content, there will be less than two percent harmonic content in the output. If, for example, the input which is applied across the terminals 24, 25, is a four hundred cycle square wave voltage, the output will be a substantially harmonic-free four hundred cycle sine wave voltage. It will, of course, be understood that the magnitude of the input and output voltages can be varied in the usual manner by varying the turns-ratios within the transformer A.

Moreover, the transformer A, when connected as shown in FIG. 7, will provide instant cycle-by-cycle limitation of the current I_p around the primary path. If a load of progressively lower impedance is connected across the output terminals 22, 23, the current will progressively increase, causing progressively increasing voltage drops across the windings 9, 10, 11. However, the set of laminations or so-called "core" 1 is proportioned so that it will saturate magnetically when I_p reaches a peak value at which it is desired to limit the current. As the impedance of the load across the output leads 22, 23, becomes lower, the series circuit becomes detuned due to the saturation of the core 1. The detuning of the series circuit raises its impedance and thereby prevents I_p from increasing any further.

Finally, by reason of the interconnection between the different sections of the secondary winding 9 and the secondary windings 10, 11, there will be substantially equal and opposite voltages connected in series for values of I_p which are below a value sufficient to cause satura-

tion in the core 1. When the core 1 saturates, the control signal or voltage across the taps 14, 15, 16, 17, cannot increase further, while that across the taps 18, 19, 20, 21, of the secondary windings 10, 11, is free to increase as I_p increases further. Thus, signals appear across the taps 16–18 and 16–21 when I_p approaches saturation values. These signals are thus proportional to overload conditions in the load circuit and are fed to a conventional voltage regulator (not shown) to reduce or limit the amplitude of the input across the input terminals 24, 25, thereby precisely sustaining I_p at the desired value.

Adjustment of the gap g^2 allows the series inductance in the primary circuit to be varied in order to obtain minimum impedance between x and y. The gap g^3 is adjusted until the magnetizing current for the core 3 cancels out the capacitive current drawn by the harmonic traps connected to the output leads 22 and 23. The gap g^1 is a small fixed gap in the core 1 which prevents saturation of this core by D.C. components of primary current.

Adjustment of the gaps is easily accomplished by leaving stacking bolts 4 slightly loose as the transformer A is being manufactured and then gently tapping the laminations toward each other to close the gap. The unique geometrical relationship and method of stacking, as shown in FIG. 4, makes this readily possible.

If desired, a modified form of circuit can be provided, as shown in FIG. 8, wherein the core 1 is provided with an additional secondary winding 34 having end-taps 35, 36, and an additional intermediate tap 37, which furnishes signals that are proportional to I_p. Such signal can be fed in any conventional manner to a voltage regulator and, if desired, to a phase detector circuit so as to prevent a drop in the output voltage across the output terminals 38, 39, as a load is placed across such terminals. The voltage regulator and phase detector circuits are conventional and are, therefore, not shown or described herein. The set of laminations or so-called "core" 3 may also be provided with additional secondary windings 40, 41, and 42, which can be conventionally connected to an auxiliary voltage regulator and a phase regulator.

It should be understood that changes and modifications in the form, construction, arrangement, and combination of the several parts of the inverters may be made and substituted for those herein shown and described without departing from the nature and principle of my invention.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. Current-limiting means for use with a device adapted to generate alternating current for a load-circuit; said means comprising output leads from the device, transformer means having a primary circuit connected across the output leads, a first winding inductively coupled to the primary circuit for delivering current to the load-circuit, a second winding inductively coupled to the primary circuit, the second winding having a plurality of intermediate taps thereby dividing the second winding into a plurality of sections, and a pair of auxiliary windings inductively coupled to the primary circuit and respectively connected in series with different portions of the second winding whereby to generate a current-limiting signal proportional to overload conditions in the load-circuit.

2. Current-limiting means for use with an inverter adapted to generate alternating current for a load-circuit, said means comprising output leads from the inverter, transformer means having a plurality of separate cores and a primary circuit connected across the output leads, a power-supply secondary inductively coupled to the primary circuit by one of said cores for delivering current to the load-circuit, a control secondary inductively coupled by another of said cores to the primary circuit and having a signal tap for receiving a control signal and at least two other taps, and a pair of auxiliary secondaries inductively coupled to the primary circuit by still another of said cores, each of said auxiliary secondaries each having two taps, one tap of each auxiliary secondary being a signal tap for receiving a control signal, the other taps of each auxiliary secondary being respectively connected to the other taps of the control secondary whereby to generate a current-limiting signal responsive to overload conditions in the load-circuit.

3. Current-limiting means for use with an inverter adapted to generate alternating current for a load-circuit, said means comprising output leads from the inverter, transformer means having first, second and third separate cores and a primary circuit connected across the output leads, a power-supply secondary inductively coupled by said first separate core to the primary circuit for delivering current to the load-circuit, a control secondary inductively coupled by the second separate core to the primary circuit, and a pair of auxiliary secondaries inductively coupled by the third separate core to the primary circuit and respectively connected in series with at least portions of the control secondary whereby to generate a current-limiting signal responsive to overload conditions in the load-circuit, said first, second and third cores having gaps whereby to increase the impedance of the transformer means.

4. Current-limiting means for use with an inverter adapted to generate alternating current for a load-circuit, said means comprising output leads from the inverter, transformer means having first, second and third separate cores and a primary circuit connected across the output leads, a power-supply secondary inductively coupled by said first separate core to the primary circuit for delivering current to the load-circuit, a control secondary inductively coupled by the second separate core to the primary circuit, and a pair of auxiliary secondaries inductively coupled by the third separate core to the primary circuit and respectively connected in series with at least portions of the control secondary whereby to generate a current-limiting signal responsive to overload conditions in the load-circuit, said first, second and third cores having gaps whereby to render said transformer means saturable at a selected value.

5. Current limiting means for use with an inverter adapted to generate alternating current for a load-circuit, said means comprising output leads from the inverter, transformer means having a primary circuit connected across the output leads, a power-supply secondary inductively coupled by a separate core to the primary circuit for delivering current to the load-circuit, a control secondary inductively coupled by a separate core to the primary circuit, a pair of auxiliary secondaries inductively coupled by a separate core to the primary circuit and respectively connected in series with at least portions of the control secondary whereby to generate a current-limiting signal responsive to overload conditions in the load-circuit, and capacitance means in parallel across the control secondary.

6. Current limiting means for use with an inverter adapted to generate alternating current for a load-circuit, said means comprising output leads from the inverter, transformer means having first, second and third separate cores and a primary circuit connected across the output leads, a power-supply secondary inductively coupled by said first separate core to the primary circuit for delivering current to the load-circuit, a control secondary inductively coupled by the second separate core to the primary circuit, a pair of auxiliary secondaries inductively coupled by the third separate core to the primary circuit and respectively connected in series with at least portions of the control secondary whereby to generate a current-limiting signal responsive to overload condi-

tions in the load-circuit, said first, second and third cores having gaps whereby to modify the impedance of the transformer means, and capacitance means in parallel across the control secondary.

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