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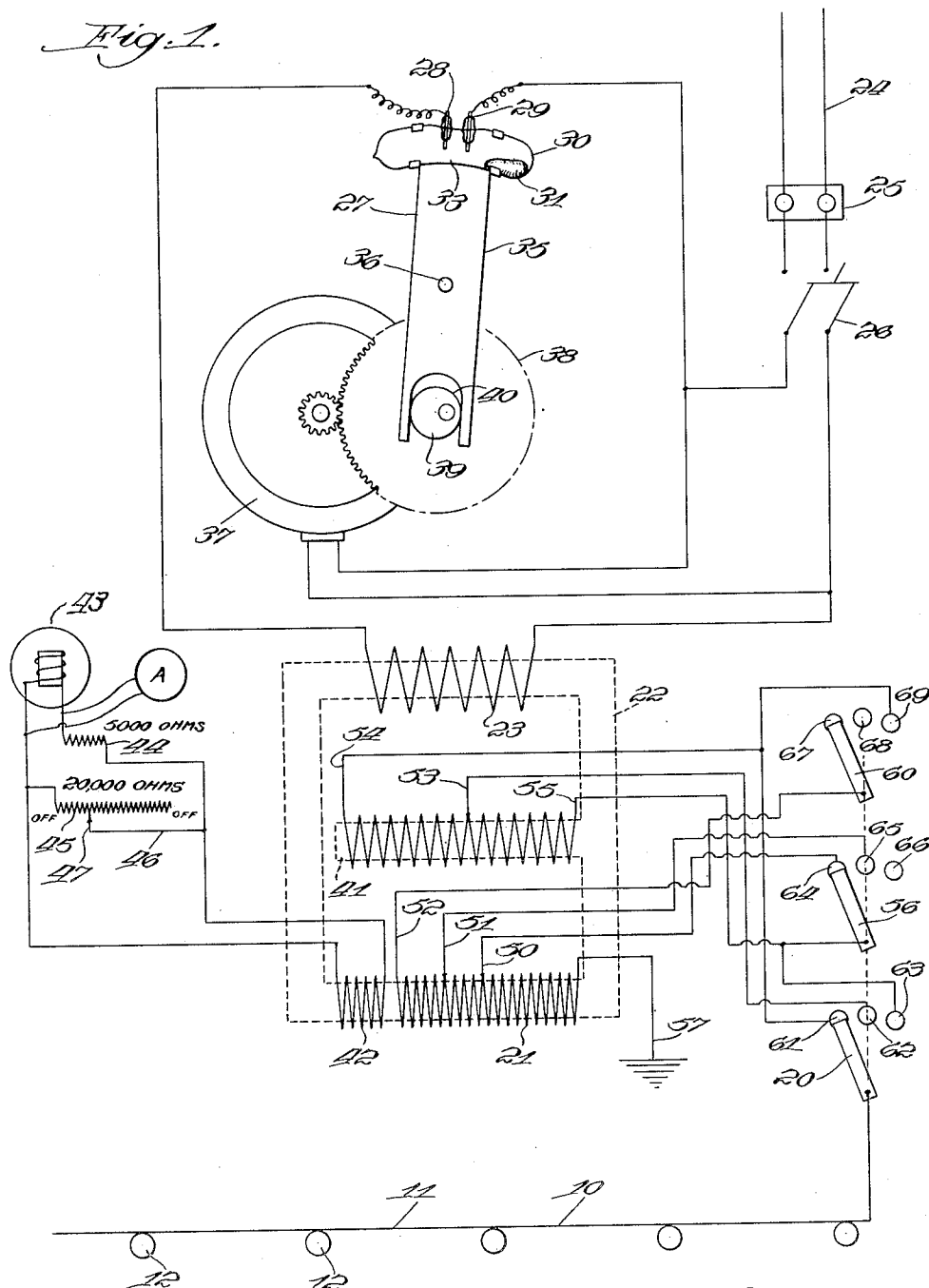
C. PFANSTIEHL

2,249,696

ELECTRIC FENCE

Filed Nov. 4, 1938

2 Sheets-Sheet 1



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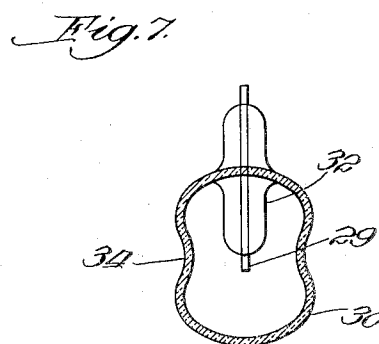
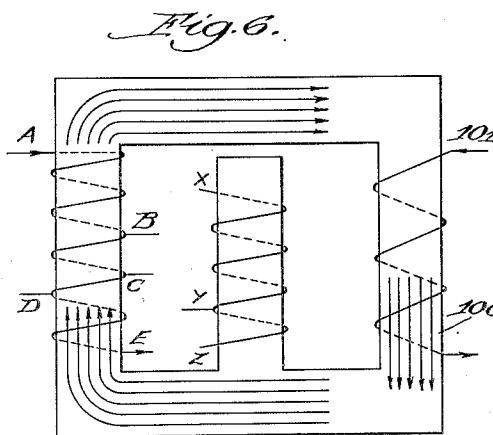
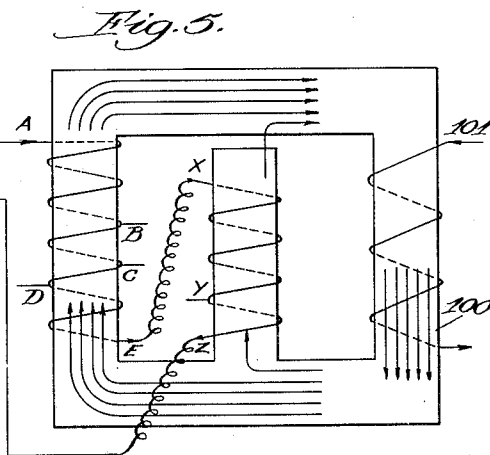
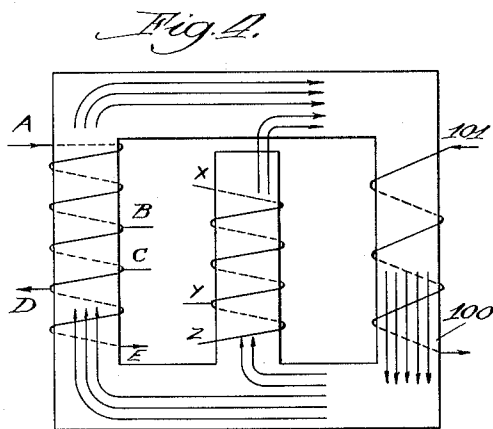
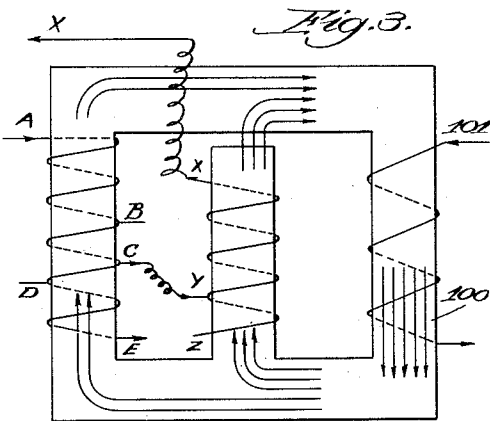
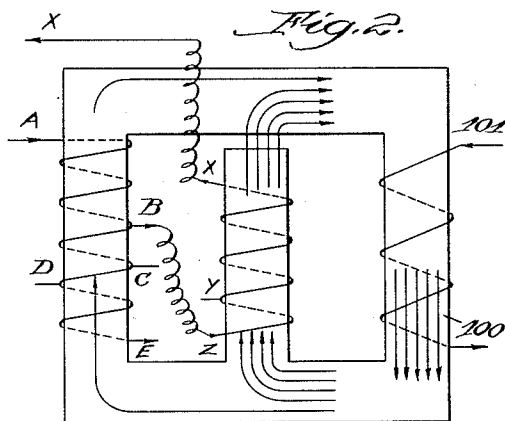
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ELECTRIC FENCE

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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ELECTRIC FENCE

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7 Claims. (Cl. 256—10)

This invention relates to an electric fence and particularly to a means for providing a variable voltage and having a fixed maximum milliamperage on all voltages.

Electric fences designed to prevent passage of animals by use of a mild electric shock have recently come upon the market. These fences consist generally of a step-up transformer designed to increase the usual 60 cycle alternating current 115 volt supply up to voltages between about 500 to about 2,000 volts. Generally, a timing or intermittent device is provided to close the primary circuit of the transformer for very short times at periodic intervals. Generally, the circuit is not closed for more than one-tenth of a second.

Under the general rules and regulations applicable to such fences, this shocking period cannot be applied oftener than once a second, and the maximum milliamperage available upon short circuiting of the high voltage winding should not exceed 25 milliamperes. If a current of 25 milliamperes is exceeded, the device may be fatal to humans as well as to animals. Nevertheless, devices now on the market fail to provide means for insuring that the milliamperage at all times shall be less than this maximum. As a result, there have been several recent fatalities, particularly to children, from the use of such fences. One of the primary reasons for the failure of the fence systems to hold the current available below 25 milliamperes is the fact that variable voltages are necessary under different atmospheric conditions. For example, on a wet day, a voltage of 600 volts may be most suitable for a fence, whereas, on a dry day, 2,000 volts might be more desirable. The transformer employed may make use of a magnetic shunt which will limit the maximum current to the proper amount under one particular voltage condition. However, at lower voltages the maximum current cannot be so controlled under the former systems and can greatly exceed the proper safe amount. In the present system a single multiple tap transformer is employed with a single magnetic shunt, but the transformer and the shunt are so wound and interconnected as to provide at all voltages the proper maximum current and no more.

The invention is illustrated somewhat diagrammatically in the drawings, in which:

Figure 1 illustrates the electric fence circuit; Figure 2 illustrates somewhat diagrammatically the operation of the transformer when operating at short circuit on a 765 volt tap; Figure 3 represents the same transformer action at 1,050 volts; Figure 4 represents the transformer at 1,540 volts;

Figure 5 represents the same transformer at 2,200 volts; Figure 6 shows it as open circuit with no connection; and Figure 7 is a detailed cross sectional view of the interrupter element.

As shown in the drawings, the fence 10 comprises posts 12 and wire 11, which are connected through the switch arm 20 to the secondary 21 of a transformer 22. The primary coil 23 of the transformer is suitably connected to a source of A. C. current 24 which, in this case, is 118 volts A. C. Preferably a low amperage fuse is placed in the system as indicated at 25. A switch 26, adapted to be manually operated, connects the transformer to the A. C. supply 24. In addition, a circuit making and breaking device 27 is provided in series with the transformer, which consists of a pair of contacts 28 and 29, 29 being connected to switch 26 of the A. C. supply and 28 connected at all times with the transformer.

The two contacts are sealed into a glass tube 30 containing a small drop of mercury 31. The base of each of the contacts is protected by an insulating mound 32 which has sufficient height that in no position of the device can the mercury drop extend above the insulation, assuming even that the device is inverted. The glass tube 30 is so shaped that the mercury drop 31 can only contact the two electrodes when it is immediately beneath them, and it is further shaped so that no matter what the position of the glass tube is the droplet is in unstable equilibrium at the time of such contact. This may be accomplished by arching the bottom of the tube as shown at 33 and, further, by carrying the arching around the tube to produce an hour glass effect as shown in Figure 7 at 34. The tube 30 is mounted upon an arm 35 pivotally mounted at 36.

The arm 35 is oscillated by the synchronous motor 37, which operates the gear 38 carrying the cam 39 positioned in a recess 40 in the arm 35. The motor is preferably run at such speed as to provide one contact per second between the mercury droplet and the contacts 28 and 29.

The transformer shown in Figure 1 is a three tap transformer provided with a primary coil 23 having 950 turns, a secondary coil 21 provided with 13,500 turns, and a magnetic shunt 41 provided with 1,950 turns. All of the turns are in the same direction.

Also wound upon the secondary of the transformer is an independent winding 42 of 1,100 turns adapted to produce about 122 volts when energizing the 1 watt neon lamp 43 and when the secondary winding is on open circuit. A resistance 44 of approximately 5,000 ohms is connected

in series with the lamp, and a second resistance 45 of approximately 20,000 ohms is connected in parallel across the winding circuit. This resistance is preferably in the form of a rheostat having off positions at both sides of the resistance and having the connection 46 provided with a movable contact 47.

Under all conditions of the fence, (except when it is completely grounded) when the rheostat 45 is adjusted to include only a very small portion of its total resistance, the light 43 will go out. As the amount of resistance is increased, the light will finally just begin to glow and ultimately it may reach full brilliance. When the fence is completely grounded, however, the light will not glow at any adjustment of the rheostat 45. By calibration, the point on the rheostat 45 at which the light first begins to glow will indicate the amount of voltage being applied to the electric fence. When the fence is in good condition, that is, highly insulated from the ground, there will be a maximum voltage applied to it because, under these conditions, the secondary will be developing its maximum voltage and it follows that the independent winding 42 also will be developing its maximum voltage. Under these conditions it will be necessary to include only a relatively small part of the resistance before the light 43 will begin to glow. In the event of a "dead ground" or short-circuit, however, in the fence, there will be relatively very little voltage in all of these lines, and the light will not glow so readily or not at all. If, on the other hand, the fence is partially grounded, as when weeds or growing plants contact it, there will be a relatively moderate voltage developed by the secondary and also by the winding 42, and it then will be necessary to adjust the rheostat 45 to include more resistance before the light will begin to glow.

The transformer 22 consists of a stack of stampings approximately one inch in height, the stampings being about $\frac{1}{8}$ inch in width. Three taps are provided on the secondary winding of the transformer, namely, 50, 51 and 52, which are placed respectively, at 6,750; 9,000 and 13,500 turns. They are designed to deliver, respectively, 750; 1,000 and 1,500 volts on open circuit. A magnetic shunt 41 having a .030 inch air gap is provided with a winding having a tap 53 located at 750 turns and a tap 54 located at 1,950 turns. The winding on the shunt is also connected through 55 to the switch arm 56. The secondary winding 21 is connected through line 57 to the ground.

A "tap" is here used to mean any means of introducing all or any part of the turns of a winding into the system.

The voltage applicable to a given fence will vary in accordance with atmospheric and other conditions, so that it may be desirable under various conditions to apply widely different voltages. Therefore, the transformer taps are provided at the different points already mentioned. In an ordinary transformer the maximum current deliverable through a given tap connection is different from that deliverable at other connections. In an electric fence it is imperative that the maximum milliamperage which is deliverable through any of the secondary taps under short circuit conditions never exceed 25. On the other hand, in order that the fence be effective in keeping the animals enclosed, it is highly necessary that all of the taps on the secondary be capable respectively of providing not less than 25 milliamperes when on short circuit. A three or more tap transformer having an ordinary

magnetic shunt as used heretofore, may readily be adjusted so that any chosen one of the taps will deliver a maximum milliamperage on short circuit of 25, but under these conditions all of the other taps will deliver different maximum milliamperages on short circuit.

In the present invention, however, the magnetic shunt 41 is constructed so that the maximum milliamperage deliverable at all the different voltage taps respectively may be made not more or less than 25 under short circuit conditions. The theory of such operation is somewhat obscure but will be explained, as it is now understood, later in connection with Figures 2 to 6, inclusive.

In the device shown in Figure 1 the switch arms 20, 56 and 60 are physically connected so that the movement of one automatically moves the other correspondingly. The contacts 61 to 69, inclusive, are respectively connected to the transformer as shown in Figure 1, tap 54 being connected to 61 and 69, tap 53 being connected to 62, the winding on the shunt being connected at 55 to 56 and 63, tap 52 being connected to 60, tap 51 being connected to 65, tap 50 being connected to 64, 63 likewise being connected to 56.

When the switch arm 20 is in contact with contact 61, the other switch arms will be at 64 and 67, respectively. In this case the current will be carried from tap 50 through contact 64, to the shunt winding through line 55, out of tap 54 on the shunt, and then to the fence through 61.

When the switch is in the middle position, the current will be carried to the fence from tap 53 on the shunt through 55 and 65 from tap 51 on the secondary of the transformer. When the switch arms are in the right hand position, the current will be carried to the fence from tap 52, through 69 to tap 54 to line 55 and through 63 to the fence.

In Figures 2 to 6 a transformer, made according to my invention, is shown provided with four taps of 755; 1,050; 1,540; and 2,200 volts, respectively, on open circuit. The transformer comprises a square $4\frac{1}{2}$ inches in width by $3\frac{3}{4}$ inches in height comprising a 1 inch stack $\frac{1}{4}$ inch in width provided with a magnetic shunt of the same width and having an air gap of .032 inch. The primary of the transformer is provided with 950 turns, and the supply circuit is 118 volts 60 cycles. The secondary coil is provided with 18,000 turns and is tapped at 6,750; 9,000; 13,500 and 18,000 turns, respectively.

The following table gives the maximum milliamperage of the various taps at short circuit with the magnetic shunt disconnected.

Taps	Open circuit volts	Max. m. a. short circuit	Turns
A-B-----	765	50	6,750
A-C-----	1,050	37	9,000
A-D-----	1,540	25	13,500
A-E-----	2,200	18.6	18,000

Figure 2 illustrates the arrangement in connection for tapping the transformer at 765 volts. The drawings illustrate what I believe takes place in the transformer during one half cycle when the primary is connected to a 118 volt 60 cycle supply line. As shown in Figure 2, the current enters the primary winding 101 in the direction indicated by the arrow, producing lines of force acting in the direction of the arrows 100 and diagrammatically illustrated thereby. These lines of force pass around the transformer core. The represen-

tation in Figure 2 shows a diagram of the arrangement of the transformer lines of force on short circuit. Four of the lines are shown as being diverted through the shunt and across the air gap, whereas only one of the lines of force passes through the secondary winding. For this connection the ground connection is at tap A, B is connected to the shunt at Z, and tap X of the shunt is connected to the fence. The effect of the winding upon the shunt is to lower markedly the maximum current passing through the secondary winding when it is short circuited. In other words, the number of lines of force diverted through the shunt is greater on account of the winding thereon; therefore the maximum milliamperes is reduced to 25, whereas it would be 50 if the shunt winding were not provided.

In Figure 3 the ground is connected at A, tap C of the secondary is connected to tap Y of the shunt, and tap X of the shunt is again connected to the fence. In this instance only three of the lines of force, indicated by the arrows 100, are diverted through the magnetic shunt. Two of them pass through the secondary winding. In other words, the amount of force diverted through the shunt has been increased but not so much as in the case of the arrangement shown in Figure 2. Again the maximum short circuit milliamperage is 25. Without the winding upon the magnetic shunt the milliamperage would be approximately 37. In the arrangement shown in Figure 2 it would be approximately 50. Therefore, it is not necessary to cut down the current as much in the arrangement shown in Figure 3 as it is in Figure 2.

In Figure 4 the ground is again connected at A, and the fence is connected at tap D. There is no connection to the magnetic shunt. Two lines of force are represented as passing through it, whereas three pass through the secondary winding. This may be taken diagrammatically as the normal arrangement. Again the maximum milliamperage on short circuit is 25.

In Figure 5 the ground is again connected with A, tap E of the secondary is connected to tap X of the shunt, tap Z of the shunt is connected to the fence. In this instance only one line of force is shown as diverted through the shunt as compared to the normal two lines of force passing therethrough. As a result, the maximum milliamperage which would ordinarily be 18.6 on short circuit is increased to approximately 25.

In Figure 6 the transformer is shown on open circuit with no connections. The secondary and magnetic shunt windings of this particular transformer are with 37 gauge wire, these coils being wound in the same direction.

The transformer may also be used for other purposes. For example, a single tap on the secondary may be connectable to various taps, or one tap in reverse direction, on the magnetic shunt winding, in order to produce different maximum milliamperages at a particular voltage. This can also be extended to cover several taps on the secondary, each of which is variously connectable to one or more shunt taps for the same purpose. Thus, any combination of open circuit voltages with any closer shunt circuit milliamperage may be provided, limited only by the capacity of the transformer.

The foregoing detailed description has been given for clearness of understanding only, and no unnecessary limitations should be understood therefrom, but the appended claims should be

construed as broadly as permissible in view of the prior art.

I claim:

1. A variable output voltage transformer of the character described adapted to limit the maximum current deliverable thereby to a fixed value at different voltages, including: a core providing a principal magnetic circuit and a shunt path, the shunt path being provided by a portion of the core having an air gap therein and of such cross-section as to be unsaturated at all operative conditions; a primary winding on one portion of the core; a tapped secondary winding on another portion of the core; a shunt winding on the shunt portion of the core; and means for connecting at least a portion of the shunt winding in series with at least a portion of the secondary, the connecting means being so arranged that the flux density in the shunt portion of the core is high when a small number of secondary turns are in the output circuit and low when a large number of turns are in circuit, whereby the current delivered by the transformer on short circuit is maintained constant despite variations in the open circuit voltage thereof.

2. A transformer of the character claimed in claim 1, wherein the transformer is designed to have a very high voltage to maximum current ratio.

3. A transformer of the character claimed in claim 1, wherein the entire secondary winding is on a portion of the core outside of the shunt magnetic circuit.

4. Apparatus of the character described for providing a high voltage, very low amperage current, variable as to voltage but fixed as to amperage, including: a source of relatively low voltage, high amperage current; a step-up transformer having a core providing a principal magnetic circuit and a shunt path, the shunt path being provided by a portion of the core having an air gap therein and of such cross-section as to be unsaturated at all operative conditions, a primary winding on one portion of the core, a tapped secondary winding on another portion of the core, a shunt winding on the shunt portion of the core; and switch means for connecting at least a portion of the shunt winding in series with at least a portion of the secondary, the connecting means being so arranged that the flux density in the shunt portion of the core is high when a small number of secondary turns are in the output circuit and low when a large number of turns are in circuit, whereby the current delivered by the transformer on short circuit is maintained constant despite variations in the open circuit voltage thereof.

5. Apparatus of the character described for providing a high voltage, very low amperage current, the apparatus providing a plurality of open-circuit output voltages but always limiting the maximum current deliverable to the same maximum value, including: a step-up transformer having a core and primary and secondary windings on different parts of the core, one of said windings being tapped to enable the variation of open-circuit output voltage, said core also having a shunt portion of such cross section as to be unsaturated at all operative conditions and having an air gap therein, and a third winding on the shunt portion of the core; and switch means for selecting the open-circuit output voltage desired and for connecting the third winding to one of the other windings, the switch connections being such that current flow through

the third winding creates a magnetomotive force which assists flux flow through the shunt portion of the core when the open-circuit output voltage is low and bucks flux flow through the shunt portion when the open-circuit output voltage is high.

6. An electric fence comprising an exposed wire, and an electric circuit electrically energizing the wire, said circuit including: a transformer having a core providing a principal magnetic circuit and a shunt path, the shunt path being provided by a portion of the core having an air gap therein and of such cross section as to be unsaturated at all operative conditions, a primary winding on one portion of the core, a tapped secondary winding on another portion of the core, and a shunt winding on the shunt portion of the core; and means for connecting at least a portion of the shunt winding in series with at least a portion of the secondary, the connecting means being so arranged that the flux density in the shunt portion of the core is high when a small number of secondary turns are in the output circuit and low when a large number of turns are in circuit, whereby the current de-

livered by the transformer on short circuit is maintained constant despite variations in the open circuit voltage thereof.

7. An electric fence comprising an exposed wire, and an electric circuit electrically energizing the wire, said circuit including: a step-up transformer having a core and primary and secondary windings on different parts of the core, one of said windings being tapped to enable the variation of open-circuit output voltage, said core also having a shunt portion of such cross section as to be unsaturated at all operative conditions and having an air gap therein, and a third winding on the shunt portion of the core; and a switch means for selecting the open-circuit output voltage desired and for connecting the third winding to one of the other windings, the switch connections being such that current flow through the third winding creates a magnetomotive force which assists flux flow through the shunt portion of the core when the open-circuit output voltage is low and bucks flux flow through the shunt portion when the open-circuit output voltage is high.

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