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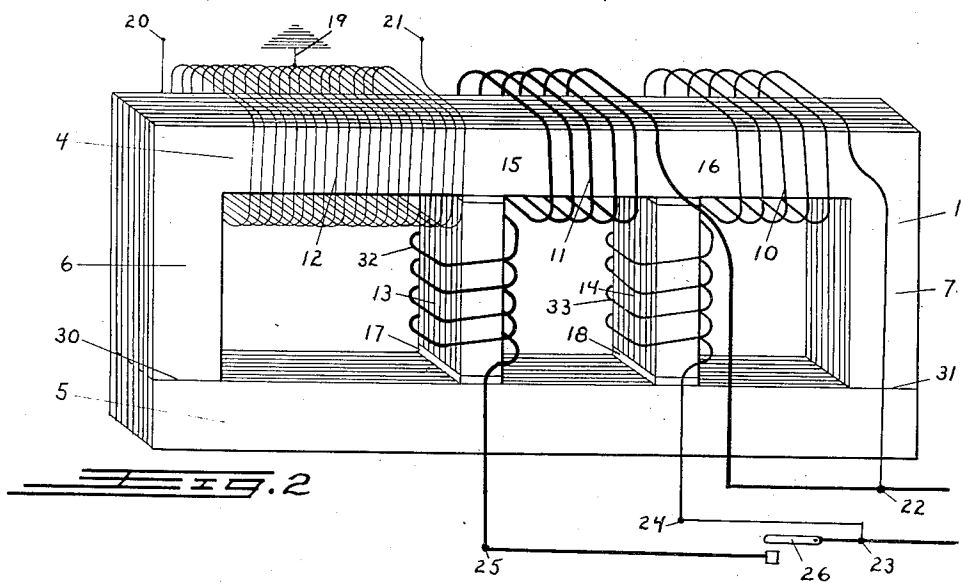
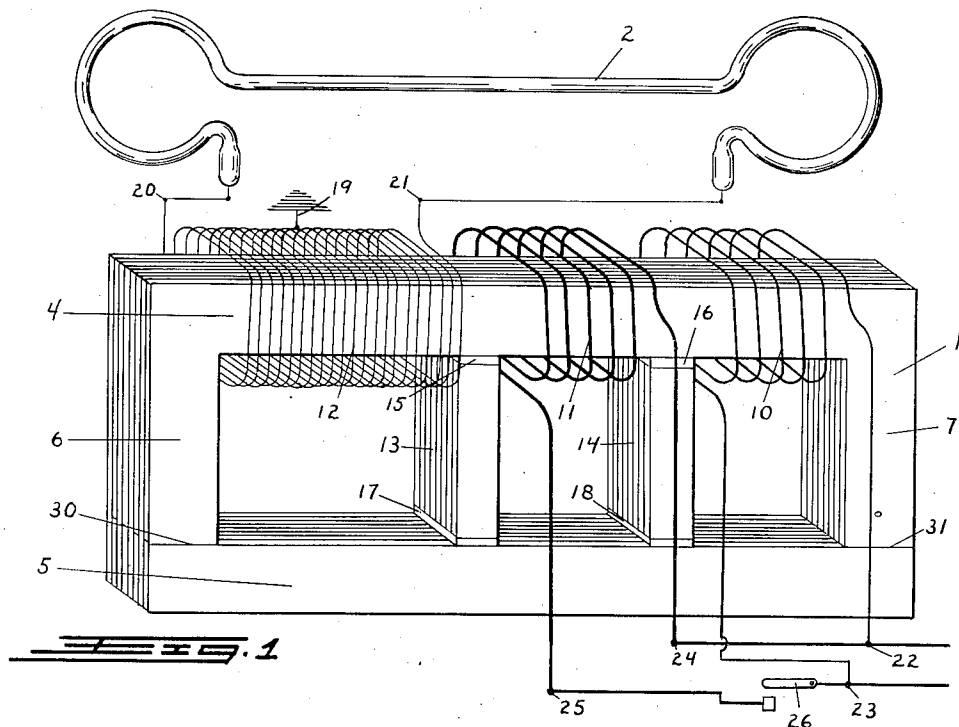
F. McCURTAIN

2,179,795

TRANSFORMER

Filed March 10, 1937

2 Sheets-Sheet 1



INVENTOR

Frank McCurtain

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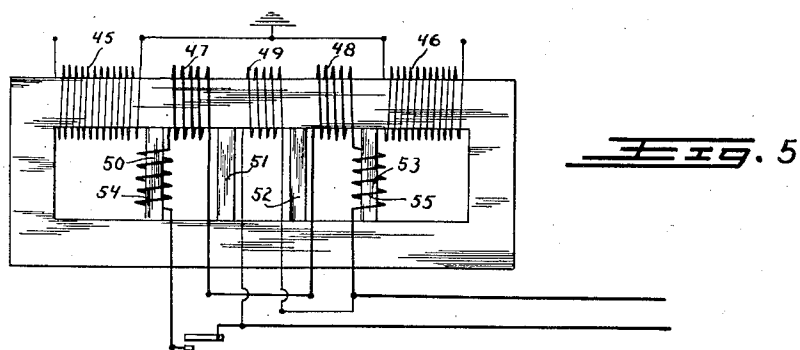
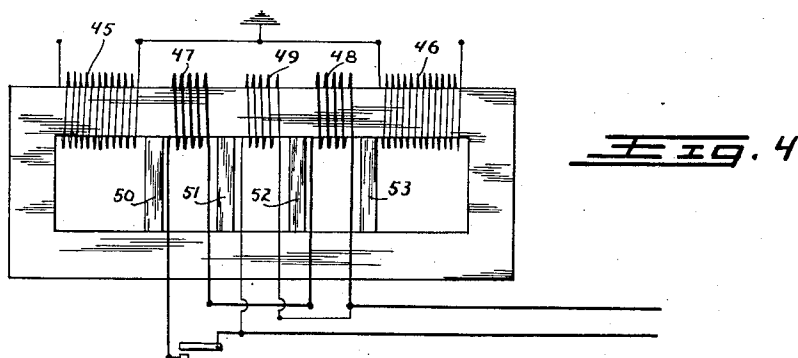
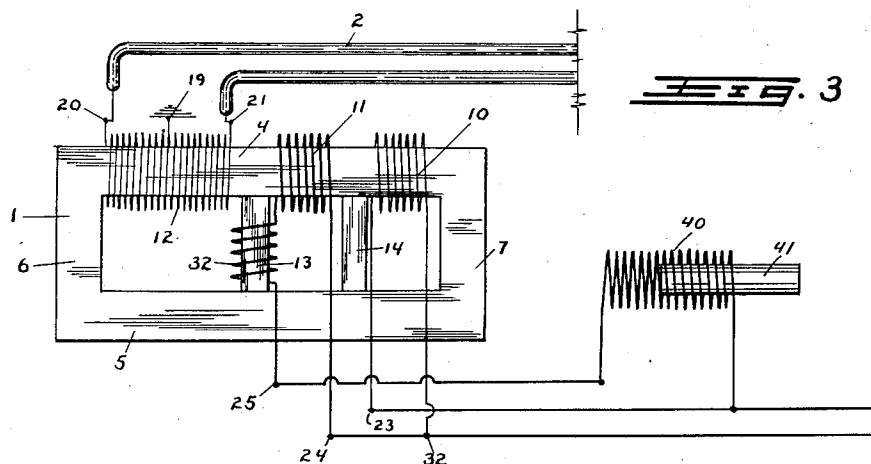
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TRANSFORMER

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2 Sheets-Sheet 2



INVENTOR

Frank McCurtain

UNITED STATES PATENT OFFICE

2,179,795

TRANSFORMER

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Application March 10, 1937, Serial No. 130,079

1 Claim. (Cl. 171-119)

This invention relates to a high reactance transformer for the supply of current to current responsive devices of unstable nature. Typical of such loads are the gaseous conduction lighting tubes, in which connection the invention is illustrated herein in its preferred embodiments. It may, however, be adapted to and used in connection with electric welding and various other loads of the variable resistance type.

The main object of the invention is to provide a transformer suitable for delivering current to unstable load devices, the mean value of which current may be controlled over a wide range of values. In connection with gaseous conduction lighting tubes, this implies that the transformer will develop on each current pulse a voltage sufficient to break down the resistance of the gas column regardless of the mean current flow, the mean current flow being independent of this initial voltage and depending on the transformer adjustment.

Various attempts have been made to produce a transformer suitable for lighting gaseous discharge tubes to variable and controlled intensity. A need exists for such a device for stage lighting, display and general illumination comparable to the uses of dimming with incandescent lamps.

Adaptation of the typical high reactance transformer of the discharge tube lighting art have not been successful for this purpose, which may be understood from a consideration of the function thereof. Such a transformer consists typically, of a primary and a secondary winding fairly loosely coupled to each other on a core structure in which a high reluctance magnetic shunt bridge provides a path for the flux alternate to that through the secondary winding. Since very little current flows in the secondary before the resistance of the gas column of the load is broken down there is very little counter motive force developed and consequently the shunt bridge does not materially effect the voltage across the terminals of the tube. After current flow has been established through the tube, the counter motive force developed by the secondary winding causes a part of the flux to take the path through the shunt bridge, thus restricting the secondary voltage and preventing excessive current flow. The transformer in one respect acts as a choke coil. The power factor is necessarily low and a heavy wattless current flows in the primary circuit.

Any impedance inserted in the primary circuit to regulate the mean current value will also interfere with the development of the minimum initial voltage necessary to establish current flow

through the tube. The degree of this interference will vary with different settings of impedance. There will be a value in each case which will determine the range of adjustment. This value will be that primary impedance which restricts the secondary voltage below the point at which a self sustaining discharge is set up in the tube. The tubes will light below this point, but with a flickering operation and accompanied with violent voltage surges and high frequency effects. Such conditions are highly destructive to the tube electrodes, the insulation and the transformer, and are to be avoided in commercial work.

It has been found also, with this type of installation, that the tendency of the tube to oscillate with its connected apparatus enters as a limiting factor in the design. The typical high reactance shunt bridge transformer has been developed to modify the voltage curve within the limitations of several variables. The degree to which the secondary voltage may be reduced through the shunt bridge action is conditioned by the fact that if the voltage is reduced too far, the discharge is unstable and the tube forms an oscillation generator with the transformer.

The use of regulating impedances with transformers properly designed for steady operation results in carrying the operation into the danger range. To design a transformer of this type for operation in connection with regulating impedances results in bulky and expensive construction. It is an object of this invention to provide a transformer which will develop the minimum striking voltage over a wide range of mean current values without flicker or undue high frequency effects and without sacrificing the light and efficient construction necessary for commercial purposes.

It is known in the art to construct transformers having shunt bridges with windings thereon, the windings being in series with impedances forming circuits independent of the primary or secondary circuits. In such a transformer, energy is drawn off in the shunt bridge coil circuit, thus reducing the energy available for the secondary. It has been found that this circuit forms an oscillating couple with respect to the rest of the device. At some point in the regulation curve a violent oscillation appears and may be strong enough to extinguish the tube. The more loosely coupled the bridge coil is with the primary and secondary, the more definite this effect will be. The regulation curve must naturally be limited to exclude this state of operation, thus placing a severe limitation on the application of this type

of device. It is an object of this invention to provide a transformer for this service in which all the windings are in forced condition with respect to the impressed voltage and in which there are no elements in a state free to set up energy transfers in accordance with any other mode.

A further object of the invention is to eliminate elements within the transformer case which effect regulation of current by consuming energy. One important condition in transformer design is to dissipate the minimum of energy around the windings, which object is complied with in accordance with this disclosure. The use of regulating windings within the transformer must always be attended with comparatively large consumption of energy in such windings and corresponding generation of heat. This heat, by the nature of the case, is developed at the point most disadvantageous for transformer operation and must be taken into consideration in the commercial design. In my transformer the windings are not charged with the duty of dissipating any heat other than that incidental to the normal currents of this work. Thus, transformers made according to my invention may be constructed in the usual manner of gaseous tube lighting transformers, sealed in wax and installed without any special cooling provisions.

Further objects of the invention will become apparent from the following specification in connection with the accompanying drawings.

In the drawings the same numeral is used throughout to indicate the same or equivalent part when found in several views.

Figure 1 is a diagrammatic representation of a transformer constructed according to this invention, provided with a flashing switch and connected to a gaseous conduction lighting tube load. Figure 2 is a representation of a similar transformer provided with windings on the shunt bridges to accentuate the bridge action.

Figure 3 is a diagrammatic representation of a similar transformer modified by the use of a winding on one bridge only and shown connected to an impedance regulator for continuous variation of the tube brilliancy.

Figure 4 is a diagrammatic representation of a transformer having a double balanced secondary winding and primary windings modified accordingly. Figure 5 is a representation of the same transformer modified by the addition of windings on two of the shunt bridges.

In Figure 1 I have shown a transformer made according to this invention connected to a gaseous discharge tube. The tube, indicated by numeral 2, will be understood to represent any of the various types of glow, vapor arc or positive column tubes common in the art. The transformer, indicated by numeral 1, is shown somewhat diagrammatically, in a fashion conducive to clear representation and without regard to physical proportions or ratio of turns in the windings.

The core proper consists of the main legs 4 and 5 and the end bars 6 and 7, which form a closed magnetic circuit. The structure is formed of C shaped and straight laminations interstacked in the joints 30 and 31. In practice these laminations will be riveted, bolted or clamped together. On the leg 4 are positioned the primary windings 10 and 11 and the secondary winding 12. The magnetic shunt bridge 14 is positioned between the windings 10 and 11 and provides a path for the flux developed by winding 10 alter-

nate to the path through the secondary winding. The magnetic shunt bridge 13 is positioned between windings 11 and 12 and provides a path for the flux developed by both primary windings alternate to the path through the secondary windings.

The reluctance of the shunt bridges should be comparatively high as compared with the reluctance of the path through the secondary winding before current flow has been established in the secondary circuit. There are various ways of constructing the bridges. I have represented them as constructed of stacks of iron laminations wedged in between the legs 4 and 5 of the core proper and separated therefrom by the non-magnetic blocks 13, 16, 17 and 18. The laminations may, however, be driven in between the core legs in direct contact therewith and reliance placed on the nature of the contact thus formed to develop the necessary reluctance. The laminations may be riveted together, held by wrappings of insulating paper or otherwise bound in a solid stack.

The terminals 22 and 23 of the primary winding 10 are shown connected to the line. The terminal 25 of the winding 11 is shown connected through the switch 26 to the line, while the other terminal 24 is connected direct to line. Ends 28 and 21 of the secondary winding are shown connected to the tube load. In practice these terminals are brought out in high tension posts set in the transformer case. The mid point of the secondary winding may be grounded as indicated at 19. In practice this is done by grounding the coil to the transformer core and case, it being understood that the case will be connected to ground when installed.

The elements of this transformer are so proportioned that, when connected to the tube load for which it is designed and the primary winding 10 alone is energized, the tube will be lighted in the typical manner to the minimum brilliancy value desired. In this respect the transformer functions in the same manner as the typical shunted bridge transformers of the art, the two bridges in this case acting in the same fashion. When the primary coil 11 is also connected in circuit the tube will be lighted to the maximum brilliancy value desired. The tube may be flashed between these two brilliancy values by means of the switch, the coil 10 remaining in circuit continuously.

I prefer to wind both primary coils so that they will be capable separately of developing a voltage in the secondary winding sufficient to ignite the tube. This means that they should have about the same number of turns, although this may be deviated from in certain cases. However, since the primary 10 in this case is always in circuit during operation, it may be charged with the duty of igniting the tube and the primary 11 in response to other demands wound so that it will not, of itself, suffice for this duty.

Since there is a greater leakage for magnetic flux for coil 10 it may be wound with finer wire than coil 11. In the proportioning of the bridges the same general conditions prevail as in the case of the typical shunt bridge transformers of the art. Close coupling between primary and secondary windings makes for definite voltage rise on each current pulse which is desirable from the viewpoint of ignition of the tube. Leakage through the bridge is desirable from the viewpoint of current regulations. The necessities of insulation also enter the problem by setting cer-

tain minimum spacing between primary and secondary winding.

In each type of installation these considerations may be met by a particular selection of design features. However, for loads which have a strong negative resistance behavior, a modification of the invention shown in Figure 2 may be used. In this view windings are supplied on the shunt bridges. The winding 33 on bridge 14 is in series with primary winding 10. The winding 32 on bridge 13 is in series with primary winding 11. The function of these windings is to intensify the bridge action and increase the spread between the igniting voltage and the burning voltage of the tube. In the application of this feature, the proportions of the transformer may be altered. The coils may be much closer coupled and the section of the bridges reduced. This feature is disclosed and claimed in my copending application, Serial No. 78,153, filed May 6, 1936.

A modification of this construction is shown schematically in Figure 3, in which view a transformer is provided with a bridge coil only on the bridge between the coils 11 and 12. Inasmuch as this bridge carries the heavier flux, it will suffice for some purposes to limit the extra winding thereto.

In this view I have shown a variable impedance in place of the switch. The choke coil 40 is connected in series with the primary winding 11. It is provided with a movable armature 41 by means of which the intensity of the tube may be continuously varied between the extreme values. It is to be understood that this type of variable impedance, or any other type, may be substituted for the switch in the various views in the drawings.

While I prefer to construct the transformer so that each primary winding will have sufficient turns to develop the minimum striking voltage by itself in the secondary winding, this may be deviated from in certain cases. One such case is illustrated in Figure 3. The winding 10 may be considered together with the effective phase of winding 11 at its lowest adjustment as developing the minimum striking voltage since the winding 11 is never completely out of circuit.

In the transformer shown in Figure 4 I have provided a double balanced secondary winding. The secondary is indicated by the numerals 45 and 46, and consists of two coils separated by the double primary 47 and 48 and the single primary winding 49. The primary 49 serves to develop the minimum igniting voltage for both

secondary coils. The primary 47 and 48 serves to develop the major current flow. Four shunt bridges 50, 51, 52 and 53 are provided and function in the same fashion as in the previously described transformers.

In Figure 5 I have shown the preferred manner of applying shunt bridge windings to the transformer of Figure 4. The windings 54 and 55 are in series with the double primary and correspond in their function to the bridge winding of Figure 3. It is to be understood that the disposition of the bridge coils in all the views may be varied in accordance with the various factors controlling the design of transformers for specific purposes.

Having thus described my invention, what I claim is:

Means for selectively controlling the current in a load circuit of varying resistance comprising a source of alternating current, a load circuit of varying resistance, a transformer connected between said source of alternating current and said load circuit, said transformer embracing as its essential parts a closed core structure on which are positioned in the order named a single secondary winding which is connected to said load circuit and two primary windings, both of which are adapted to induce current in said secondary winding, a high reluctance magnetic shunt interposed between said secondary winding and the adjacent primary winding, and a high reluctance magnetic shunt interposed between said primary windings to thereby provide a single shunt around said secondary winding for the flux developed by the adjacent primary winding and parallel shunts around said secondary winding for the flux developed by the primary winding remote from said secondary winding, and one of said primary windings being connected to said source of alternating current and so designed as to send sufficient flux through the core of said secondary winding to cause sufficient current to flow through said secondary winding and consequently through said load circuit to supply a predetermined current to said circuit and means for connecting the other of said primary windings to said source of alternating current, said last mentioned primary winding being so designed as to cooperate with said first mentioned primary winding to send sufficient additional flux through the core of said secondary winding to cause a substantial additional current to flow through said load circuit.

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