

Dec. 9, 1941.

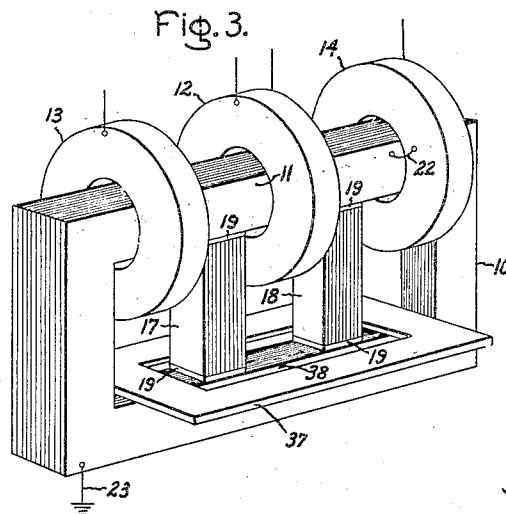
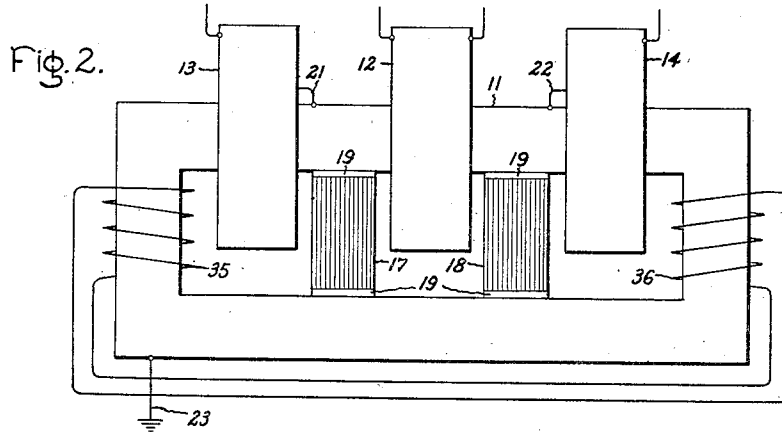
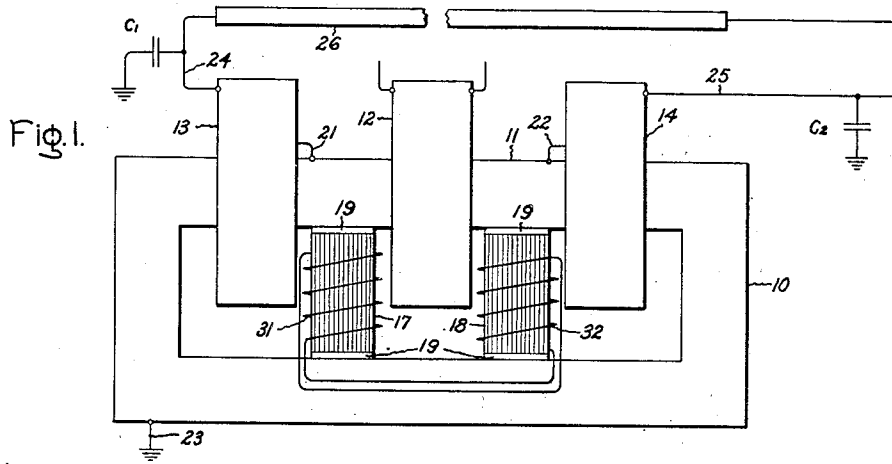
J. R. OUTT

2,265,700

TRANSFORMER

Filed May 10, 1940

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 4.

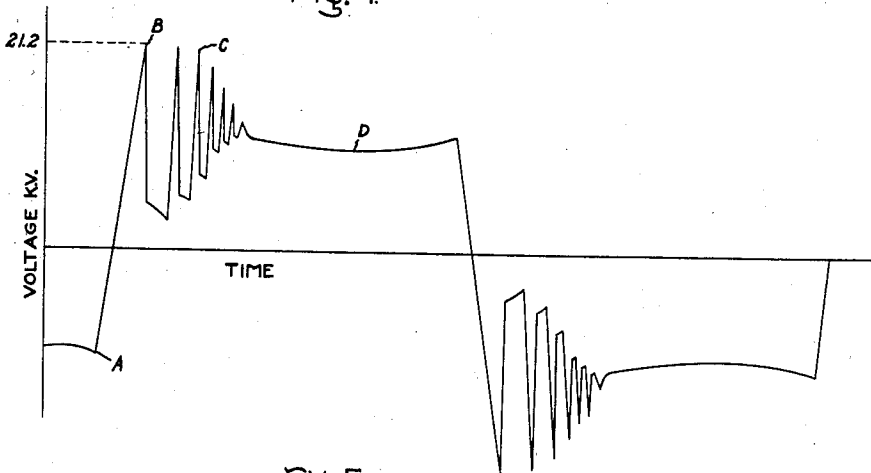


Fig. 5.

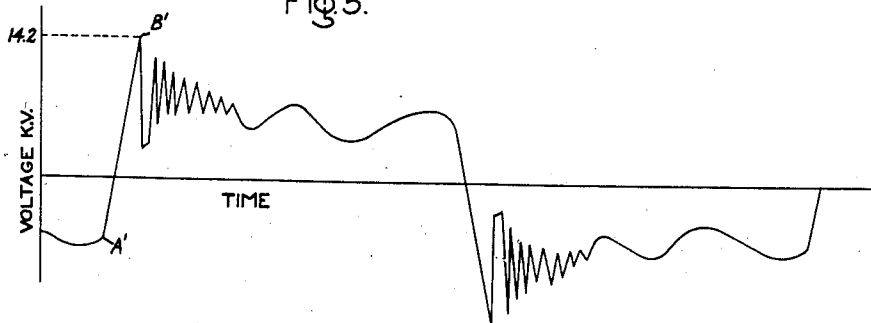
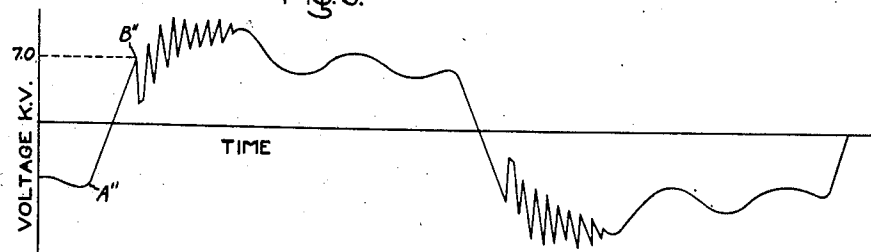


Fig. 6.



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UNITED STATES PATENT OFFICE

2,265,700

TRANSFORMER

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Application May 10, 1940, Serial No. 334,375

8 Claims. (Cl. 171-119)

This invention relates to improvements in transformers, and while it is not necessarily limited thereto it is particularly adaptable to transformers designed for operating high potential luminous tubes.

Certain types of luminous tubes require a high initial voltage in order to ionize the included gas and to overcome the drop at the electrode in each end thereof. Because of the inherent negative resistance characteristic of such tubes, the current flowing therein must be limited following the initial starting in order to prevent damage to the tube. Suitable current limitation is obtained by using transformers having high inherent reactance. Due to the high secondary potentials involved, which may be of the order of 15,000 volts, the matter of insulation for the secondary winding is of major importance and in order to reduce the necessary amount of insulation, it is desirable to ground the midpoint of the secondary winding. In a common arrangement, the secondary winding of the transformer is divided into two separate coils surrounding a core winding leg on opposite sides of a primary winding coil with the inner ends, constituting the winding midpoint, connected together through the grounded core. The high reactance for the transformer is obtained by means of magnetic shunts arranged on opposite sides of the primary coil between it and the adjacent secondary coils. By this coil arrangement the bottom conductor layers of the two secondary coils, being at substantially ground potential, may be relatively easily insulated from the core. With the total secondary potential divided equally between the two coils, the voltage across each coil would only be one-half of the line to line value or in the case of a 15,000 volt secondary, the maximum value for which each coil would have to be insulated would be 7,500 volts.

Experience has proven, however, that such insulation levels of transformers of conventional design even as adjusted by normal safety factors are inadequate for ordinary service with the result that insulation must be provided for the coils greatly in excess of the calculated amount. This procedure is costly and results in an inefficient transformer design.

A detailed study of the functional characteristics of such transformers revealed the fact that the voltage conditions in the two secondary winding coils are uniform only under ideal operating conditions which rarely occur in the normal installation. It has been discovered by a com-

parison of the oscillographic voltage wave forms of the two coils of a transformer connected in a typical manner to a tubing load that peak voltages occurred across one coil very much greater than the simultaneous voltage condition across the other coil. Such unbalanced peak voltages greatly in excess of the rated coil voltage are largely responsible for insulation failures. Tests have shown that if the transformer is so constructed that the secondary voltage is forced to divide equally between the winding coils regardless of the external circuit characteristics, the problem of insulating against excessive peak voltages is minimized.

It is therefore an object of the present invention to provide a new and improved transformer of the general type described in which a substantially balanced condition of voltage is maintained across the plurality of series connected secondary winding coils.

For a better understanding of the invention, attention is directed to the following specification taken in connection with the accompanying drawings in which Fig. 1 is a plan view of a transformer constructed in accordance with one form of my invention; Figs. 2 and 3 are other views illustrating other modifications of the invention; and Figs. 4, 5 and 6 are explanatory curves.

Referring now to the drawings, the invention will be described as applied to a transformer of the luminous tube type comprising a rectangular magnetic core structure 10 having a winding leg 11 with a primary or low voltage winding coil 12 centrally disposed therearound and a pair of secondary or high voltage winding coils 13 and 14 provided on opposite sides of the primary winding coil and spaced therefrom. A pair of magnetic shunts 17 and 18 is arranged within the core window on the opposite sides of the low voltage primary winding 12 and adjacent thereto, the shunts being secured in position in any suitable manner and spaced slightly from the adjacent core legs of the structure by suitable shims 19 of nonmagnetic material providing a relatively high reluctance for the shunt paths and providing an arrangement for producing a relatively high reluctance in the flux paths of the secondary windings.

The inner end turns of the high voltage coils 13 and 14, constituting the midpoint of the total secondary winding, may be connected as indicated at 21 and 22 to the core 10 which in turn may be grounded as indicated at 23. The opposite ends of the high voltage secondary wind-

ing coils may be connected as indicated by leads 24 and 25 to a suitable luminous tube load indicated at 26.

The leads will have a considerable capacitance to ground varying of course with the particular nature of each installation. In the case of large outdoor signs, for example, the leads may be relatively long and the distributed capacitance thereof to ground may be quite large. These capacitances may be lumped and represented by elements C_1 and C_2 for the leads 24 and 25. It has been observed by oscillographic studies that the line to ground voltages from the two leads do not have the same wave form unless the line to ground capacitances C_1 and C_2 are equal. This is a very unusual case, however, for generally one lead is much longer than the other as when the transformer is arranged near one end of the sign so that the values of the capacitances C_1 and C_2 are materially different from each other.

In Fig. 4 is illustrated a typical wave form for the secondary, line to line voltage. Starting at voltage point A, the voltage across the transformer reverses and recovers rapidly until the breakdown voltage of the tubing is reached at point B, it being assumed in this instance that the crest voltage required in this instance is 21.2 kv. Immediately following the initial breakdown of the tube the voltage fluctuates as at C for a short period as a result of the repeated breakdown and recovery phenomena and gradually stabilizes as at D for the balance of the half-cycle according to the negative volt-ampere characteristic.

In Figs. 4 and 5 are shown typical wave forms illustrating line to ground voltage conditions for the two individual winding coils 13 and 14, respectively, of the transformer thus far described with the two leads 24 and 25 having unequal capacitances to ground, it being assumed that capacitance C_2 is the larger. When the tubing stops conducting at the points A' and A'' of the respective voltage waves, the secondary coils would each immediately recover to the full value of the open circuit secondary voltage induced by the flux change at that instant, if there were no capacitance in the secondary circuit. But the line to ground voltages of the two leads are retarded in their recovery by their respective capacitances to ground and in the assumed case in which C_1 is less than C_2 the voltage from lead 24 to ground will recover more rapidly because it has a smaller capacitance to charge. Within a period of time after the voltage wave crosses the axis, the total line to line voltage reaches the breakdown value of the tube, assumed at 21.2 kv. crest, but this value is not divided equally between the two coils. Due to the greater retardation of the voltage across C_2 , an initial crest potential B' of approximately 14.2 kv. may be built up across the coil 13 while a crest potential B'' of only 7 kv. is built up across the coil 14. Such peak voltages as that occurring across the coil 13 in this instance, greatly in excess of its normal rating, impose severe stresses upon its insulation and frequently result in the ultimate failure thereof. It is obvious of course that this unbalanced condition could be corrected by a proper installation of the apparatus but this is not always feasible and what is more significant is that the matter of installation is beyond the control of the transformer manufacturer so it is desirable that the transformer itself be so designed as to compen-

sate for any irregularities of the installation arrangements.

In accordance with this invention I have provided a transformer in which the crest value of the breakdown voltage of the tubing is divided equally between the two secondary coils regardless of any unbalance occurring in the load capacitances. In the modification illustrated in Fig. 1, tertiary windings 31 or 32 are provided around or magnetically associated with the magnetic shunts 17 and 18, respectively, which windings are connected together in a closed circuit in opposition with respect to each other. Thus the windings 31 and 32 provide an energy transferring winding arranged around portions of the magnetic core, each portion having magnetic flux produced by magnetomotive force from one of the secondary winding coils. By this winding arrangement the rate of recovery of voltage in the two secondary coils 13 and 14 when the tube stops conducting is equalized, since any difference in the rate of change in flux in the two magnetic shunts of the core structure is reacted upon by a surge of current in the tertiary winding circuit. While I do not wish to limit the invention to a transformer having a tertiary winding arrangement as shown with a specific resistance value, tests have shown that a very low resistance tertiary winding circuit is not desirable since it tends to transfer too much energy at 60 cycles when one secondary coil is short circuited and the other is left open. On the other hand, since the amount of energy required to charge the capacitance of the secondary circuit is small, a considerable resistance in the auxiliary winding circuit does not seriously decrease the desired voltage balancing action. If the resistance of the tertiary circuit is made high enough so that short circuiting one secondary coil gives from one-quarter milliampere to three milliamperes more current than short circuiting both, the results obtained for voltage balancing purposes have been found to be substantially equal to those obtained by using a very low resistance tertiary winding arrangement.

In Fig. 2 is illustrated a second modification of the invention in which the tertiary winding coils 35 and 36 are provided around the outer legs of the magnetic core structure and connected together in opposition. This arrangement functions in substantially the same manner as that described above to maintain a substantially uniform distribution of the voltage in the two secondary high voltage winding coils during all conditions of operation thereof. In Fig. 3 is illustrated a simplification of the tertiary winding arrangement and in this instance comprises a single turn linking the two flux circuits of the high voltage secondary winding coils 13 and 14. The single turn may consist of sheet 37 of suitable metal having a punched aperture 38 through which the magnetic shunts 17 and 18 extend. This arrangement is the full equivalent of either of the previously described modifications but lends itself to more economical manufacture.

Having described the principle of operation of my invention together with the apparatus which I now consider to represent the embodiments thereof, I desire to have it understood that the apparatus shown is merely illustrative and that the invention may be carried out by other means.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A transformer having a magnetic core structure, a relatively low voltage primary wind-

ing, a pair of relatively high voltage secondary windings disposed on the opposite sides of said primary winding and spaced therefrom, magnetic shunts disposed between said primary winding and said secondary winding coils, said secondary winding coils having corresponding ends connected together and grounded, the ends of said secondary coils opposite said grounded ends being adapted to be connected to a luminous tube load by leads having unequal capacitances to ground, means for causing a substantially uniform distribution of voltage between said two secondary winding coils, said means comprising tertiary windings provided around said magnetic shunts and connected together in a closed loop circuit in electrical phase opposition.

2. A transformer comprising a magnetic core structure having a winding leg, a relatively low voltage primary winding coil arranged around said leg, a pair of relatively high voltage secondary winding coils arranged around said leg on opposite sides of said primary winding coil and spaced therefrom, magnetic shunts arranged between said primary and said two secondary coils, said two secondary coils being adapted to be connected in series to a load by leads having unequal capacitances to ground, and energy transferring winding means connected in a closed circuit electrically insulated from said primary and secondary winding coils and arranged around portions of the magnetic core, each portion having magnetic flux produced by magnetomotive force from one of said secondary winding coils so as to maintain a substantially balanced condition of core flux through each of said secondary winding coils.

3. In combination, a transformer having a magnetic core structure, a primary winding, a pair of secondary windings arranged on opposite sides of said primary winding, magnetic shunts arranged between said primary and said secondary windings, said secondary windings having grounded inner turns and outer turns connected in series with a load, and a current conductor electrically insulated from said windings forming a closed circuit linking the magnetic circuit for each of said secondary windings so as to maintain a substantially balanced distribution of voltage across said secondary windings.

4. A transformer comprising a magnetic core structure having a pair of relatively high voltage secondary winding coils arranged thereon, said winding coils being adapted to be connected in series to a load, said core structure including magnetic shunts for each of said winding coils,

and means including a pair of interconnected windings electrically insulated from said coils and arranged on spaced parts of said core structure for maintaining a substantially uniform balanced condition of core flux through said coils.

5. In combination, a transformer having a magnetic core structure, a primary winding coil, a pair of secondary winding coils, magnetic shunts disposed between said primary coil and each of said secondary coils, and a closed circuit winding means electrically insulated from said primary and secondary winding coils linking the magnetic circuits for each of said secondary coils so as to maintain a substantially balanced condition of core flux through each of said secondary coils.

6. In combination, a transformer having a magnetic structure, a pair of windings connected in series to a common load, said core structure providing flux paths for said pair of windings and having means producing a relatively high reluctance in said flux paths of said pair of windings and additional winding means connected in a closed circuit electrically insulated from said pair of windings and magnetically associated with said flux paths for maintaining substantially equal the instantaneous voltage condition appearing across said windings.

7. In combination, a transformer having a magnetic core structure, a primary winding and a pair of secondary windings on said core structure, said core structure providing individual flux paths for said secondary windings, said core structure having means for producing a relatively high reluctance in said flux paths of said pair of windings, and winding means connected in a closed circuit electrically insulated from said primary and secondary windings linking said flux paths for regulating the instantaneous voltage condition appearing across said secondary windings.

8. In combination, a transformer having a magnetic core structure, a primary winding and a pair of secondary winding coils, said core structure including a relatively high reluctance shunt core flux path for each of said secondary winding coils, and winding means arranged in a closed circuit electrically insulated from said primary and secondary windings interlinking the core flux paths for said secondary winding coils to regulate the instantaneous condition of core flux through said secondary winding coils.

JOHN R. OUTT.