

Dec. 16, 1941.

P. BERGER

2,265,980

ELECTRICAL ENERGY REGULATING MEANS

Filed Aug. 24, 1938

2 Sheets-Sheet 1

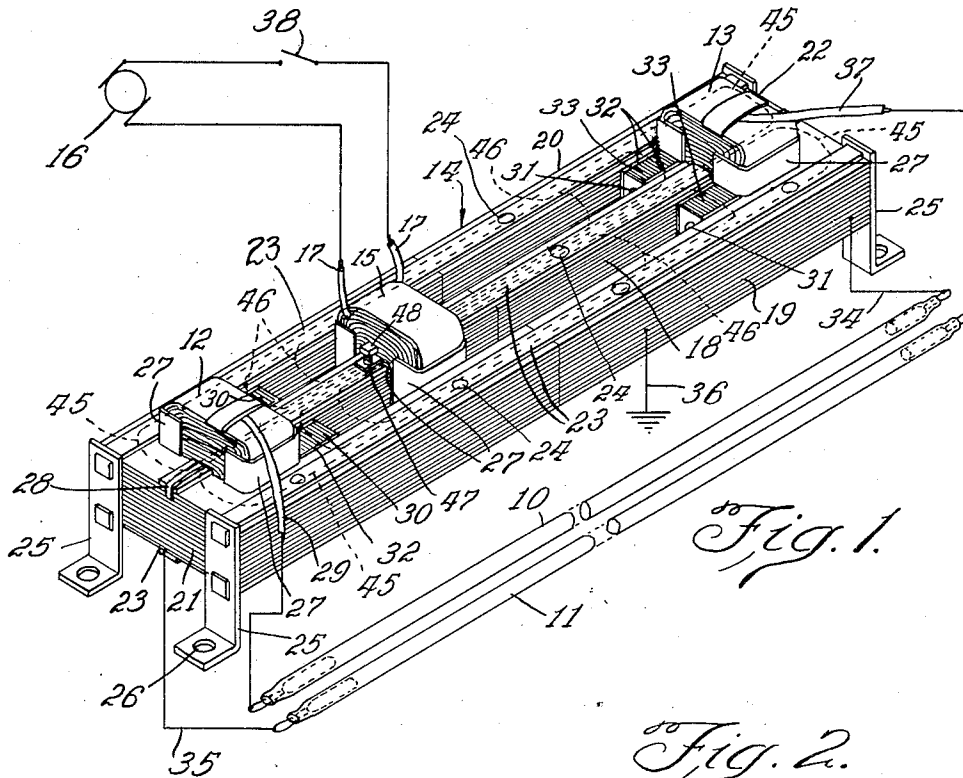


Fig. 1.

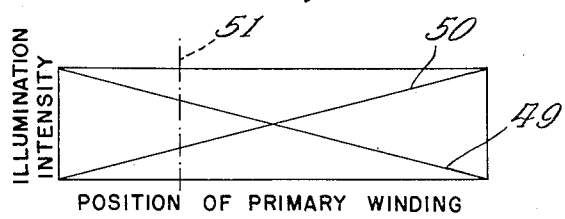


Fig. 2.

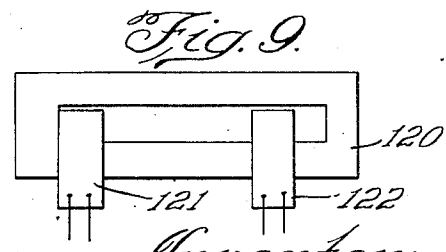
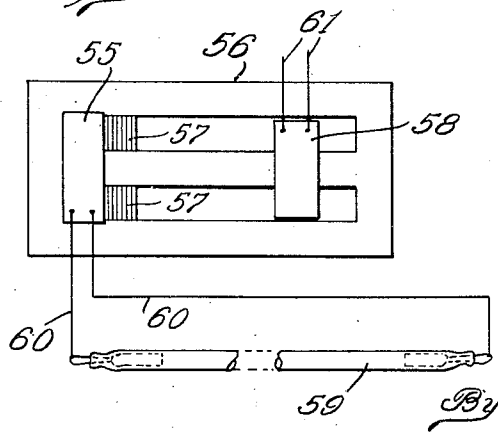


Fig. 9.

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2 Sheets-Sheet 2

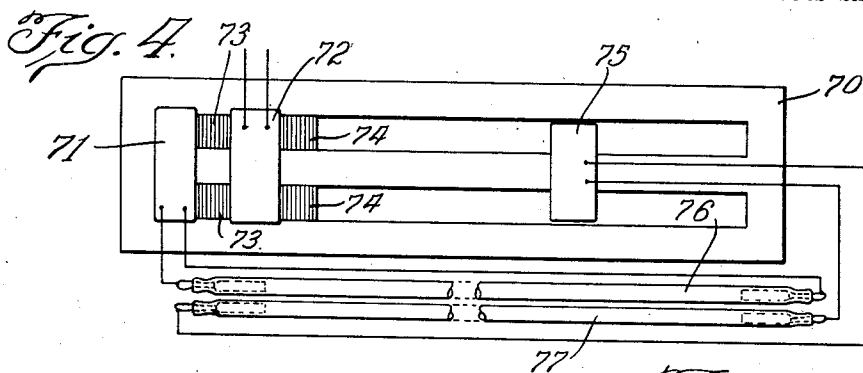


Fig. 5.

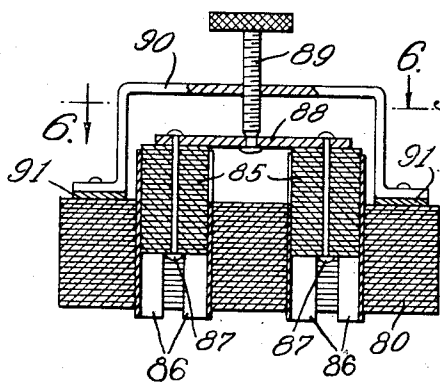


Fig. 6.

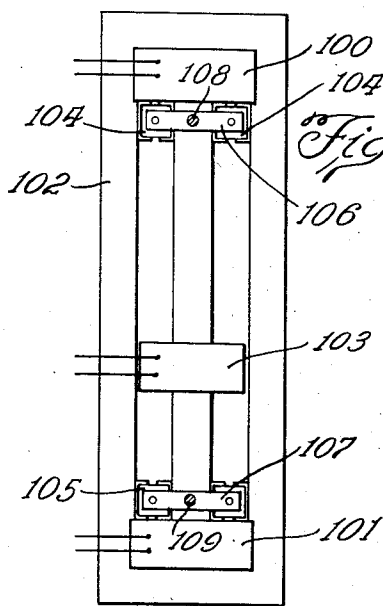
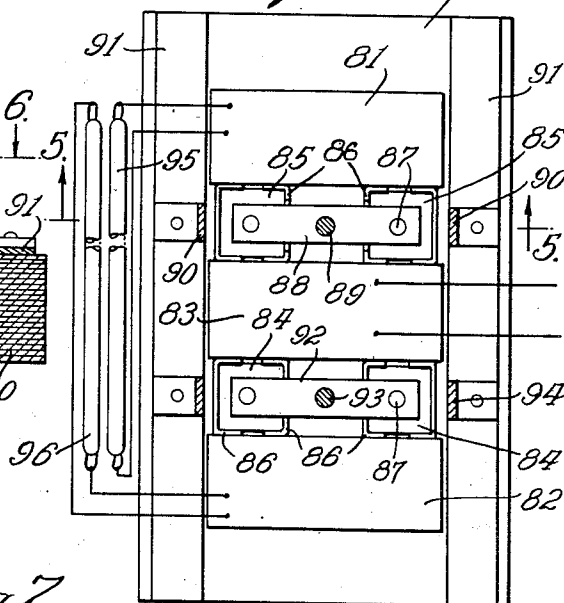


Fig. 7.

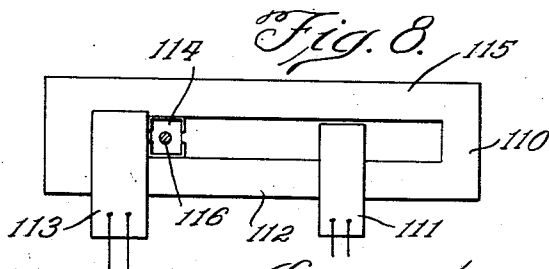


Fig. 8.

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UNITED STATES PATENT OFFICE

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ELECTRICAL ENERGY REGULATING
MEANS

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6 Claims. (Cl. 176—124)

This invention relates generally to the art of regulating the electrical energy supplied to a load circuit. It is directed especially to illumination, and particularly to illumination by means of gaseous discharge tubes, and to the provision of means for regulating the intensity of illumination from such tubes.

Gaseous discharge tubes are used to provide illumination for lighting purposes and for signs. Lighting may be accomplished by combining light from separate tubes emitting differently colored light to produce a white light which is sufficiently similar to natural daylight to be satisfactory for lighting purposes. In this art it is frequently desirable to be able to adjust the intensity of the light of the different colors so that the resulting composite light has the proper shade of white for the best lighting effectiveness. For example, the combination of a neon tube which emits an orange-red colored light, and a closely associated mercury vapor tube having a coating of green fluorescing salts upon its interior walls, produces a white light. The proportion of illumination supplied by each tube determines the color of the composite light, and if this is varied within wide limits the resultant light varies from one which is substantially green through varying shades in which the green becomes less predominant and the light takes on the character of a white light with a greenish cast, through white, to white with a reddish cast and finally to a light which is substantially orange-red. If no means are provided for regulating the quantity of illumination from the differently colored tubes, they must be associated at the outset with the proper proportion, which is often attended with difficulties. Furthermore, the colored light from a tube having a coating of fluorescing salts frequently undergoes a change of intensity with use, so that proportions which may be satisfactory at the outset may become unsatisfactory and produce a definite shade of green or red after the light has been in use for a time. Under such conditions it may be necessary to add one or more tubes to supply a deficiency. It is apparent that it is highly desirable to have a means for adjusting the color proportions in a more convenient manner.

Where surfaces and objects such as the ceilings of theatres, the sprays of fountains, and the like, are illuminated in color by indirect light, it is frequently desired to vary the intensity and the color to obtain pleasing effects. Similarly with signs, for advertising and other purposes, pleasing and also spectacular effects are obtained by

varying the colors and the intensity. The sign may be composed of one, or of a number of colors, and it may be desired to vary the color or the intensity continuously or intermittently, or merely to adjust them to some condition which will thereafter remain constant.

Means have been provided heretofore for adjusting the intensity of illumination of electrical lighting sources by varying the impedance in the electrical supply circuit. However, difficulties attend the use of such means with gaseous discharge tubes. Such tubes require a high initial or striking voltage and a relatively low operating voltage, as is well known, and the interposition of impedance in the supply circuit frequently causes the supply voltage to be lowered below the required initial voltage, especially since the system is usually constructed so as to provide a voltage not greatly in excess of such initial voltage. The applied voltage decreases to zero value twice in each complete cycle of the alternating current supply and during these times the tubes are inoperative and open circuit conditions exist and the operation of the tube must be initiated twice during each cycle. Consequently flickering of the tubes takes place, and sometimes complete extinguishment, when the applied voltage on open circuit is not adequate to meet the initial voltage requirements of the tube.

It is the general object of the invention to provide an improved means for regulating the energy supplied to a load circuit.

It is the specific object of the invention to provide an improved means for regulating the intensity of illumination of gaseous discharge tubes which is simple and economical, and is convenient in operation, requiring only the manipulation of a movable member, and not requiring the addition of tubes to supply a deficiency of a color.

It is a further object of the invention to provide such a regulating means which overcomes the flickering and extinguishment mentioned above and provides an even continuous illumination at all intensities down to the condition in which the light is substantially extinguished.

It is a still further object of the invention to provide a regulating means which accomplishes a smooth, continuous intensity change rather than an irregular, step-by-step change.

To describe the invention briefly, the supply circuit for gaseous discharge tubes usually contains a transformer of the so-called high-leakage reactance type, in which there are magnetic shunts between the primary and secondary wind-

ings, through which shunts the magnetic flux leaks, or by-passes, the secondary winding. The transformer may be of the shell or core type both of which are well known, and in which fixed stationary windings surround one leg of the magnetic core, called the winding leg, and the shunts are located in the spaces between the winding leg and the other leg or legs. In accordance with this invention, one of the windings of the primary and secondary windings is movable along the winding leg into positions at varying distances from the other. As the distance between the windings is increased the proportion of the flux which follows the leakage path through the shunts and the air gaps adjacent the shunts becomes greater with the result that the flux which follows the useful path, that is, which threads the secondary winding, is proportionately less and the illumination of the tubes which are connected in the output of the secondary winding is correspondingly decreased. While this is the effect during that portion of the alternating current wave cycle during which the tubes are operative, that is, the active portion of the cycle, the variation of the distance between windings produces little or no such effect during the inactive portion of the cycle. At that instant the relative reluctance of the leakage path and the useful path is substantially the same regardless of the distance apart of the windings. As a result the initial voltage is not affected to any substantial degree by the movement of one of the windings, and the requisite initial voltage is always available and applied to the tubes. It has been found in practice that the windings may be moved so far apart that the illumination is only barely visible while a steady light without any flickering is maintained. In a modification of the regulating means, the shunt members of the transformers, rather than one of the windings, are movable to vary the leakage reactance.

In the drawings:

Fig. 1 is a perspective view, partly diagrammatic, of several colored gaseous discharge tubes and a supply circuit therefor including the means of this invention for regulating the intensity of illumination of the tubes;

Fig. 2 is a graphic representation of the variation of illumination intensity provided by the invention, with particular reference to the combination illustrated in Fig. 1;

Figs. 3 and 4 illustrate diagrammatically two modified forms of the intensity regulating means of this invention;

Fig. 5 is a fragmental, sectional view of a modification of the intensity regulating means in which the shunt members of the supply transformer are movable to vary the leakage reactance said view being taken along line 5-5 of Fig. 6;

Fig. 6 is a sectional view, partly diagrammatic, taken along 6-6 of Fig. 5; and

Figs. 7, 8 and 9 are diagrammatic plan views showing three further modifications of the invention.

In Fig. 1, tubes 10 and 11 are differently colored gaseous discharge tubes, which may be of any desired color. For purposes of representation, tube 10 is a neon tube emitting an orange-red light, and tube 11 is a mercury vapor discharge tube having a coating of green fluorescing salts, emitting a light which is predominantly green but also contains the visible blue of mercury vapor. The tubes are connected separately to each of the two secondary windings 12 and 13 of the

supply transformer 14. The primary winding 15 of the transformer is connected to a suitable source of alternating current electrical energy 16 by means of conductors 17.

The transformer 14 comprises a closed magnetic core composed of steel laminations. The core is of the so-called shell type, comprising an elongated central or winding leg 18 and two outer legs 19 and 20 which are spaced from the central leg 18 in the usual manner, the legs all being connected together at their ends by the end portions 21 and 22. The laminations are fastened together into a unitary structure by means of iron straps 23 which extend along the top and bottom surfaces of the legs and are fastened together by means of rivets 24 and end bars 25. The latter also serve as feet for supporting the transformer and are provided with openings 26 by means of which the transformer may be fastened in position upon a suitable support.

The windings all surround the winding leg 18 and are preferably separated from the adjacent portions of the core by members 27 of electrical insulating sheet material. The secondary winding 12 is fixed in position adjacent the end portion 21 of the core. The inner end of this winding is connected to a conductor 28 which is brought out and clamped between laminations of the core as shown, and the other end of the winding is connected to a conductor 29 which is connected to one terminal of the neon tube 10. The other secondary winding 13 is arranged similarly at the opposite end of the core. The inner end of this winding (not shown) is connected to the core in the same manner as described in connection with winding 12, and the other end of the winding is connected to one terminal of mercury tube 11 by conductor 31. The other terminals of tubes 10 and 11 are connected to the core by conductors 34 and 35 respectively, and the core is connected to the ground as indicated at 36. This is a preferred method of connection, but the two terminals of each tube may be connected to the two terminals of each winding respectively, as will be described hereinafter, if that is desired.

Shunt members 30 of steel laminations are positioned in the spaces between the central leg 18 and the outer legs 19 and 20 adjacent the side of secondary coil 12 and are separated from said core legs by members 32 of thin electrical insulating sheet material, these parts fitting tightly to maintain them in fixed position. In the same manner shunt members 33 are arranged adjacent the other secondary winding 13. The laminations of the shunt members are fastened together by rivets 31.

The secondary windings are spaced apart a distance which is greater than is usual in transformers known heretofore, and the sections of the core legs between the shunt members 30 and 33 are relatively elongated. The primary winding 15 is mounted slidably upon the winding leg 18, and is readily slidable from a position adjacent shunt members 30 to one adjacent shunt members 33, that is, to positions at varying distances from the secondary windings. The heads of rivets 24 are countersunk so as not to interfere with the sliding motion. When the transformer is operative in supplying energy to the load circuit there are magnetic forces of repulsion between the windings, and the movable primary winding is mounted upon winding leg 18 in such manner that there is sufficient fric-

tion between them to withstand such forces and the primary winding is normally fixed in position. If desired, means may be provided for clamping the movable winding in the desired position, comprising a thin, stiff metallic or non-metallic member 47 projecting from the inner portion of the winding at one side thereof, said member having a threaded opening through which a clamping bolt 48 may pass and serve to clamp the said member 47 to the winding leg 18.

The shunt members 30 and 33 provide leakage paths through which the magnetic flux may bypass the portions of the core which are beyond them, these latter portions being called the secondary core portions, the balance, or middle portion, of the core being called the primary portion. The members of thin, insulating sheet material 32 provide air gaps between the shunt members and the core legs, and these are of a thickness to regulate the magnetic reluctance of the leakage paths to be greater than the reluctance of the secondary core portions on open circuit. Upon the closing of the secondary circuit, the current flowing therein causes an increase in the reluctance of the secondary core portions whereby a proportion of the magnetic flux follows the leakage paths, this proportion becoming greater as the current in the secondary windings becomes greater.

In operation, the system is energized by closing switch 38 in the alternating current energy supply circuit. The initial flux substantially all passes through the secondary core portions and produces a striking voltage in the output of the secondary winding sufficient to initiate operation of the tubes. Immediately the impedance of the tubes decreases greatly and the current through them and through the secondary winding increases. This current opposes the flux in the secondary core portion and increases the reluctance of such portion whereby a substantial proportion of the flux by-passes it and follows the leakage path through the shunt members and adjacent air spaces. The path of the initial flux and of the useful flux while the tubes are operative is indicated by the dotted lines 45 and the path of the leakage flux during operation of the tubes is indicated by dotted lines 46.

As stated heretofore the primary winding 15 is readily slidable along the winding leg 18 into positions at varying distances from the secondary windings 12 and 13, this sliding movement being accomplished by hand or other suitable mechanical means. The position of the primary winding 15 does not have any appreciable effect upon the distribution of the initial or open circuit flux, and this remains substantially constant under conditions whereby substantially all of it passes through the secondary core portions. As a result, the initial or striking voltage induced in each of the secondaries remains substantially the same regardless of the position of the primary winding, and is always adequate to initiate operation of the tubes. As a result the tubes operate steadily under all conditions of intensity. However, during the time that the secondary windings are operative, and closed circuit conditions obtain, the proportion of flux which by-passes each secondary winding is proportional to the distance between that secondary winding and the primary winding. In Fig. 1 the primary winding is shown as being farther from secondary winding 13 than from secondary winding 12. The leakage path 46 between pri-

mary winding 15 and secondary winding 13 is relatively large because more area of legs 18, 19 and 20 are exposed to each other across the intervening air gaps, and the reluctance of said leakage path is decreased while that of the useful path 45 is increased because of the increased distance from the primary winding. As a result, a greater proportion of the flux follows the leakage path. The phenomenon may also be expressed by saying that the coupling between the primary winding 15 and the secondary winding 13 becomes weaker as the two windings are moved farther apart. The result is that the intensity of illumination of mercury vapor tube 11 becomes less. Conversely, the coupling between primary winding 15 and secondary winding 12 is increased and the intensity of neon tube 10 becomes greater. When the windings are in the positions shown in Fig. 1, the magnetic forces of repulsion between windings 12 and 15 are greater than those between windings 13 and 15. As mentioned heretofore, there is sufficient friction between winding 15 and winding leg 18 to prevent this difference from causing movement of winding 15 and the latter remains stationary until it is moved or manipulated mechanically by hand or some other suitable means. Similarly, in the constructions which are described hereinafter the movable regulating members are adapted to withstand the magnetic forces present.

In practice, the movement of primary winding 15 from a point adjacent secondary winding 13 to a point adjacent secondary winding 12 causes a smooth decrease of illumination intensity in the mercury vapor tube 11 and a smooth increase in neon tube 10. Fig. 2 shows a graphic illustration of the manner in which the intensity of the two tubes varies, the line 49 representing the intensity of the neon tube and line 50 the intensity of the mercury vapor tube. The dot and dash vertical line 51 represents the relative intensities of the two tubes when the primary winding 15 is in the position shown in Fig. 1.

The tubes 10 and 11 are intended to be closely associated so that the light given off by them is a composite, or resultant, of the light from the two tubes. Where two tubes, one of them emitting the orange red light of a neon tube, and the other the green and blue light of a mercury vapor tube having a coating of green fluorescing salts are associated together in proper proportions of illumination, the resulting light is of a white color and is satisfactory for lighting purposes. As was stated earlier in this description, when the primary winding 15 moves beyond the region in which such a white light is obtained the light will have a definite green, or orange-red cast, depending upon the direction in which the primary winding has been moved. The shade of white, of course, varies as the proportion of orange-red varies within the mentioned range. It has been found that different shades are satisfactory for different purposes. With the arrangement of this invention it is possible to obtain the exact shade of light desired with great convenience. It is also possible to restore the combination to the exact shade desired if such shade has become disturbed due to intensity changes having occurred with use.

In the arrangement illustrated in Fig. 3 the transformer has only one stationary secondary winding 55. The closed or shell type magnetic core 56 has relatively elongated legs and has a pair of shunt members 57, similar to the shunt

elements described in connection with Fig. 1, extending between the core legs and located adjacent the secondary winding 55. The primary winding 53 is readily movable into positions at varying distances from the secondary winding 55. Gaseous vapor discharge tube 59 is connected in the output circuit of the secondary winding, this output circuit being somewhat different from those described in connection with Fig. 1 in that both terminals of the secondary winding are connected to the terminals of the tube by the conductors 60. The primary winding 53 is connected to a suitable source of electrical energy by means of conductors 61. In this combination, the intensity of illumination of tube 59 decreases as the distance between the primary and the secondary windings increases. It is obvious that such an arrangement is useful for varying the intensity of a single tube or of a number of tubes which may be connected in series with one another in the output circuit. Where it is desirable to use a combination of more than two colors the arrangement of Fig. 3 may be combined with that of Fig. 1 and the illumination intensity of all of the tubes may be varied as desired. If it is desired to have each tube variable individually, a number of combinations such as is shown in Fig. 3 may be used.

In Fig. 4 is illustrated a modification of the invention in which the primary winding is stationary and there are two secondary windings, one of which is stationary and the other movable. The transformer has a shell type of core 70 and the windings surround the winding leg in the usual manner, stationary secondary winding 71 being located at one end and stationary primary winding 72 being located in adjacent spaced relation to secondary winding 71, a pair of shunt members 73 being located between them, and a second pair of shunt members 74 being located on the opposite side of primary winding 72. The secondary winding 75 is movable along the winding leg into positions at varying distances from the primary winding 72. Gaseous discharge tubes 76 and 77 are connected in the output circuits of secondary windings 71 and 75, respectively. The illumination intensity of tube 77 is varied by moving secondary winding 75 along the winding leg while the intensity of tube 76 remains substantially constant except for such variations as are due to flux changes at that end of the core as an effect of the changing flux conditions at the opposite end.

In Figs. 5 and 6 is illustrated a transformer in which the variation in the leakage reactance is obtained by the movement of the shunt members into and out of the air spaces between the legs of the magnetic core. The shell type core 80 is of the usual construction and the secondary windings 81 and 82 and primary winding 83 are located in fixed position surrounding the winding leg, the primary winding being located between the secondary windings. Pairs of shunt members 84 and 85 are located between the primary winding and the secondary windings. The shunt members are each slidable laterally between a pair of thin members of non-magnetic material 86, this material preferably being brass. The laminations of the shunts are held together by means of rivets 87, which also fasten these shunt members to a cross bar 88 which extends between them. A threaded thumb screw 89 has its end portion fastened revolvably to the mid-portion of the cross bar 88. A bracket member 90 is mounted upon the iron straps 91 which

cover the laminated leg of the core 80 similar to the straps 23 of Fig. 1. The bracket 90 has a central aperture in threaded engagement with the thumb screw 89. The thumb screw is adapted for manual manipulation, and serves to move the shunt members 85 laterally into and out of the space between the core legs as indicated in Fig. 5. Movement of the shunt members out of the space causes an increase in the magnetic reluctance of the flux leakage path with the result that the proportion of the operating flux which threads the secondary core portion is increased and the voltage which is impressed upon the output of the secondary, and likewise the intensity of the tube, are correspondingly increased. The shunt members 84, see Fig. 6, are fastened in a similar manner to a cross bar 92 which is adapted to be manipulated by a thumb screw 93 which passes through a bracket member 94. In operation, the secondary windings 81 and 82 are connected to gaseous discharge tubes 95 and 96 of different colors. When it is desired to increase the intensity of tube 95 shunt members 85 are drawn laterally outwardly from the space between the core legs. In the same way when it is desired to increase the intensity of tube 96 shunt members 84 are drawn outwardly. When it is desired to decrease the intensity of the tubes the shunt members are moved inwardly into the spaces. The arrangement is such that the shunt members cannot be moved outwardly farther than a point beyond which an unsafe current is obtained in the output circuit. It is understood that the invention is not limited to the mechanism including the thumb screws for moving the shunt members but any suitable mechanism may be used.

In Fig. 7 is illustrated an arrangement in which both the primary winding and the shunt elements are movable. The secondary windings 100 and 101 are mounted over the winding leg of the core 102 in fixed position at the ends thereof, and the primary winding 103 is mounted over the same leg and is readily slidable into position at varying distances from the secondary windings. The pairs of shunt members 104 and 105 are arranged adjacent the secondary winding 100 and 101, respectively, and are movable laterally in the spaces between the core legs in the same manner as is illustrated in connection with Figs. 5 and 6, the cross bars 106 and 107 and thumb screws 108 and 109 being used for moving the said shunt members. This construction possesses the advantage that it is possible to supplement the intensity variation provided by movement of the primary winding with the variation provided by movement of the shunt members.

In Fig. 8 is illustrated a transformer of the so-called core type in which there is only one leg in addition to the winding leg. The core 110 has primary winding 111 mounted slidably upon the winding leg 112, and the secondary winding 113 mounted in fixed position at one end of the winding leg. A shunt member 114 is mounted adjacent the secondary winding 113 in the space between the two legs and is movable laterally in said space in the same manner described in connection with Figs. 5 and 6, such lateral movement being imparted to it by means of thumb screw 116. In general, this arrangement possesses properties similar to that of Fig. 7.

In Fig. 9 a transformer is illustrated which does not employ shunt members. For some ap-

plications it may be desirable to omit the shunt members. Although the shunt members facilitate varying the energy supplied to the output circuit, this may be accomplished without their presence, the leakage path in such case being across the air space between the core legs. The core 120 has primary winding 121 and secondary winding 122 surrounding the winding leg thereof, these windings both being movable along the winding leg, whereby movement of either causes variation in the output of the secondary winding 122 by varying the coupling between the windings.

The mechanism described above for varying the illumination intensity of gaseous discharge tubes without impairing the steady, smooth light emission therefrom has many useful applications. Particularly in decorative sign work they may be used to impart many pleasing color change effects. While the movable parts are shown as being adapted to be moved by hand, it is obvious that they may also be moved by an electric motor under the control of a hand switch, the motor being adapted to move the member in either direction as desired. Mechanism may be incorporated for moving the movable members continuously to provide a continual color change, or intermittently at desired intervals. Such mechanism, driven by electric motors, may be readily applied to the regulating means of this invention. It may be applied to the shunt members as well as the movable winding.

While the invention is directed primarily to the regulation of the illumination intensity of gaseous discharge tubes, and possesses particular advantages for such use, as has been explained heretofore, in its broad aspects it provides means for regulating the supply of electrical energy to a load circuit by regulating the transfer of energy from a primary winding to a secondary winding and is of general application where such regulation is desired.

I claim:

1. In combination, a discharge lamp and a transformer, said transformer comprising a substantially closed magnetic core having a relatively long winding leg and at least one other relatively long leg, primary and secondary windings surrounding different portions of said winding leg, and fixed magnetic shunt members located between said primary and secondary windings and extending between said winding leg and said other leg, at least one of said windings being movable along said winding leg into positions at varying distances from the other of said windings, said secondary winding being electrically connected to said discharge lamp.

2. In combination, two discharge lamps and a transformer, said transformer comprising a magnetic core having a winding leg, two secondary windings surrounding different portions of said winding leg, and a primary winding surrounding said winding leg and located between said secondary windings, magnetic shunt members between said primary and each of said secondary windings, at least one of said windings being movable along said winding leg into varying po-

sitions, said secondary windings being electrically connected to said discharge lamps respectively.

3. In combination, two discharge tubes, and a transformer, said transformer comprising a closed magnetic circuit core having a winding leg, two secondary windings surrounding said winding leg and located at fixed, spaced-apart locations, a primary winding surrounding said winding leg and located between said secondary windings, fixed magnetic shunts between said primary winding and said secondary windings and adjacent said secondary windings, said primary winding normally being fixed in position but being mechanically movable along said winding leg into positions at varying distances from said secondary windings, said secondary windings being electrically connected to said gaseous discharge tubes, respectively.

4. In a composite lighting unit composed of two differently colored light sources and a source of electrical energy therefor, means for regulating the color of the light from said composite lighting unit comprising a transformer comprising a magnetic core having a winding leg, two secondary windings mounted in fixed, spaced-apart positions surrounding said winding leg, and a primary winding surrounding said winding leg and located between said secondary windings and movable along said winding leg into varying positions between said secondary windings, said secondary windings being electrically connected to said differently colored light sources respectively, and said primary winding being connected to said energy source.

5. In a composite lighting unit composed of two differently colored light sources and an electrical energy supply circuit therefor, means in said supply circuit for regulating the color of the light from said composite lighting unit comprising a transformer comprising a magnetic core having a winding leg, a primary winding and a secondary winding mounted in fixed adjacent positions surrounding said winding leg, and a second secondary winding surrounding said winding leg and located on the opposite side of said primary winding from said first secondary winding, magnetic shunt members between said primary winding and each of said secondary windings, said second secondary winding being movable along said winding leg into positions at varying distances from said primary winding, said secondary windings being electrically connected to said differently colored light sources respectively.

6. In combination, a discharge tube and a transformer in the input of said tube, said transformer comprising a magnetic core having a winding leg, primary and secondary windings surrounding said winding leg, and a magnetic shunt between said primary and secondary windings, said shunt providing a flux leakage path for said transformer, one of said windings being movable along said winding leg into positions at varying distances from the other of said windings, and said shunt being movable to vary the magnetic reluctance of said flux leakage path.

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