April 22, 1952 L. F. BIRD 2,593,651

WATTAGE CONTROL SYSTEM FOR VAPOR ARC LAMPS

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Fig. 1.

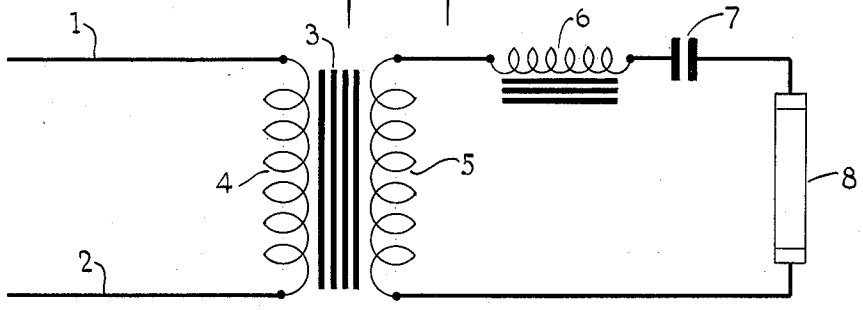


Fig. 2.

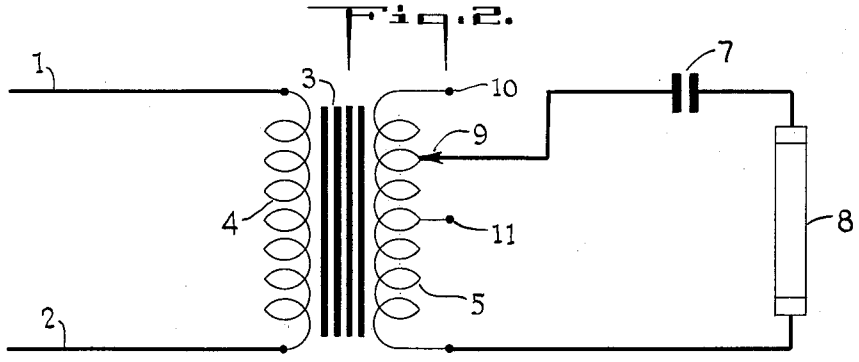
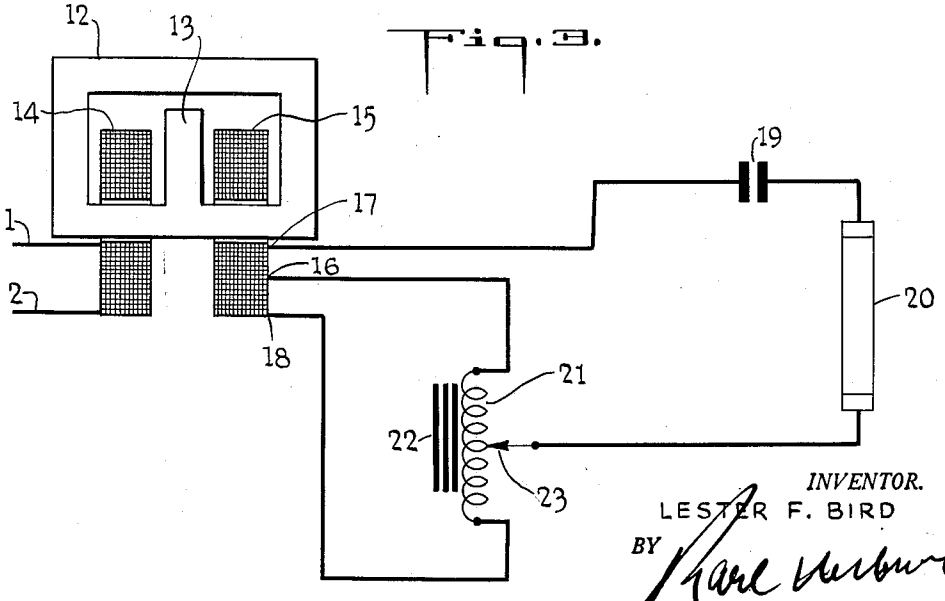


Fig. 3.



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WATTAGE CONTROL SYSTEM FOR VAPOR ARC LAMPS

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2 Claims. (Cl. 315—100)

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The present invention relates to a wattage control system for vapor arc lamps and particularly to a controlled regulating circuit therefor.

Metal vapor arc lamps and discharge tubes are usually operated from high reactance transformers whereby the secondary reactance limits the current that will flow from the transformer secondary to any resistance load between a short circuit condition and the maximum input of the arc lamp.

It is a common practice to design the transformers so that the starting currents are about 1.45 times the usual operating currents and so that during operation the voltage drop across the transformer secondary is the voltage drop across the lamp itself. The reactance of the transformer secondary serves to stabilize the arc lamp and keep it lighted. Such reactance is inductive in character and the current in the lamp circuit lags behind the induced secondary voltage causing a lagging power factor for the supply currents. With such a transformer, the wattage consumed by the lamp varies approximately as the square of the percentage change of the line voltage supply, i. e. a 10% change in line voltage results in a 21% change in lamp wattage. Fluctuations in line supply voltages, therefore, result in wide variations in light output of the lamp and continuous readjustment of the input connections is required on the transformer if the lamp wattage is to be maintained at or near a constant value.

According to my Patent No. 2,482,894, I have overcome the above disadvantage by providing an operating system for vapor arc lamps and discharge tubes, being supplied from alternating current sources, whereby the input to arc lamps and discharge tubes, and also the light generated thereby, are rendered less affected by the voltage of the operating supply circuits and are substantially freed from variations resulting from fluctuations in the supply voltage.

The present invention deals with a system similar to and which retains all the desirable features of my said patent and which in addition thereto relates to a controlled regulating circuit whereby the output of the stabilized control system may be adjusted or varied from level to level as desired while at the same time the levels of output are effectively stabilized to be independent of the variations in the line supply voltage.

It is an object of the present invention to provide a controlled regulating circuit for adjusting the output of an operating system which maintains a substantially constant wattage. It is

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another object of the present invention to provide an adjustable output operating system for vapor arc lamps whereby the adjusted output level of said lamps remains effectively stabilized and free of variations in line supply voltage. It is a further object of the present invention to provide the combination of a constant wattage control system and means to vary the output level thereof under substantially stabilized conditions. Other objects and advantages of the present invention will become apparent from the description hereinafter following and the drawings forming part hereof, in which:

Figure 1 is a diagrammatic representation of an operating circuit for metal vapor arc lamps,

Figure 2 is a diagrammatic illustration of an adjustable output operating system according to the present invention, and

Figure 3 is a modification of the system shown in Figure 2.

According to the present invention, I provide a discharge device operating system for maintaining a substantially constant wattage and which system comprises the combination of a high reactance type transformer having a magnetic core structure and mounted thereon a primary input coil and a secondary inductive coil in spaced relation to each other with a high reluctance magnetic shunt between the coils, a stabilizing wattage circuit connected to the terminals of the secondary coil and comprising a capacitor connected between one of the terminals of the secondary coil and a discharge device, the stabilizing wattage circuit being operative under a series stabilizing reactance provided by the reactance of a secondary coil wound about a core material operating at the knee of the saturation curve for the core material in combination with the reactance provided by the abovementioned capacitor having a kv.-a. rating of about 1½ to 6 times the kv.-a. rating of the discharge device.

The above described discharge device operating system is identical with the operating system of my Patent No. 2,482,894 and, therefore, according to Figure 1, 1 and 2 are supply lines of variable alternating current voltage from which an enclosed vapor arc lamp is to be operated. A high reactance transformer 3, having a primary 4, a secondary 5 and a leakage reactance 6, such that the secondary short circuit current lies between 1.1 and 1.7 times the normal lamp operating current, is diagrammatically illustrated. The reactance 6 is shown as a separate unit for illustrative purposes although it is in fact built into the structure of the transformer as a character-

istic of the transformer and is an electrical rather than a physical entity. The series capacitor 7 has between 1½ and 6 times the kv.-a. rating of the arc lamp 8. Since the arc lamp 8 can only operate in a stable system if it has sufficient series reactance to constitute a complete circuit having a positive volt-ampere characteristic, it must at all times and under all conditions of operation and during all parts of the current cycle have an adequate reactance in series with it to maintain stability. It is inherently impossible to operate with only a series capacitor for the stabilizing means in the circuit of my invention because of an oscillating condition which follows the use of only series capacitative reactance for the stabilization of the arc lamp. I actually utilize a resultant capacitative reactance for stabilization because the capacitor employed is in an effective series connection with an inductive reactance, leaving the sum total, for both, capacitative. The reactance of the series capacitor 7 is chosen to be approximately twice the value of the inductive reactance 6, leaving a resultant capacitative reactance in the circuit essentially equal in value to 6 since in this combination the inductive reactance and the capacitative reactance subtract from each other. Since the resultant reactance is the one which provides stabilization for the lamp, and in this case is capacitative, the lamp is actually operating from a capacitative reactance and so that currents flowing in the secondary or lamp circuit are of leading power factor.

Having set forth the particular system to which my invention is applicable, I provide therefor and in combination therewith an electrical control means which enables the abovementioned system to function as an adjustable output operating system such that the output of a lamp, in said system, can be varied or adjusted from level to level as desired while at the same time being effectively stabilized to be independent of the variations in line supply voltage at a chosen output level.

Figure 2 illustrates the adjustable output operating system according to the present invention. The basic circuit is similar to the circuit of Figure 1 regardless of the fact that the reactance 6 is not illustrated since, as stated, it exists as an electrical entity. The adjustment of the output of the lamp is accomplished by providing in combination with the circuit therefor the equivalent of a commutating device such as a moveable member or brush 9 in contact with more or less of the secondary turns of the transformer within the limits through which the lamp 8 will function. The brush 9 is in series connection with the other embodiments of the circuit substantially as illustrated. I vary the output level of the lamp 8 by adjusting the secondary voltage of the transformer while the lamp is in operation by means of the movement of the brush 9 which contacts more or less of the windings of the secondary coil between the chosen limits, e. g. limits established by a tap 10 and a tap 11 on the secondary coil. The taps function to include only such portion of the secondary coil which contains a maximum and minimum number of windings through which the operating voltage of the lamp may be safely adjusted. Adjustment of the position of the brush 9 from one winding to another between the taps 10 and 11 causes a change in the secondary voltage and, as a result, a change in the lamp current. Such a performance makes it possible to adjust the light strength of a given lamp from one level to another to an exact output and at the same time maintains a steady output when the brush has been set for a desired level of output.

The output of a lamp under these conditions varies approximately as the square of the percentage change of the secondary voltage and such that a change of 10 percent in secondary voltage causes about a 21 percent change in light output from a lamp. A 20 percent change in secondary voltages results in about a 44 percent change in light output, etc. Since for various reasons, it may not be desirable to vary the output of a lamp more than about 35 percent, such a maximum variation can be secured by the operation of a commutating device producing about 17 percent change in secondary voltage. Such changes, as above stated, result in light levels that are substantially free of variations of the line input voltage.

A commutating device associated with the secondary of a transformer in a lamp operating system where the lamp is operated only from a purely reactive type transformer does not function in accordance with my invention because the reactance of the coil, which determines the current delivered to the lamp, varies as the square of the number of turns in the secondary. At the same time, the no load voltage delivered by such a reactive transformer varies directly with the number of the secondary turns. A condition can easily result where the reactance changes with the number of turns more rapidly than the voltage and an increase in turns actually results in a decrease in lamp wattage. Therefore, instead of a ten percent increase in voltage producing approximately a twenty-one percent increase in light output, it actually results in a smaller increase or in an actual reduction. No independence of the light output from line voltage changes is ever present with such a combination.

In a lamp operating system according to my invention, the core material associated with the secondary winding of the transformer is operating at a maximum flux density which is normally considered very high, e. g. of the order of 120,000 lines per square inch, where very substantial increases in magnetizing force produce only slight increases in the maximum flux or in the induced voltages associated with the flux.

The expression "at or near the knee of the saturation curve for the core material," as hereinbefore set forth, when used in connection with alternating current, is understood to indicate that during an appreciable portion of each half-cycle of the alternating current, the core is in a saturated condition.

The high average saturation of the iron greatly reduces the reactance of the secondary coil until it acts as a source of voltage with but little reactance. An increase in turns, therefore, can increase the voltage of the secondary without a corresponding increase in reactance. For this reason, an increase in secondary turns and voltage will at all times produce an increase in lamp wattage and this wattage can be adjusted by manipulation of the secondary voltage turns. At the same time, the lamp wattage remains stable and essentially free of fluctuations, due to changing line input voltages to the transformer, at whatever level results from the secondary voltage settings.

The adjustable output operating system of my invention makes it possible to reproduce or main-

tain optimum light output for uses where such optimum light output is essential, e. g. for irradiation or exposure purposes where optimum light output is highly advantageous.

Figure 3 illustrates a modification of the system as shown in Figure 2 and whereby the commutating device may be removed from intimate contact with the transformer secondary and still provides the same results. The entire system comprises a transformer having a core 12 and a magnetic leakage path 13 located between the primary coil 14 and secondary coil 15. The secondary coil 15 has a voltage limiting tap 16 positioned thereon at a prescribed distance from the inner end 17 and the outer end or top 18. A capacitor 19, as hereinbefore described, is connected in series between one terminal of the secondary coil and the lamp 20. Between the taps 16 and 18 is connected a commutating coil 21 provided with a core 22. A brush 23 is contacted with the coil 22 to act as an equivalent to a commutating device and connected in series to the lamp 20. Adjustment of the position of the brush 23 causes variations in the voltage supplied from the transformer to result in a change in lamp currents. The voltage change across the commutating coil 22 is so chosen that the necessary output variation is imparted to the lamp 20. The characteristics of the modified system are similar to the characteristics of the system described under Figure 2.

As an example, the transformer has a core 12 and primary winding 14 adapted to operate from a supply line delivering 220 volts at 60 cycles. The secondary of the transformer is wound to deliver about 750 volts and has sufficient leakage reactance to limit the short circuit current to about three amperes. A capacitor 19 of about twelve microfarads is placed in series with a 2000 watt lamp 20 which is designed to operate normally at 550 volts and about 4 amperes. The commutating coil is designed for operation with 230 volts across the extremes and the brush capacity is about five amperes. Variations in lamp output were secured between 1800 watts and about 2500 watts. Variations due to line input voltages were limited to about one-fifth of the percentage change in the line voltage, i. e. a twenty percent change in line voltage caused about a four percent change in light output. This variation in output due to line voltage was independent of the wattage at which the lamp was operated.

What I claim is:

1. An operating system for varying the output level of discharge devices during operation and maintaining a substantially constant wattage at the selected levels of output, comprising in combination a transformer having a magnetic core structure and mounted thereon a primary input coil and a secondary inductive coil in spaced relation to each other with a high reluctance magnetic shunt between said coils, a source of current for said transformer said secondary coil being wound about a core composed of a material saturable during an appreciable portion of each half-cycle of alternating current, said secondary winding having a plurality of electrical taps, a movable commutating brush member electrically contactable with the turns of said secondary winding between two of said taps, a stabilizing wattage circuit, a capacitor and a gaseous discharge lamp in electrical series in said circuit, said capacitor having a kv.-a. rating of about 1½ to 6 times the kv.-a. rating of said gaseous discharge lamp, said circuit being connected to said brush member and across at least a portion of said secondary coil, said circuit being operative under a series stabilizing reactance provided by the reactance of said secondary coil in combination with the reactance provided by said capacitor.

2. An operating system according to claim 1, comprising an auxiliary coil connected across a portion of said secondary coil to two of said taps, said movable commutating brush member being electrically contactable with the windings of said auxiliary coil.

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