In the conventional circuit arrangement shown in Fig. 1, the single lamp is designated by l, while L designates the inductive ballast and T the filament transformer. The secondary windings s, s' of the transformer T are connected to the filaments at the opposite ends of the lamp l in the usual manner (not shown). On application of the supply voltage, e.g. 240 volts, to the terminals M, M, the transformer T becomes energized and the two filaments are pre-heated, and when their temperature is high enough, the lamp ignites, provided it has a conductive strip along its envelope, or is mounted in a metallic reflector. Before ignition occurs, the terminal voltage of the transformer T is slightly lower than the supply voltage, say 210 volts instead of 240 volts, the difference being due to voltage drop in the ballast L. After ignition, the transformer voltage is equal to the lamp voltage which, for instance in the case of a 40 watt or 80 watt fluorescent lamp is 108 volts, i.e. about half the value before ignition. In this way the electrode heating current is reduced to a low value during operation of the lamp. Thus the heating current may be, for instance, 0.7 ampere before, and 0.3 ampere after ignition.

If hitherto it was desired to operate two lamps in a single unit, instead of one lamp only, it was necessary to provide each lamp not only with its own ballast but with its own transformer as well. If now the assumption is made that each lamp is equipped with its own ballast, but the four filaments are heated by a common transformer which is connected across one lamp (lamp 1) only, then it can happen that lamp 1 is started first, 6 whereupon the transformer voltage would drop immediately so that the other lamp (lamp 2) would not obtain sufficient pre-heating current and would therefore not be started at all. Even if, due to biasing, lamp 2 could always be started in the first place, it could still happen that lamp 1 fails to start, for instance due to its age. In this event, the pre-heating current in lamp 2 would not drop after ignition, and the life of the lamp would suffer. These drawbacks are avoided in the circuit according to the invention as depicted in Fig. 2. In Fig. 2 the two lamps are designated by l1, l2 and the ballast by L, while D is the heating transformer. D is a small choke, a center tap E of which is connected to the common terminal F of the ballast L and transformer T. The secondaries s1, s'1, s2 and s'2 for the filament of lamp l1, and the secondaries s2, s'2 for the filaments of the lamp l2 are all embodied in the transformer T.

Assuming for the sake of definiteness that the lamps l1, l2 are 40 watt lamps, the ballast L is then an 80 watt ballast, bearing in mind that an 80 watt lamp has the same voltage and twice the current of each 40 watt lamp. The dimensions of the choke D are such that the impedance of each half thereof substantially equals that of the 80 watt ballast choke.

On application of the supply voltage to M, M the transformer T becomes energized and heats up the four filaments s1, s'1, s2 and s'2. When now one of the lamps starts, the transformer voltage does not drop to the value of the lamp voltage but to some value between the lamp voltage and the supply voltage, the dimensions of all components of the arrangement being such as to make that voltage sufficient for keeping the filaments of the other lamp hot. After the second lamp has started, the current flows in opposite directions through the two halves of the choke D and as a result the induction in the core of the said choke is virtually zero. This makes it possible to design the choke D to small size. Admittedly, the induction in the core may be very high during the period in which only one lamp operates, but this is immaterial since, as a rule, that period is only short.

In one specific example, the choke D for two 40 watt lamps was made to comprise 360 turns of 28 B & S gauge (0.32 mm. diameter) enamelled copper wire wound on a core of 5.7 cm.2 cross section having a magnetic path of 11.2 cm. length, the core consisting of 0.5 mm. laminations of electric steel having 1.5% silicon content. Obviously, the choke may be made larger or smaller within the scope of this invention, to meet particular requirements, for instance of design. The choke D thus serves a dual purpose. During the starting period of the second lamp, it supplements the ignition voltage by the voltage induced in the open-circuited half of the choke. During the operation of the lamps, on the other hand, it divides the current admitted through the 80 watt choke equally between the two lamps. Should, for some reason or other, the current in one lamp tend to become larger, this would upset the balance in the choke D and as a result a voltage would be induced in the circuit of the second lamp to increase the current in that lamp as well.

The cost of an 80 watt ballast is less than the cost of two 40 watt ballasts, and this difference is ample to cover the cost of the additional choke D. The cost of the transformer T for four filaments is lower than the cost of two transformers for two filaments each.

Similarly two 20 watt lamps can be operated across a common ballast by means of a current balancing choke D. Here however, the common ballast is not the con-
ventional 40 watt ballast since the voltage of the 20 watt lamps is not the same as that of the 40 watt lamp, but is designed to carry twice the current of a 20 watt lamp, i.e., about 0.72 ampere, and to have during operation the same terminal voltage as the single 20 watt ballast.

The same applies to two 80 watt lamps operated through a common ballast. Generally, the common ballast for two lamps has to carry twice the current of the single ballast for the same terminal voltage.

An advantage of the improved circuit will be evident from the following. At the end of their lives, lamps of the kind in question sometimes show rectification effects, which means that the lamp voltage is smaller in one sense than in the opposite sense. If only a single ballast choke is provided in the circuit, the D.C. components created by the rectification polarize that choke and reduce its impedance. Consequently, the current in one direction increases still further and the lamp rectification grows, with the result that the life of that lamp becomes shorter.

In the arrangement according to Fig. 2 this could only happen if both lamps were to start rectifying at the same time and in the same sense. By slightly biasing the filament voltages, the rectification of both lamps in the same sense could be rendered unlikely.

It is sometimes desirable to step up the supply voltage in order to make the ignition more reliable. A known method of achieving this in an arrangement embodying only a single lamp is illustrated in Fig. 3, where one of the terminals M is connected through the ballast to a terminal of a transformer T or like inductance coil and the other terminal M is connected to a tap point G of the said transformer or coil. The drawback of this method, however, is a poorer power factor of the circuit.

Fig. 4 shows a modification of the improved arrangement according to which the supply voltage is somewhat stepped up for the lamp \( l_1 \) by a transformer T or equivalent inductance, and is stepped down for the other lamp \( l_2 \), with the result that the power factor remains unimpaired. The number of turns of the choke D has to be increased accordingly and the tap point E shifted from the center so as to still keep the two currents equal, and in order to safely supplement the ignition voltage of the lamp which is started later.

Another modification of the arrangement of Fig. 2 is depicted in Fig. 5. In Fig. 5, only one lamp \( l_2 \) is pre-heated by the transformer T whereas the other lamp \( l_1 \) is pre-heated by two secondaries \( s', s'' \), wound on the auxiliary choke D. The sequence of events then is as follows. On applying the supply voltage to M, M the filaments of the lamp \( l_2 \) becomes pre-heated and that lamp is started. The current through the lamp \( l_2 \) which also passes one half of the choke D induces a voltage in the heating windings \( s', s'' \) on the choke D, and lamp \( l_1 \) is started. After lamp \( l_1 \) is started the voltage of the secondaries \( s', s'' \) drops virtually to zero, resulting in an increase of the circuit efficiency.

While the invention has been described by means of specific examples and in specific embodiments, I do not wish to be limited thereto, for obvious modifications will occur to those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. A circuit-arrangement comprising two arc-discharge tubes each having a pair of electrodes, a filament transformer having a primary winding, said transformer being connected to heat the electrodes of one of said tubes, a common ballast for limiting the operating current of said tubes, an auxiliary choke having an intermediate tap disposed thereon forming two sections, said two sections being magnetically coupled in inductive relationship to the extent that equal currents flowing in opposite directions through said sections produce a substantially zero resultant magnetic flux, each of said sections being connected to one electrode of a different one of said two tubes and said tap being connected to one end of said common ballast thereby to form two parallel circuit branches, said circuit branches having similar phase characteristics whereby current flow through one of said choke sections cancels the inductive efficiency in the said choke by the current flow through the other of said sections when both of said tubes are in the operating condition, circuit means for connecting said transformer between said tap and each of the other electrodes of said two discharge tubes, and means for connecting a voltage source in series with said common ballast across the primary of said transformer.

2. A circuit-arrangement as set forth in claim 1, wherein said transformer is connected to heat all of said electrodes.

3. A circuit-arrangement as set forth in claim 2, wherein said circuit means includes means for applying a voltage of a given magnitude to one of said tubes and for applying a voltage of a different magnitude to the other of said tubes.

4. A circuit-arrangement as set forth in claim 1, wherein said choke further comprises at least one secondary winding connected to heat the electrodes of the other of said two tubes.

References Cited in the file of this patent

UNITED STATES PATENTS

2,269,978 Kronmiller Jan. 13, 1942
2,429,162 Kelser Oct. 14, 1947
2,504,548 Lemmers Apr. 18, 1950
2,578,395 Brooks Dec. 11, 1951