Sept. 29, 1942. E. O. SEITZ ET AL 2,297,257

ALTERNATING CURRENT DISCHARGE LAMP

Filed Nov. 25, 1938

Fig. 1

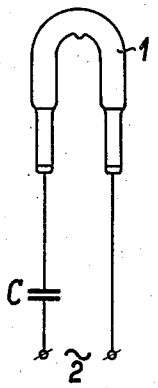


Fig. 1a



Fig. 2

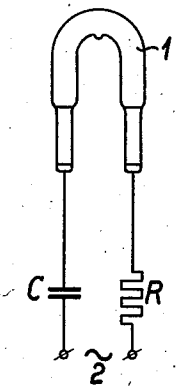


Fig. 3

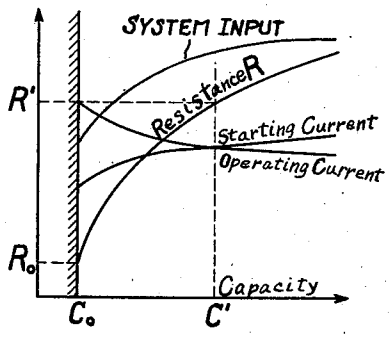
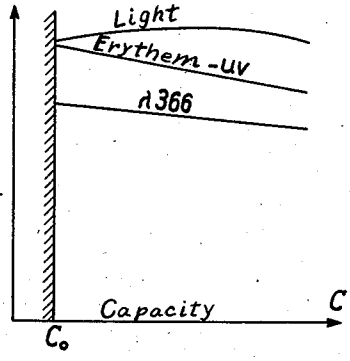


Fig. 4



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ALTERNATING CURRENT DISCHARGE LAMP

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Application November 25, 1938, Serial No. 242,394
In Germany November 25, 1937

1 Claim. (Cl. 176—124)

Alternating current discharge lamps filled with gas or vapor, particularly high pressure metal vapor lamps, for example, mercury vapor lamps having electrodes adapted to operate at incandescence, generally require, for stabilizing the discharge, a current limiting device, which may consist of a non-inductive resistance, a choke coil or a condenser. For high pressure mercury vapor lamps a choke coil is generally used for limiting the current, as the power loss in the coil is small. Where low cost is of greater concern than efficiency use is made also of a non-inductive resistance. However, both of these means are defective in that the starting current is always considerably greater than the operating current. This is due to the fact that the initial terminal potential of a high pressure metal vapor lamp is very low after ignition although when stable conditions are reached, the voltage drop rises to about 100–150 volts or more. It is generally calculated that the starting current is about two or three times as great as the operating current. For this reason high pressure metal vapor lamps must be operated in circuits which are safeguarded to a higher degree than would be necessary in consideration of only the operating current. It is well known that this defect exerts an injurious influence in many cases, for example, when the current rate or cost is based only on the maximum current which can be taken from a power supply system and automatic circuit breakers disconnect the supply system when this current is exceeded.

According to this invention these disadvantages are avoided by using stabilizing means including a condenser in connection with the high pressure metal vapor arc. It has been surprisingly discovered that when a condenser is used as an interposed apparatus in series with the lamp the starting current is smaller than the operating current. In this manner it has been possible to prevent the disadvantages resulting from the difference of the lamp potential at starting and during operation. A further advantage consists in that, with the same power consumption in the lamp, a lamp operated with a condenser has a higher radiation efficiency than one operated with a choke. This applies to the total light output efficiency, but chiefly to the long wave and erythema producing ultra violet radiation. Thus, the same radiation efficiency can be attained at reduced load, either by reducing the dimensions and thereby the cost of production, or, while retaining the same dimensions, reducing the specific power consumption of the discharge tubes and therewith the current consumption during continued operation. In addition, by the present invention, the defect, consisting in that powerful current surges can occur shortly after ignition, with the choke operation, which surges are based on a rectifier action and are due to unequal heating of the two electrodes, is not present. With condenser operation this can not be manifested, as the condenser has an infinite resistance for direct current.

When a condenser is used the starting current is generally about 20% below the operating current. Notwithstanding this however, the starting period is only a few minutes. It is hence practically the same as when operating with a choke coil or a resistance. When operating with a condenser the terminal voltage of a high pressure mercury lamp, wherein the mercury is completely vaporised during operation, is somewhat higher than when operating the same lamp with a choke coil at the same load. In many types of lamps, however, the terminal voltage may increase to such a degree that the lamp is extinguished. Special consideration must be given this possibility, particularly with such types which have, of themselves, little stability, such for example as those in which the discharge path is bent or U-shaped, or which operate with a high potential gradient as a result of having a vapor pressure substantially exceeding 1 atmosphere. More stable operation can be provided for such types of lamps also under all conditions if non-inductive resistance is connected in series with the condenser. By the use of this arrangement it is true that additional losses occur in the series apparatus which reduce the efficiency or output with respect to the load or power consumption as compared with pure condenser operation. Nevertheless, the efficiency is always greater than with choke operation. This is due to the fact that when operating with only a condenser as current control element the efficiency is substantially greater than that obtainable with a choke.

In the accompanying drawing two preferred embodiments of the invention are represented:

Figure 1 is a diagrammatic showing of a lamp circuit in which a condenser is used.

Figure 1*a* is an enlarged view of one end portion of a lamp partly in cross section.

Figure 2 is a view similar to Figure 1 of a different embodiment in which a resistance is used in addition to the condenser in circuit with the lamp.

Figure 3 is a diagram of the characteristics of a system according to the invention.

Figure 4 is a diagram of the radiation of a lamp controlled according to the present invention.

Figs. 1 and 2 show two possibilities of condenser operation. According to Fig. 1 a high pressure gas-filled metal vapor lamp 1 is connected series with a condenser C to the terminals of an alternating current supply circuit *a*. The connection shown in Fig. 2 differs from the former in that non-inductive resistance R is connected in series with the condenser and lamp. The high pressure metal vapor lamp used is preferably a high pressure mercury vapor lamp which, in addition to a rare gas filling, contains some mercury, which completely vaporizes in operation. As electrodes use is made of incandescible electrodes, preferably oxide electrodes heated from an extraneous source or, preferably, heated by the discharge.

It has been found that the stabilization of the arc can be effected by the use of different values for the condenser and the resistance if a certain power consumption or load of the lamp is prescribed. Fig. 2 graphically shows the conditions or characteristics for an exemplary embodiment. In Fig. 3 it is assumed that the load or power consumption in the lamp is constant. This graph shows that there is co-ordinated with each capacity of the condenser a certain predetermined resistance value R and also that the resistance must be increased with increasing capacity. Thus, a certain lamp, required to operate with a prescribed load, can be operated stably either with a capacity C_1 and resistance R_1 or with the values C_2, R_2. When C_2 is greater than C_1, R_2 is also greater than R_1. Below a predetermined value of the capacity designated C_0 and with which a resistance R_0 is co-ordinated, stable operation is impossible.

Fig. 3 also shows the effect on the starting current and on the operating current, and that at a value C′ of the capacity, with which the resistance R′ is co-ordinated, the starting current is equal to the operating current. Only above this value C′ does the starting and operating current manifest the same relation as when operating with a choke or resistance. C_0 is the smallest value of the capacity in which, with a given lamp and a given load as well as frequency, stable operation is still possible. If a condenser with a capacity less than C_0 is selected, the discharge is unstable and must become extinguished. Finally, the power consumption is shown on Fig. 3. This increases in proportion to the loss in the auxiliary series resistance, as the power consumption in the lamp itself is assumed to be constant, and the slight losses in the condenser may be disregarded.

The critical values (C_0, R_0) or (C′, R′) are different with different types or lamps and at different loads. In cases in which operation with the condenser only is possible, if then R_0 is equal to zero, the value of C_0 then lies at the intersecting point of the resistance curve R with the abscissa axis.

For stabilizing high pressure vapor lamps it has often been proposed to use incandescent lamps and thus put to some use the loss of power in the series resistances. All hitherto known arrangements fail therein because the incandescent lamps are operated at too high current during the starting period and are therefore rapidly destroyed. A number of artificial circuits or current modifying arrangements has therefore been proposed in order to render operation of an ordinary mercury lamp possible with an incandescent lamp as a series apparatus. None of these connections have given practical results, however, as their operation is not sufficiently reliable. Therefore, if it is absolutely necessary to operate a mercury vapor lamp with incandescent lamps, for example to improve the color of the light, they have up to the present time been connected to the supply circuit independently of each other.

According to the arrangement of the present invention it is also possible, with the use of condensers whose value lies between C_0 and C′, to replace the resistance R by an incandescent lamp, as within this range the starting current is less than the operating current. The incandescent lamp can thus under no conditions be damaged by excessive current during starting. If the capacity of the condenser is equal to C′, the incandescent lamp will burn with its normal brilliancy at all times since the starting current is the same as the operating current.

As the power converted in the resistance R increases strongly between the capacity values represented by the points C_0 and C′ (see Fig. 3) it is possible to select a point at which the desired relation between the power consumed by the high pressure lamp to that consumed by the incandescent lamp is secured. In the vicinity of the point C_0, R is small and the power converted in the resistance or in the incandescent lamp is small, but it increases with increasing values of the capacity. It is possible to convert in the incandescent lamp up to double of the power which is converted in the metal vapor lamp.

With the combination of a mercury vapor lamp and a series incandescent lamp according to the arrangement of the invention, the mixed light furnishes light efficiencies substantially above the values obtainable when the two lamps are connected independently because, as previously stated, the vapor lamp when operated with a condenser, gives a greater output than when operated with a choke. Moreover, use may be made of a low voltage incandescent lamp the radiation efficiency of which, as known, is better than that of 220-volt incandescent lamps.

Also when used as a therapeutic ultraviolet radiator, good results are obtained by the connection with incandescent lamps in accordance with the invention, and which can be used not only for supplementing the mercury light in reds and ultra-reds, but also for filling out the ultraviolet spectrum, as the incandescent filament of a low voltage incandescent lamp can be heated substantially higher than one for 200 volts and thus also emits more ultraviolet radiation.

The range between C_0 and C′ is thus of great practical importance. The capacity of the condenser is generally selected within this range, in the endeavor, relative to low production cost, to employ the smallest possible condenser, particularly as in this range the outputs, with respect to net power consumption are in many cases the best and operation is carried out very advantageously in the vicinity of the point C_0.

The advantages of condenser operation are manifested to a particularly great degree when the mercury lamp is used as an ultraviolet radiator. The intensity in the erythematic range (250–315μ), with equal energy conversion in the burner, is about 80% greater than with choke operation, while the corresponding figures for the total light are about 20% and for the wave length 366μ 70%. The arrangement is thus particularly suitable for use as an ultraviolet light radiator.

In explanation, the following table gives the

values for the condenser and resistance with different types of lamps.

Type of lamp	A	B	B	C
Load in watts	100	200	250	580
C_0 in mf	19	27	36	63
R_0 in ohms	37	7	3	0
C' in mf	22	44	52	78
R' in ohms	57	33	22	6

The mercury lamps A, B and C are ordinary types, developed for choke coil operation. The values given for the condenser and resistance are for operation of these lamps on alternating current of 220 volts, 50 cycles. Use may be made of the ordinary types without it being necessary to modify the lamp.

It is found that for lamps for operation on 220 volts A. C. 50 cycles, values of C_0 and C' can be calculated from the following equations

$$C_0 = 1.30 . B^{0.60} \pm 15\%$$

and

$$C' = 0.98 . B^{0.70} \pm 15\%$$

where B is the load on the burner in watts. The values for C_0 and C' are then obtained in microfarads. According to the invention the condenser should have a value preferably between C_0 and C'.

The values of the resistances can be calculated from the following equations for the same conditions

$$R_0 = \frac{2760\ (1 \pm 0.15)}{B^{0.60}} - \frac{3190}{C_0}\ \text{ohm}$$

and

$$R' = \frac{7900\ (1 \pm 0.15)}{B^{0.82}} - \frac{3190}{C'}\ \text{ohm}$$

Figure 4 shows the variation of the intensity in the different spectral ranges, and also the outputs, with respect to the power converted by the lamp, for different values of C and R. Fig. 4 relates to the same lamp as Fig. 3 and also the same scale for C. For the erythematic ultraviolet and also for wave lengths 366 it is advisable to operate with small values of C and R, for other reasons before pointed out.

We claim:

A system for operating high pressure gas- or vapor-filled alternating current discharge lamps having incandescent electrodes comprising an electric circuit, a high pressure, metal vapor-filled electric discharge lamp having its electrodes connected in said circuit, a condenser connected in said circuit, in series with said lamp for stabilizing the current flow in said circuit, and a heat radiating non-inductive resistance element in the form of an incandescent lamp connected in series with said condenser and discharge lamp.

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