Oct. 18, 1966 M. Z. AHMED 3,280,366

AIRCRAFT WING LIGHT

Filed March 20, 1964

FIG. I

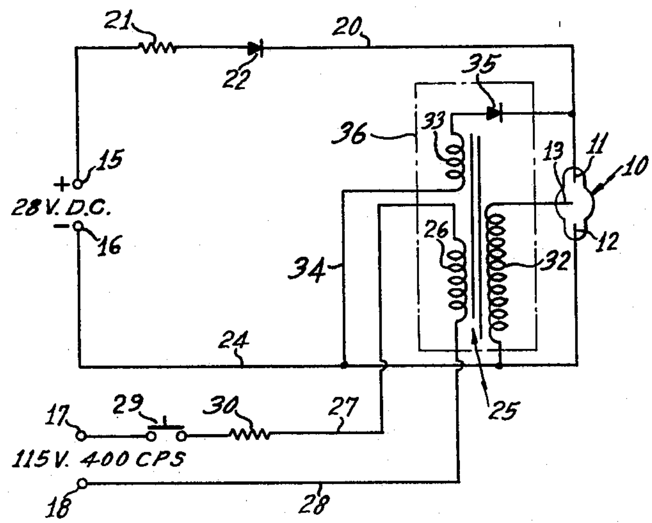
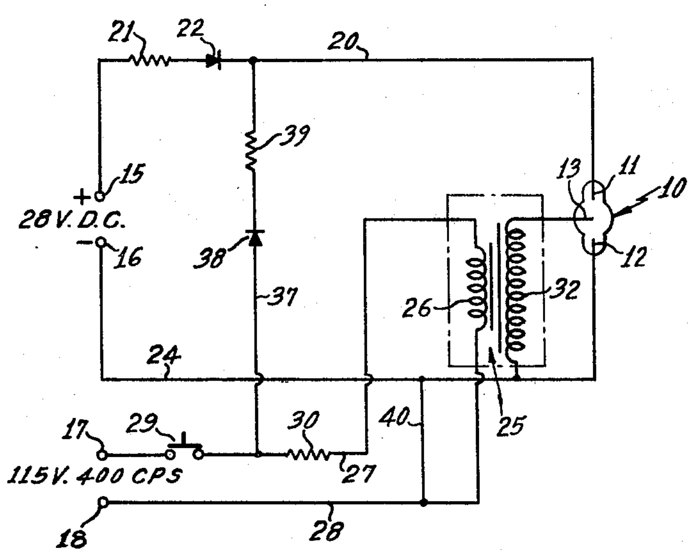



FIG. 2

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# AIRCRAFT WING LIGHT

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The present invention relates to wing lights for aircraft and particularly to a compact arc lamp circuit adapted for aircraft wing tip "hazard" lights.

Filament light bulbs have been used for aircraft wing-tip lights up to the present time despite serious drawbacks. Specifically, filament light bulbs are too fragile for the purpose. The vibration and shock to which the wing-tip lights are subjected cause the filaments in the bulbs to break prematurely and it is not an uncommon practice to replace wing-tip filament light bulbs after each flight in order to be as sure as possible that the lights will last throughout the next flight.

The premature break-down and conventional practice of bulb replacement after a short period of use is expensive and inconvenient, but, more importantly, the general unreliability of filament light bulbs for aircraft wing-tip lights is dangerous. Obviously a broken bulb cannot be replaced in flight and its fragility makes it susceptible to breaking at times when it is most needed for the safety of the aircraft—landing or taking off in rough weather, for example.

Compact arc lamps are rugged and have a long service life which would be unaffected by the shocks and vibration at the wing tip of an aircraft. From the standpoint of reliability and economy compact arc lamps would be ideally suited for use as aircraft wing lights. They have not been so used however because of the nature and bulk of the type of starting circuits which have heretofore been considered necessary for the purposes of starting the lamp.

A compact arc lamp as referred to herein is an arc lamp in which the operating electrodes are spaced apart in an ionizable atmosphere under pressure within an envelope made of high melting point glass or fuzed quartz. The ionizable atmosphere is provided by a gas, a vapor or a combination, such as xenon gas and mercury vapor.

To start the arc in a compact arc lamp, the atmosphere in the envelope must be ionized sufficiently for a spark to cross the gap between the operating electrodes. Successive sparks increase the level of ionization and the temperature of the electrodes to a point at which the operating voltage of the lamp will produce a steady arc between the electrodes.

Ionization of the atmosphere to start the lamp is accomplished by applying high voltage in the form of either unidirectional pulses or of alternating current across the operating electrodes of the lamp. The voltage applied to start the lamp is higher than the voltage required to operate the lamp, therefore two separate circuits are required—a lamp operating circuit and a starting circuit.

Compact arc lamps are of two general types. The most common type is one having only the two operating electrodes so that the starting voltage is applied across the operating electrodes. In this case blocking and filtering elements are included in the lamp operating circuit to keep the higher starting voltage from damaging the components of the operating circuit.

The other type is the three electrode type which includes a third or starting electrode spaced from the operating electrodes. In this type the starting voltage is applied between the starting electrode and one of the operating electrodes. The higher starting voltage therefore cannot get into the operating circuit so that the



blocking and filtering elements required with two electrode lamps are unnecessary with three electrode lamps. Consequently, the circuitry required for starting and operating three electrode lamps is less complicated and lighter than required for the two electrode lamps.

The power for starting compact arc lamps is applied in the form of high voltage pulses as already mentioned and these pulses have customarily been applied well up in the radio frequency (R.F.) range. For example, it is conventional for arc lamp starters to apply a voltage of 40 to 50 kilovolts at a frequency of up to 40 megacycles per second.

The R.F. range is particularly suitable for two electrode lamps since R.F. voltage may be kept from the lamp operating circuit with smaller and less expensive components than lower frequencies. In addition to this it was felt that the "shower of sparks" provided by R.F. pulses assured positive and quick starting. Starting circuits supplying R.F. pulses are customarily built around spark gaps and radio frequency transformers. A conventional starting circuit for compact arc lamps is illustrated in Patent No. 2,889,489 to L. F. Bird.

Arc lamps having starting circuits which include spark gaps and radio frequency transformers are too heavy and bulky to be carried in the wings of aircraft and are therefore impractical for use as aircraft wing lights. Moreover, the voltage applied by conventional starters is so high it would be impractical to put the heavy and bulky components of the starter in the body of the aircraft and use cables to conduct the high voltage pulses to the wing lights. The cable required would be expensive and would add too much weight to the wing. In the face of these practical difficulties arc lamps have not heretofore been seriously considered for use as aircraft wing lights and the industry has been compelled to put up with the inconvenience, expense, and danger involved in using filament-type light bulbs for aircraft wing lights.

As already mentioned the circuitry for three electrode lamps is less complicated and lighter than for two electrode lamps. But for some reason this has not heretofore suggested the possibility of designing suitable circuitry to permit practical use of three electrode compact arc lamps for aircraft wing lights. This may be due in part to a belief in the art that high frequency or radio frequency pulses are best to assure positive quick starts for even three electrode arc lamps.

In any event it has been found that low frequency pulses are entirely suitable for starting three electrode arc lamps and in accordance with the present invention circuitry is provided which enables practical use of three electrode compact arc lamps for aircraft wing lights. Moreover, the circuitry of the present invention utilizes the power sources which are normally provided on larger conventional aircraft. Specifically it is common for civilian and military aircraft to have two sources of electric power to operate the electrical equipment and instruments. One supplies 28 volt direct current and the other supplies 115 volt 400 cycles per second alternating current.

It is a principal object of this invention to provide a compact arc lamp starting circuit formed of simple components which fit easily in a small space normally available in the wing tips of aircraft without appreciably increasing the weight of the wing. It is a particular advantage of the circuitry of this invention that it makes possible the use of compact arc lamps for wing tip lights of aircraft and results in greater safety, economy and convenience as compared with the present wing tip lighting systems based on the use of filament type light bulbs.

In accordance with this invention a three electrode type compact arc lamp is adapted to be started and operated from the source of power available in conventional aircraft. As mentioned these are normally a source of 28 volt direct current and a source of 115 volt 400 cycles per second alternating current. The lamp may conveniently be operated from the direct current source and the starting circuit of the invention is adapted to utilize power from both the A.C. and D.C. power source to start the lamp.

The starting circuit includes a step-up transformer having a primary coil connected to the A.C. source and a secondary coil connected between the third or starting electrode of the lamp and the negative operating electrode of the lamp.

When the starting circuit is closed, preferably by momentarily closing a normally open switch the transformer delivers stepped-up alternating current across the starting electrode and negative operating electrode at the cyclic rate of the A.C. source which is conventionally 400 cycles per second. At the same time a D.C. booster voltage, higher than operating voltage of the lamp, is applied across the two operating electrodes of the lamp. In accordance with the invention the D.C. booster voltage may be supplied either by a second secondary coil associated with the transformer and connected across the operating electrodes of the lamp or by connecting one side of the A.C. power source to the positive operating electrode through a diode and resistor and connecting the negative operating electrode to the other side of the A.C. power source. In the latter arrangement the diode rectifies the current and the resistor limits the current to the level desired.

The arc lamp circuit of this invention will now be explained in detail with reference to the accompanying drawings in which:

FIGURE 1 is a schematic diagram of the wing-tip light circuit of the present invention, and

FIGURE 2 is a schematic diagram similar to the diagram of FIGURE 1 but showing an alternative arrangement of the portion of the starting circuit which supplied the D.C. booster voltage.

Referring now to the drawings, a compact arc lamp circuit for aircraft wing lights in accordance with the present invention includes a three electrode D.C. compact arc lamp **10** having a positive operating electrode **11**, a negative operating electrode **12** and a starting electrode **13**. The lamp **10** is started and operated from a source of direct current electric power having a positive terminal **15** and a negative terminal **16** and a source of alternating current having terminals **17** and **18**. The lamp starting and operating circuit in accordance with the present invention is particularly adapted to utilize the 28 volt direct current power source and the 115 volt 400 cycle per second alternating current power source which are conventional for the operation of equipment and instruments on civilian and military aircraft.

The positive terminal **15** of the D.C. source is connected to the positive lamp electrode **11** by a conductor **20** which includes a resistor **21** and a diode **22**. The negative terminal **16** of the D.C. source is connected through a conductor **24** to the negative lamp electrode **12**.

In practice a suitable aircraft wing tip light is provided by a 150 watt compact arc lamp. The resistor **21** is therefore provided to reduce the D.C. voltage applied to operate the lamp and would normally be a one ohm resistor. The diode **22** is provided to prevent stray stepped-up voltage in the remainder of the circuit (subsequently to be described) from traveling back to the D.C. source.

The lamp **10** is started by a combination of high voltage pulses derived from the A.C. source, a D.C. booster voltage. The A.C. pulses are applied between the starting electrode **13** and the negative operating electrode **12** and at the same time the D.C. booster voltage is applied across the operating electrodes **11** and **12**. The D.C. booster voltage to be applied in starting the lamp is higher than D.C. voltage applied to operate the lamp after it has started.



In accordance with the invention the stepped-up A.C. or pulsating voltage is provided by a step-up transformer **25** which has a primary coil **26** connected across the A.C. power source. One end of the primary coil **26** is connected to the A.C. terminal **17** by a conductor **27** and the other end of the coil **26** is connected to the A.C. terminal **18** by a conductor **28**. A switch **29** is shown in the conductor **27** as means to close the starting circuit when it is desired to start the lamp **10**. A current limiting resistor **30** is also inserted in the conductor **27** to shield the transformer **25** from excessive current when the lamp starts.

A secondary coil **32** of the transformer **25** is connected between the starting electrode **13** and the negative operating electrode **12** of the lamp.

The D.C. booster voltage to be applied across the operating electrodes **11** and **12** of the lamp may be derived from a second secondary coil **33** associated with the transformer **25** as shown in FIGURE 1 or by reducing and rectifying power from the A.C. source and applying it across the electrodes **11** and **12** in a manner illustrated in FIGURE 2.

Referring to FIGURE 1 the second secondary coil **33** associated with the transformer **25** has one end connected to the negative operating electrode **12** by a conductor **34** tapped into the conductor **24** which goes to the electrode **12**. The other end of the secondary coil **33** is connected through a diode **35** to the positive operating electrode **11** by being tapped into the conductor **20** which is connected to the electrode **11**. When the switch **29** is closed the alternating current induced in the second secondary coil **33** by the operation of the step-up transformer **25** is thus rectified by the diode **35** and the resulting D.C. voltage is applied between the operating electrodes **11** and **12** at the same time the secondary coil **32** applies stepped-up pulsating voltage between the starting electrode **13** and the negative operating electrode **12**.

In practice with a 150 watt compact arc lamp **10** and an A.C. power source of 115 volts at 400 cycles per second the transformer **25** is selected to step up the voltage to 6500 volts from the secondary coil **32**. This A.C. voltage will of course be pulsating at the rate of 400 cycles per second as at the source. The second secondary coil **33** is adapted to deliver a booster D.C. voltage of 65 volts across the operating electrodes **11** and **12** in combination with the pulsating voltage across the starting electrode **13** and negative operating electrode **12** is more than adequate to start the lamp **10** in a matter of seconds when the switch **29** is closed.

Still looking at FIGURE 1 the only elements of the circuit which should be located close to the lamp **10** in order to avoid having to use heavy conductors for high voltage are the elements shown in the dotted square **36**. These are the transformer **25** with the primary coil **26** and two secondary coils **32** and **33** and the diode **35**. These elements fit in a space less than 2 x 2 x 4 inches and would weight about 2½ pounds. This permits the arc lamp circuit of this invention to be used for aircraft wing lights without structural changes in the aircraft and without significantly adding to the weight of the wing.

The resistor **30** which prevents excessive current from passing through the transformer **25** when the lamp starts and the switch **29** for the circuit are preferably carried in the body of the aircraft. The resistor **30** for the circuit described will normally be an element approximately 1½ inches in diameter and 6 inches long weighing a few ounces. Space might easily be found for it in the wing of larger aircraft but as already mentioned it need not be located in the proximity of the lamp **10** and therefore may be carried inside the aircraft. It should also be noted the resistor **30** may be eliminated from the circuit if a reactive transformer is used for the transformer **25**.

Looking now at FIGURE 2, as illustrated in this figure the D.C. booster voltage may be provided by rectifying power from the A.C. source instead of utilizing a second secondary coil **33** associated with the transformer as described above. For this purpose a conductor **37** having a diode **38** and a resistor **39** therein is connected between the conductor **27** from the A.C. source and the conductor **20** from the positive terminal **15** of the D.C. source. The return for the circuit through the conductor **37** is provided by a conductor **40** between the conductor **24** from the negative electrode **12** of the lamp and conductor **28** to the terminal **18** of the A.C. source. The circuit through the conductor **37** thus rectifies and reduces power from the A.C. power source and applies the resulting D.C. voltage across the operating electrodes **11** and **12** of the lamp. As shown, the conductor **37** is connected into the conductor **27** between the switch **29** and the resistor **30** so that the switch **29** will close both the circuit through the primary coil **26** of the transformer **25** and the circuit through the conductor **37**.

The resistor **39** is selected to limit the current delivered across the lamp electrodes **11** and **12** from the booster circuit and to protect the diode **39**.

The operation of the circuit shown in FIGURE 2 is the same as the operation of the circuit shown in FIGURE 1. That is, closing the switch **29** causes the transformer **25** to deliver stepped up pulsating voltage across the starting electrode **13** and the negative operating electrode **12** of the lamp **10** and at the same time directs a D.C. booster voltage across the operating electrodes **11** and **12** of the lamp. This combination of a pulsating voltage and a booster voltage effectively starts the lamp.

In the circuit shown in FIGURE 2 the only component which should be adjacent the lamp, and hence carried in the wing of an aircraft, is the transformer **25**. As in the circuit shown in FIGURE 1 the resistor **30** may be in the wing or in the body of the aircraft or may safely be eliminated from the circuit by using a reactive transformer for the transformer **25**.

What is claimed is:

**1.** A wing light for aircraft having a source of direct current and a source of alternating current and in combination, a direct current compact arc lamp having a starting electrode and a pair of operating electrodes, said source of direct current having a positive terminal and a negative terminal connected respectively to the operating electrodes of the lamp, a step-up transformer having a primary coil and a secondary coil, said primary coil being connected in a circuit across the source of alternating current, a switch connected to open and close the circuit through the primary coil, said secondary coil being connected between the starting electrode and one operating electrode of the lamp, circuit means connected to apply direct current across said operating electrodes when said switch is closed, resistance means connected to apply direct current across said operating electrodes when said switch is closed, resistance means connected to block excessive current through the transformer during lamp ignition, said circuit means comprising a second secondary coil associated with the transformer, said second secondary coil being connected across the operating electrodes of the lamp with a diode in series between one of the operating electrodes and one end of said second secondary coil.

**2.** A wing light for aircraft having a source of direct current and a source of alternating current and in combination, a direct current compact arc lamp having a starting electrode and a pair of operating electrodes, said source of direct current having a positive terminal and a negative terminal connected respectively to the operating electrodes of the lamp, a step-up transformer having a primary coil and a secondary coil, said primary coil being connected in a circuit across the source of alternating current, a switch connected to open and close the circuit through the primary coil, said secondary coil being connected between the starting electrode and one operating electrode of the lamp, circuit means connected to apply direct current across said operating electrodes when said switch is closed, resistance means connected to apply direct current across said operating electrodes when said switch is closed, resistance means connected to block excessive current through the transformer during lamp ignition, said circuit means comprises a first conductor including a diode in series connected between one side of the source of alternating current and one operating electrode of the lamp, and a second conductor between the other operating electrode and the other side of the source of alternating current.



**3.** A wing light for aircraft having a source of direct current and a source of alternating current and in combination, a direct current compact arc lamp having a starting electrode and a pair of operating electrodes, said source of direct current having a positive terminal and a negative terminal connected respectively to the operating electrodes of the lamp, a step-up transformer having a primary coil and a secondary coil, said primary coil being connected in a circuit across the source of alternating current, a switch connected to open and close the circuit through the primary coil, said secondary coil being connected between the starting electrode and one operating electrode of the lamp, circuit means connected to apply direct current across said operating electrodes when said switch is closed, resistance means connected to apply direct current across said operating electrodes when said switch is closed, resistance means connected to block excessive current through the transformer during lamp ignition, said resistance means is provided by having said transformer a reactive transformer.

**4.** A wing light for aircraft having a source of direct current and a source of alternating current at higher voltage than the direct current and in combination, a direct current compact arc lamp having a starting electrode and a pair of operating electrodes, said source of direct current having a positive terminal and a negative terminal connected respectively to the operating electrodes of the lamp which are respectively positive and negative electrodes, a step-up transformer having a primary coil and a secondary coil, said primary coil being connected in a circuit across the source of alternating current, a switch connected to open and close the circuit through the primary coil, said secondary coil being connected between the starting electrode and the negative electrode of the lamp, circuit means connected when said switch is closed to apply direct current across said operating electrodes at higher voltage than the direct current source and at lower voltage than the alternating current source, resistance means connected to block excessive current through the transformer when the lamp starts, said circuit means comprising a first conductor including a diode and a resistor in series connected between one side of the source of alternating current and the positive operating electrode of the lamp, and a second conductor connecting the negative operating electrode of the lamp to the other side of the source of alternating current.


**References Cited by the Examiner**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 2,736,840 | 2/1956 | Tosswill | 315—168 |
| 2,909,705 | 10/1959 | Husson | 315—168 |
| 3,115,594 | 12/1963 | Mallory | 315—176 X |



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