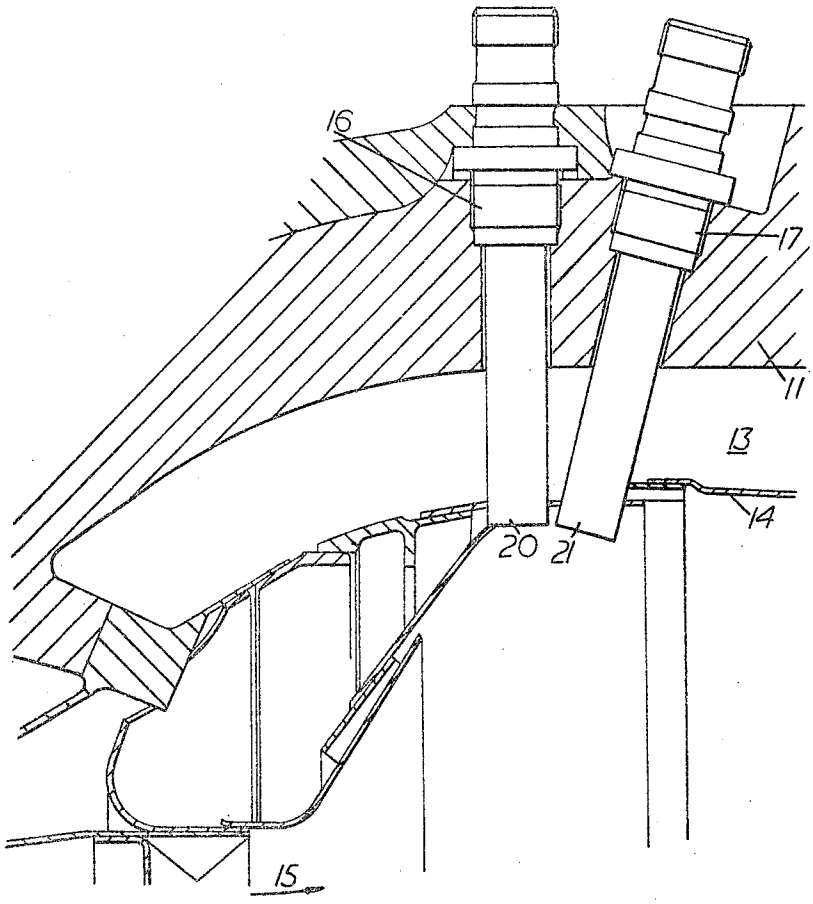
Aug. 9, 1966 G. A. HALLS ETAL 3,264,825

GAS TURBINE JET PROPULSION ENGINE IGNITER

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FIG. 1.



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FIG. 3.

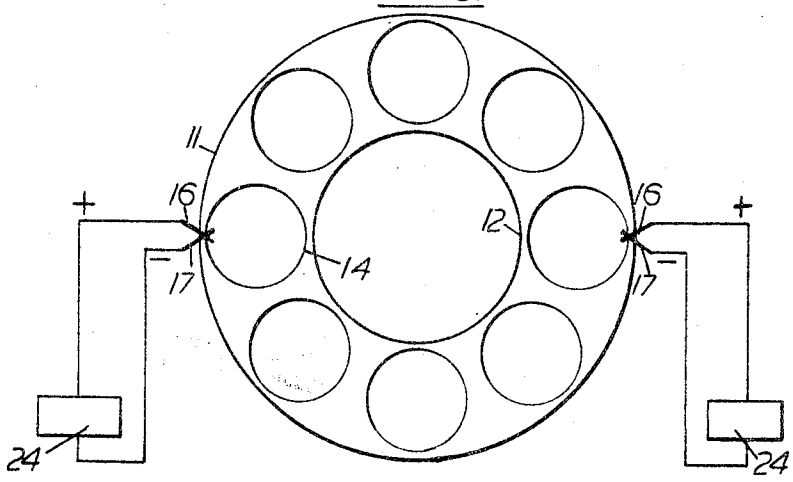
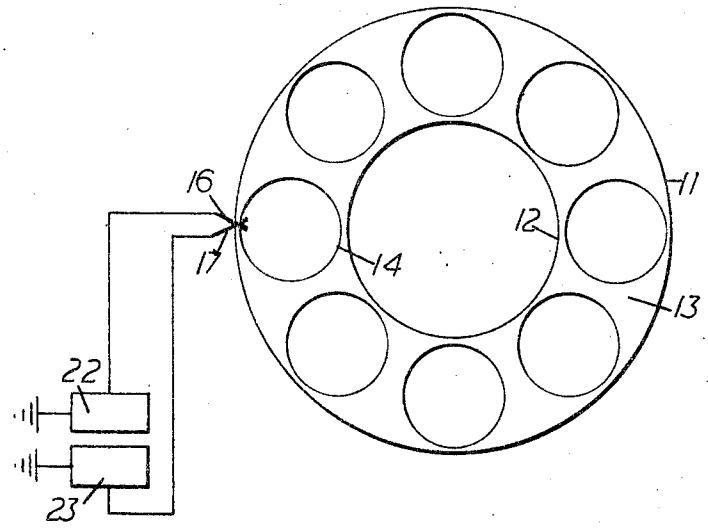


FIG. 2.



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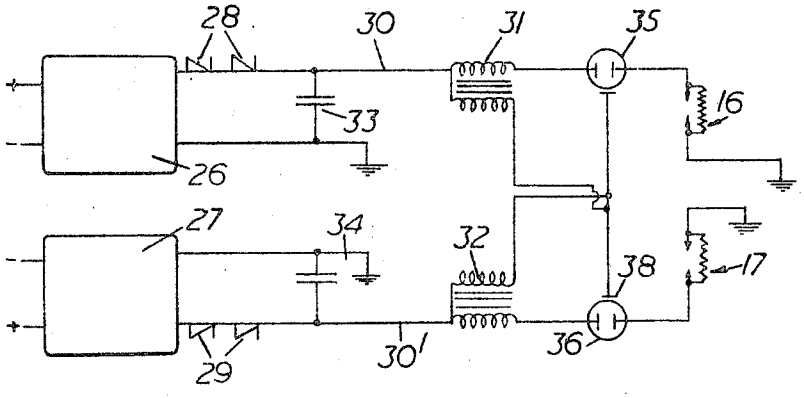
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GAS TURBINE JET PROPULSION ENGINE IGNITER

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FIG4.



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GAS TURBINE JET PROPULSION ENGINE IGNITER

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6 Claims. (Cl. 60—39.82)

This invention concerns a gas turbine jet propulsion engine combustion chamber and is a continuation-in-part of our application Serial No. 183,907, filed Mar. 30, 1962, now abandoned.

A problem associated with all internal combustion engines using electrical ignition systems is that of ensuring continuity of operation even after failure of a component of the system. This problem is particularly serious in gas turbine jet propulsion engines since failure in operation could result in loss of life and/or loss of an expensive aircraft.

It is clear that the problem can be overcome by duplicating the ignition system. Thus, if a 12 joule igniter is required to "relight" an engine should "flame out" occur at 40,000 feet, then two 12 joule igniters and associated circuits could be employed to ensure increased safety. However, the obvious penalty of the solution is an increase in weight of 100% in the ignition system.

To reduce this penalty, we propose to replace a single 12 joule ignition system with two 6 joule ignition systems. By arranging the surface discharge igniters of two 6 joule systems such that their discharges combine, it has been found that an ignition equivalent to or even better than that produced by a single 12 joule system is obtained. Thus "relight" at, say, 40,000 feet is possible. Should one of the igniters or systems fail, "relight" can be obtained by dropping to, say 30,000 feet, when the remaining igniter would be capable of "relighting" the engine. Thus an effectively duplicated system is provided, the weight increase of which is only 8% compared with a single 12 joule system. Although some loss in height may be necessary to effect ignition with the remaining igniter, this is obviously preferable to being without an additional igniter or having a weight penalty of 100%.

It will be appreciated that the system herein proposed may be of particular use at take-off or on an approach run when, if flame out should occur and one igniter should fail, the remaining 6 joule igniter can be used to relight. If a single 12 joule igniter is used, no relight would be possible, and if two 12 joule igniters are used the weight penalty is excessive.

In employing two 6 joule igniters to provide ignition similar to or better than a single 12 joule igniter, it is important to ensure that the combustion zones produced by the igniters combine to provide the equivalent of a 12 joule combustion zone since otherwise performance will be no better than with a single igniter. It will be seen that the consideration here is totally different from that used in employing two igniters in a piston engine, for example, where, to obtain a rapid flame propagation in the combustion chamber, two igniters may be placed therein, as far apart as possible.

According, therefore, to the present invention, a combustion chamber, in a gas turbine jet propulsion engine, has two surface discharge spark igniters which individually could not produce light-up at a predetermined altitude, and means for simultaneously firing the two spark igniters to produce combustion zones which combine and can produce light-up at said predetermined altitude, said means being capable of firing the spark igniters individually to produce light-up at altitudes less than said predetermined altitude.

Each of the spark igniters may be connected to a separate source of electrical energy, the two sources of electrical energy being so arranged that the spark igniters are fired simultaneously or substantially simultaneously.

In this case each said source may be connected to its spark igniter by a circuit which is electrically or magnetically coupled to the other circuit. Thus each said circuit may comprise a sealed spark gap having a trigger electrode which is triggered by the passage of current in the other circuit.

Alternatively, and preferably, the two spark igniters may be connected in series across a single source of electrical energy.

The or each said source of electrical energy may be substantially of the value six joules.

The invention is illustrated, merely by way of example in the accompanying drawings, in which:

FIGURE 1 is an axial section through part of a combustion chamber according to the present invention, the said combustion chamber forming part of a gas turbine engine and being provided with a pair of spark igniters,

FIGURES 2 and 3 are schematic cross sections illustrating alternative electric circuits in which the spark igniters shown in FIGURE 1 may be connected, and

FIGURE 4 is a circuit diagram illustrating a circuit which may be employed to effect substantially simultaneous operation of the spark igniters shown in FIGURE 1.

Referring first to FIGURE 1, a gas turbine engine has an engine casing **11** and an inner casing **12** (shown in FIGURES 2 and 3) which are separated by an annular space **13** and which constitute the outer and inner walls respectively of the combustion chamber of the engine.

Mounted within the space **13** are a number (e.g. eight, as shown) of flame tubes **14** which are angularly spaced apart from each other. Between each adjacent pair of flame tubes **14** there are interconnecting passages (not shown) through which flame propagation may occur.

Alternatively, instead of providing a number of angularly spaced apart flame tubes, a single fully annular flame tube may be employed.

Air enters each of the flame tubes **14** at **15**, fuel being injected into each of the flame tubes by means not shown.

One of the flame tubes **14** is provided with a pair of spark igniters **16**, **17**.

The spark igniters **16**, **17** are fixed in the casing **11** and extend across the space **13** so that their respective inner ends **20**, **21** (which are provided with spark electrodes, not shown) project through the wall of the respective flame tube **14** and into the combustion zone within.

The spark igniters **16**, **17** are situated very close together such that on simultaneous or substantially simultaneous operation of the spark igniters, the hottest parts of the immediately developed individual combustion zones produced by the spark igniters are closely adjacent to or meet each other.

It has been found that when the hottest parts of the immediately developed combustion zones from the spark igniters **16, 17** combine, a superior ignition performance is obtained to that produced by a single spark. Moreover even if the spark igniters **16, 17** are energised by separate six joule sources of electrical energy, the ignition performance obtained is substantially equal to that obtained from a single spark igniter energised by a twelve joule source of electrical energy.

It will be appreciated that once the spark igniters **16, 17** effect ignition within the flame tube **14** within which they are disposed, the provision of the above-mentioned interconnecting passages will ensure that ignition also occurs within the remaining flame tubes **14**.

Although the spark igniters **16, 17** are shown as being inclined to one another, this is not essential and indeed it is preferred that they should be parallel to each other.

In FIGURE 4 there is shown a circuit which may be employed to effect substantially simultaneous operation of the spark igniters **16, 17** of FIGURE 1.

The circuit of FIGURE 4 includes two charging sources **26, 27** each of which is connected across a twenty-four volt source of direct current. The charging sources **26, 27** are adapted to chop the direct current supply to produce high voltage pulses of current.

The charging sources **26, 27** are connected, by way of rectifiers **28, 29** respectively, and lines **30, 30'** respectively, to choke couplings **31, 32** respectively. Earthed condensers **33, 34** are arranged to be charged with pulses of current from the rectifiers **28, 29** respectively. The condensers **33, 34** when fully charged, each contain six joules of stored energy.

The choke couplings **31, 32** are connected to the spark igniters **16, 17** respectively by way of sealed spark gaps **35, 36** respectively.

The sealed spark gaps **35, 36** are provided with trigger electrodes **37, 38** respectively. The trigger electrodes **37, 38** are respectively connected to the choke couplings **32, 31.**

Accordingly, if, for instance, the condenser **33** becomes fully charged before the condenser **34**, the sealed spark gap **35** will break down and ignition current will pass to the spark igniter **16**. The passage of current through the choke coupling **31** will, however, trigger the sealed spark gap **36** by way of the trigger electrode **38**, and ignition current will also pass substantially simultaneously to the spark igniter **17**.

Thus the spark igniters **16, 17** will always be operated substantially simultaneously.

The arrangement shown in FIGURE 4 is only one of several ways in which the spark igniters **16, 17** may be operated substantially simultaneously.

Thus the choke couplings **31, 32,** instead of being connected to trigger electrodes **37, 38,** may be connected to third electrodes (not shown) in the sealed spark gaps **36, 35** respectively.

Alternatively the choke couplings **31, 32** may be dispensed with and the lines **30, 30'** magnetically coupled together by incorporating chokes (not shown) which are wound on a common core (not shown).

Another possibility is to dispense with the choke couplings **31, 32** and the two sealed spark gaps **35, 36,** and to use instead a single common sealed spark gap (not shown), whereby the discharge of one condenser would cause discharge of the other.

It is also possible to couple the lines **30, 30'** by transformer coupling or by resistance coupling.

In FIGURE 2, the spark igniters **16, 17** are respectively energised from separate, six joule, sources **22, 23** of electrical energy, the spark igniters **16, 17** being caused to operate simultaneously e.g. by the use of a circuit as shown in FIGURE 4.

In FIGURE 3, each of two diametrically opposnely disposed flame tubes **14** is provided with a pair of spark igniters **16, 17.** The spark igniters **16, 17** of each said pair are wired in a series circuit across a single, six joule, source **24** of electrical energy. The said series circuit may incorporate a switch (not shown). This system is particularly useful in direct lift engines.

The arrangements described above also have the advantage over conventional gas turbine engine combustion systems that the life of the spark igniters is substantially increased due to the lower electrical energy used (six joules as opposed to twelve joules).

Thus the double igniter arrangements described above may be used to replace each of the single igniters of conventional ignition systems, even if two or more single igniters are used at opposite sides of the annular chamber to promote flame propagation. By replacing each 12 joule igniter with two adjacent 6 joule igniters, a duplicate ignition system is provided with a weight penalty of, say, only 8% compared with the 100% to be expected by using two 12 joule igniters. By employing two six joule systems, "re-light" may be effected at, say 40,000 feet, which is as good as if not better than that provided by a 12 joule igniter. Should one of the 6 joule igniters fail, re-light may be obtained by dipping to, say, 30,000 feet and operating the remaining igniter alone.

It has been found that the "time to light" of an engine using the combustion chamber illustrated in FIGURE 2 or 3 is not substantially different from the time to light of an engine using the above-mentioned conventional combustion system. Also, the engine is lighter, and due to the duplicated ignition system, is safer.

We claim:

1. In a gas turbine jet propulsion engine, a combustion chamber having two closely adjacent surface discharge spark igniters which individually could not produce light-up at a predetermined altitude, and means for simultaneously firing the two spark igniters to produce combustion zones which combine and can produce light-up at said predetermined altitude, said means being capable of firing the spark igniters individually to produce light-up at altitudes less than said predetermined altitude.

2. In a gas turbine jet propulsion engine, a combustion chamber having two separate sources of electrical energy, two closely adjacent surface discharge spark igniters, which individually could not produce light-up at a predetermined altitude, connected one to each source, and means for simultaneously firing the two spark igniters to produce combustion zones which combine and can produce light-up at said predetermined altitude, said means being capable of firing the spark igniters individually to produce light-up at altitudes less than said predetermined altitude.

3. In a gas turbine jet propulsion engine, a combustion chamber having a single source of electrical energy, two closely adjacent surface discharge spark igniters, which individually could not produce light-up at a predetermined altitude, connected across said single source, and means for simultaneously firing the two spark igniters to produce combustion zones which combine and can produce light-up at said predetermined altitude, said means being capable of firing the spark igniters individually to produce light-up at altitudes less than said predetermined altitude.

4. In a gas turbine jet propulsion engine, a combustion chamber having two relatively inclined, closely adjacent surface discharge spark igniters which individually could not produce light-up at a predetermined altitude, and means for simultaneously firing the two spark igniters to produce combustion zones which combine and can produce light-up at said predetermined altitude, said means being capable of firing the spark igniters individually to produce light-up at altitudes less than said predetermined altitude.

5. In a gas turbine jet propulsion engine, a combustion chamber having two electrical circuits, a source of electrical energy and a surface discharge spark igniter

in each circuit, the igniters being closely adjacent and unable, individually, to produce light-up at a predetermined altitude, means effecting electrical coupling between the circuits to effect simultaneous firing of the two spark igniters to produce combustion zones which combine and can produce light-up at said predetermined altitude, and means capable of firing the spark igniters individually to produce light-up at altitudes less than said predetermined altitude.

6. In a gas turbine jet propulsion engine, a combustion chamber as claimed in claim 5, each circuit comprising a sealed spark gap having a trigger electrode which is triggered by the passage of current in the other circuit.

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