Jan. 3, 1956 S. ALLEN ET AL 2,729,060

MEANS FOR PROVIDING WORKING FLUID FOR A FLUID-OPERABLE STARTER MOTOR FOR A PRIME MOVER

Filed June 14, 1952 2 Sheets-Sheet 1

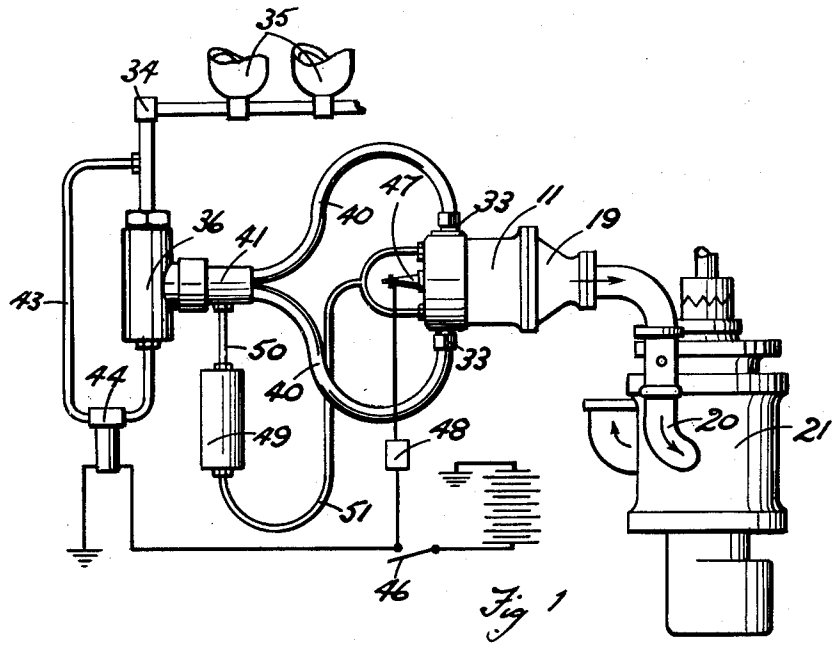
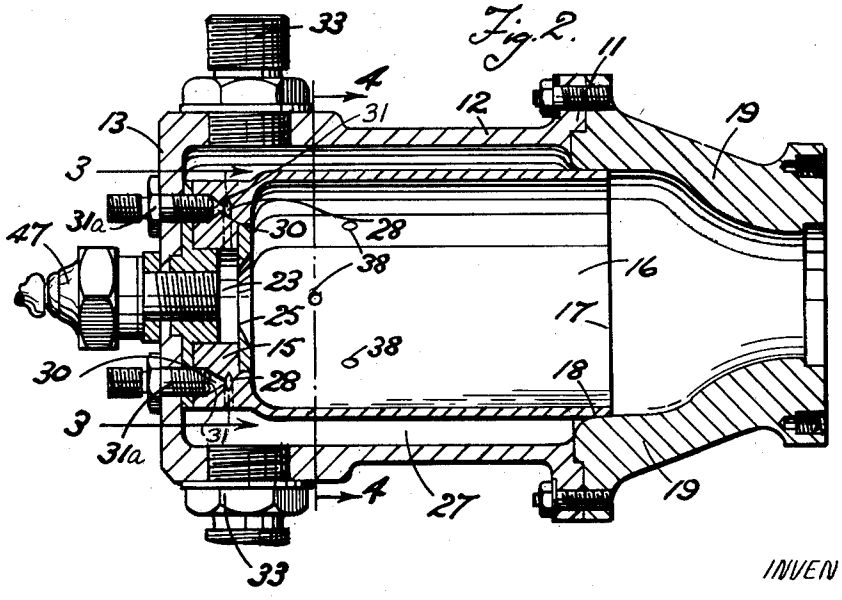


Fig. 1

Fig. 2.



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MEANS FOR PROVIDING WORKING FLUID FOR A FLUID-OPERABLE STARTER MOTOR FOR A PRIME MOVER

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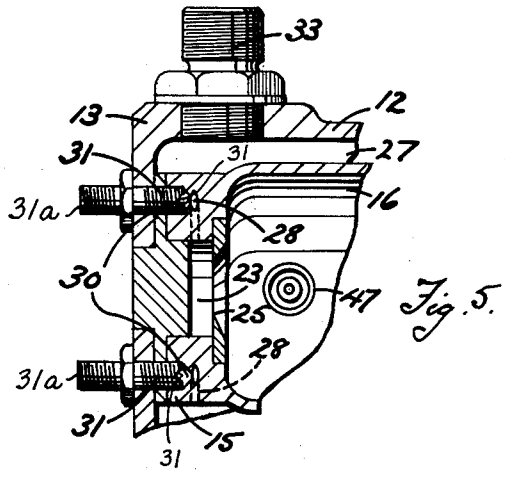

Fig. 5.

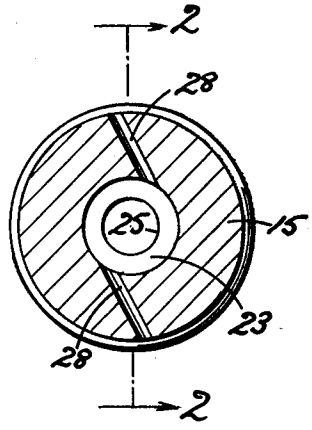

Fig. 3.

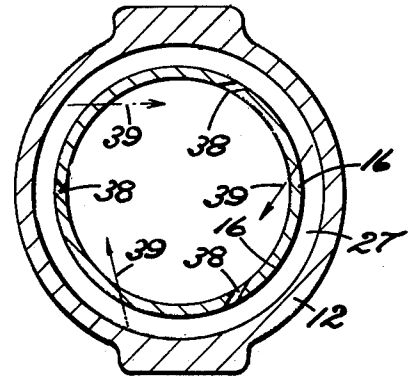

Fig. 4.

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MEANS FOR PROVIDING WORKING FLUID FOR A FLUID-OPERABLE STARTER MOTOR FOR A PRIME MOVER

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Claims priority, application Great Britain July 7, 1951

4 Claims. (Cl. 60—39.14)

This invention relates to means for providing working fluid for use in a fluid-operable starter motor for a prime mover—particularly for a gas turbine engine, though the invention is not limited in this respect. The starter motor may be of the vane type, or, alternatively, a gaseous fluid turbine.

The main object of the invention is to provide a simple supply and combustion system, for the starter motor, which does not require the use of any fuel pump or atomising spray devices or special vaporizing means, and which can, if desired, utilize as fuel the fuel of the prime mover when this is one operating on liquid fuel.

According to the invention, the means for supplying working fluid, for a fluid-operable starter motor, includes a source of compressed air the delivery from which is controlled by a main valve, a source of liquid fuel the delivery from which is effected by the compressed air when the main valve is opened, and a combustion chamber in which the fuel is burnt in the air, the products of combustion being passed to the starter motor as the working fluid.

Preferably the main valve is a pneumatically-operated one, the operating pressure being obtained from the source of compressed air when a solenoid operated valve is opened, which is the first step to be taken when the starter motor is to be operated.

In the accompanying drawings—

Figure 1 is a diagram of one form of apparatus according to the invention;

Figure 2 is a sectional elevation to an enlarged scale of the combustion chamber of Figure 1, the section being on the line 2—2 of Figure 3;

Figures 3 and 4 are cross sections on the lines 3—3 and 4—4 respectively of Figure 2; and

Figure 5 is a fragmentary view, in sectional elevation, showing a fragment of the combustion chamber of Figure 2 but with the igniter plug in a different position.

In the construction of Figures 1 to 4, the combustion chamber **11** includes an outer casing **12** having a closed end **13** to which is rigidly attached, with annular clearance from the casing wall, the closed end **15** of a cylindrical flame tube **16** the opposite end **17** of which is open and slidably mounted in a reduced bore **18** of the casing **12** or of a part **19** attached thereto and adapted for connection in any appropriate manner to the inlet **20** of the starter motor **21**. The closed end **15** of the flame tube **16** is formed with a co-axial cylindrical chamber **23**, hereinafter called the swirl chamber, of smaller diameter than that of the flame tube. One end of the swirl chamber is open to the interior of the flame tube through a sharp-edged aperture **25** of smaller diameter than the swirl chamber.

The swirl chamber **23** is connected with the annular chamber **27** formed between the flame tube **16** and outer casing **12** by means of at least one relatively-small-diameter passage **28** (see Figure 3) which is disposed tangentially to the bore of the swirl chamber. At an intermediate position this tangential passage **28** communicates with a transverse passage **30** provided with a fuel metering orifice **31** which is preferably formed in the nose of a fuel supply union **31***a* which has a threaded engagement in the passage **30** and can also be used for attaching the flame tube to the closed end of the outer casing, as shown by Figure 2. Preferably there are two or more such tangential passages and fuel metering orifices.

At diametrically opposite points **33** the outer casing is provided with means for putting the annular chamber **27** into communication with a source of compressed air (for example, with an appropriate reducing valve means **34** connected to compressed air storage bottles **35**) when the main valve **36** is open. The flame tube wall has at least one ring of holes **38** radially or tangentially disposed in it for placing the interior of the flame tube in communication with the annular chamber **27**, and when there are two or more tangentially disposed rings of holes, the holes in each succeeding ring may be of opposite sense (tangentially) to those in the preceding ring, as indicated by arrows **39** in Figure 4.

The number of such holes in a ring and the number of such rings axially spaced along the length of the flame tube would be in accordance with the combustion requirements depending on whether the starter motor **21** which has to be operated requires a working fluid of relatively high or low temperature.

The diametrically-opposite points **33** of the outer casing are shown as being connected to pipes **40** merging into a common passage **41** connected to the main valve **36**, this being a pneumatic valve which is closed when the starter motor is not being operated and is opened by air pressure from a bleed along a pipe **43**, from the main supply, controlled by an electrically-operated valve **44**. The switch **46** for the circuit of this valve **44** may also be arranged to complete a circuit through a spark generator **48** for an igniter plug **47**. This may be co-axially mounted in the closed end of the outer casing to communicate with the swirl chamber. Alternatively, as indicated by Figure 5, it may extend through the outer casing **12** and annular chamber **27** into the flame tube **16** near the closed end thereof.

Liquid fuel in a closed fuel reservoir **49** is connected at the top by a pipe **50** with the common air passage **41** and at its lower end by a pipe **51** to the fuel metering orifice union or unions. This reservoir may be supplied from the main fuel tank of the prime mover and can be automatically replenished as required in any preferred manner.

To put the combustion system into operation, the switch **46** is actuated to open the solenoid valve **44**, and thus the pneumatic valve **36**, and at the same time, or by a separate switch, the igniter plug **47** is brought into operation. Compressed air is therefore supplied to the annular chamber **27**, a portion of this air being fed through the tangential passages **28** communicating with the swirl chamber **23**. Due to the pressure drop in the passages **28** and the pressure applied by the pipe **50** to the fuel in the reservoir **49**, fuel is delivered through the metered orifices **31** into the high velocity air stream passing through the tangential passages which acts to atomise the fuel on its way to the swirl chamber, where intimate mixing takes place in the vortex so formed. As the rich mixture in this vortex passes into the flame tube the sharp-edged aperture **25** acts further to atomise the fuel particles in the mixture and prevent dribble.

Combustion takes place in the flame tube, air for this purpose being led from the annular chamber through the aforesaid ring or rings of holes **38** therein, thereby promoting a still further beneficial mixing of this air with the rich mixture from the swirl chamber, due to the relatively high velocity of this air through these holes **38**.

It will be understood that control of the amount of fuel depends on the size of the metering orifices 31 which can be chosen to suit the particular application. Also, the supply of compressed air into the annular chamber 27 need not be as described, as, in some cases, a single feed thereto may be sufficient.

What we claim as our invention and desire to secure by Letters Patent of the United States is:

1. Means for providing working fluid for use in a fluid-operable starter motor, including a source of compressed air, a source of liquid fuel, a main valve controlling the delivery from the source of compressed air, the latter being connected to the source of liquid fuel so that the delivery of fuel is effected by the compressed air when the main valve is opened, the fuel is delivered under the pressure of the air and the source of compressed air can supply a combustion chamber in which the fuel is burnt in the compressed air and which delivers the products of combustion to the starter motor as the working fluid, said combustion chamber including an outer casing having one end closed, a flame tube having annular clearance from said casing and having a closed end rigidly attached thereto at said one end, the opposite end of said casing having a reduced bore in which the adjacent end of said flame tube is mounted, the compressed air being supplied to the annular chamber between said casing and said flame tube and being supplied to said flame tube through at least one ring of holes provided therein, said flame tube having at its closed end a cylindrical chamber communicating with said annular chamber by at least one relatively-small-diameter passage disposed tangentially to the bore of said cylindrical chamber whereby air will pass at high velocity through said passage and enter said cylindrical chamber with a whirling motion, and the closed ends of said casing and flame tube carrying a fuel metering device disposed in a transverse passage leading to said tangential passage whereby the high velocity air passing through the latter will eject and atomise fuel from said device for burning in said combustion chamber.

2. Means for providing working fluid for use in a fluid-operable starter motor, including a source of compressed air, a source of liquid fuel, a main valve controlling the delivery from the source of compressed air, and a combustion chamber in which the fuel is burnt in the compressed air and which delivers the products of combustion to the starter motor as the working fluid, said combustion chamber including an outer casing having one end closed, a flame tube having annular clearance from said casing to leave an annular chamber therebetween, said flame tube being closed at the end adjacent said one end of said casing, means for supplying the compressed air to said annular chamber and thence to said flame tube through at least one ring of holes provided therein, said flame tube having at its closed end a cylindrical chamber communicating with said annular chamber by at least one relatively-small-diameter passage which is disposed tangentially to the bore of said cylindrical chamber and through which the air will pass at high velocity for delivering to said cylindrical chamber with a whirling motion, and means for supplying metered fuel to a transverse passage in the closed end of said flame tube leading to said tangential passage.

3. Means for providing working fluid for use in a fluid-operable starter motor, including a source of compressed air, a source of liquid fuel, a main valve controlling the delivery from the source of compressed air, and a combustion chamber in which the fuel is burnt in the compressed air and which delivers the products of combustion to the starter motor as the working fluid, said combustion chamber including an outer casing having one end closed, a flame tube having annular clearance from said casing to leave an annular chamber therebetween, said flame tube having a closed end rigidly attached to the closed end of said casing, the main valve connected to said annular chamber, said flame tube having along its length at least one ring of holes provided therein, and said flame tube having at its closed end a coaxial cylindrical chamber communicating with said annular chamber by at least one relatively-small-diameter passage which is disposed tangentially to the bore of said cylindrical chamber and through which the air will pass at high velocity for delivering to said cylindrical chamber with a whirling motion, the closed ends of said casing and flame tube also having through them a transverse passage leading to said tangential passage and connected to the source of fuel, and a metered orifice in said transverse passage whereby the high velocity air passing through said tangential passage will eject and atomise fuel from said orifice for burning in said combustion chamber.

4. Means for providing working fluid for use in a fluid-operable starter motor, including a source of compressed air, a source of liquid fuel, a main valve controlling the delivery from the source of compresed air, and a combustion chamber in which the fuel is burnt in the compressed air and which delivers the products of combustion to the starter motor as the working fluid, said combustion chamber including an outer casing having one end closed, a flame tube having annular clearance from said casing to leave an anular chamber therebetween, said flame tube having its closed end rigidly attached to the closed end of said casing, said main valve being connected to said annular chamber, said flame tube having along its length at least one ring of holes provided therein, and said flame tube having at its closed end a coaxial cylindrical chamber communicating with said annular chamber by at least one relatively-small-diameter passage which is disposed tangentially to the bore of said cylindrical chamber and through which the air will pass at high velocity for delivering to said cylindrical chamber with a whirling motion, said cylindrical chamber being of smaller diameter than said flame tube and communicating with the latter through a sharp-edged aperture of still less diameter, and the closed ends of said casing and flame tube carrying a fuel metering device connected to the source of fuel and disposed in a transverse passage leading to said tangential passage.

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