

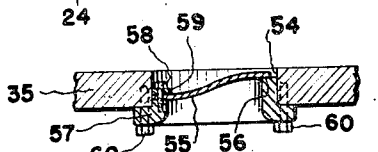
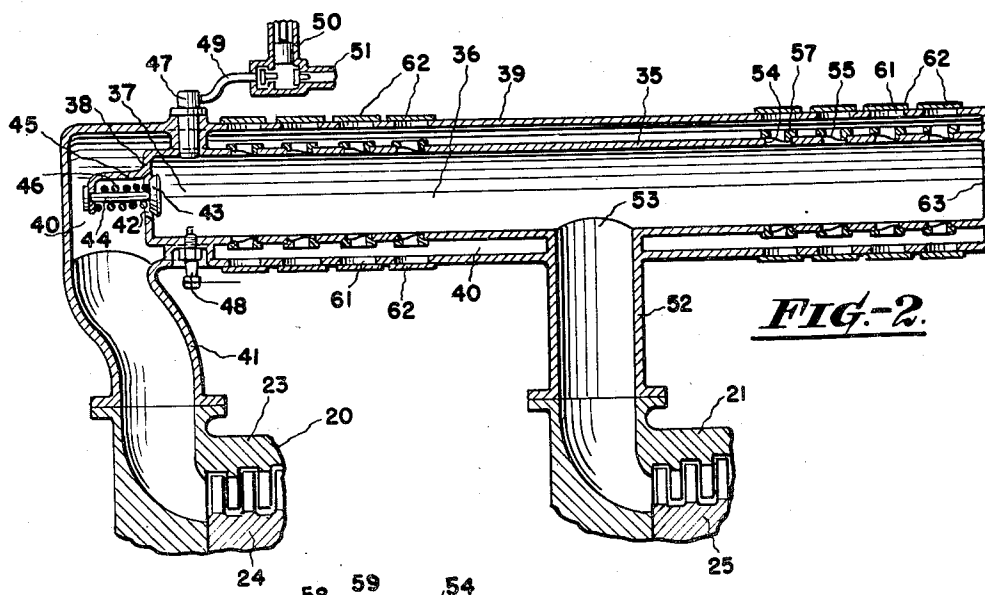
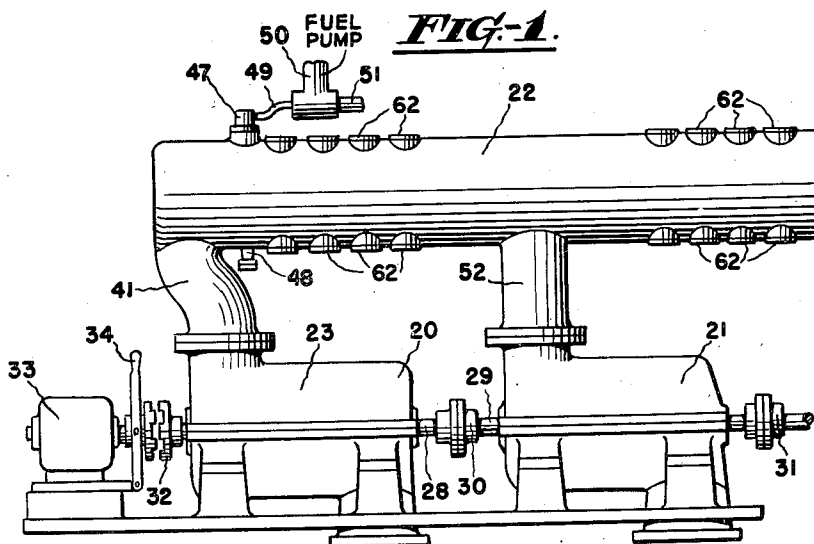
July 8, 1952

G. FARNELL

2,602,291

RESONANT EXPLOSION POWER UNIT WITH DILUTION AIR

Filed Dec. 16, 1947



INVENTOR
GEORGE FARNELL
BY *Carroll*
HIS ATTORNEY.

UNITED STATES PATENT OFFICE

2,602,291

RESONANT EXPLOSION POWER UNIT WITH
DILUTION AIRGeorge Farnell, Phillipsburg, N. J., assignor to
Ingersoll-Rand Company, New York, N. Y., a
corporation of New Jersey

Application December 16, 1947, Serial No. 792,071

2 Claims. (Cl. 60—39.65)

1

This invention relates to turbines, and more particularly to a resonant explosion unit for generating gases to operate a turbine.

One object of the invention is to introduce cooling air into the explosion chamber of the unit between successive explosions, in such a manner that the cooling air will thoroughly intermingle with the hot explosion gases in the chamber.

Another object is to discharge explosion gases at practically constant pressure from the explosion chamber of a resonant power unit having a single explosion zone.

Other objects will be in part obvious and in part pointed out hereinafter.

In the accompanying drawing in which similar reference numerals refer to similar parts,

Figure 1 is a side elevation of a gas turbine plant showing a resonant explosion chamber constructed in accordance with the practice of the invention,

Figure 2 is a transverse view of the resonant explosion power unit, somewhat enlarged, showing the position of the controlling devices when at rest, and

Figure 3 is an enlarged sectional view of a detail of Figure 2.

Referring more particularly to the drawing and at first to Figure 1, a resonant explosion gas turbine plant, designated in general by 20, is shown as including a turbine 21, a resonant explosion power unit 22 for providing operating gases for the turbine, and a compressor 23 driven by the turbine for delivering compressed air to the power unit 22.

The compressor and turbine are shown as being of the axial flow types having their rotors 24 and 25 coaxially arranged with each other and the opposed ends of their shafts 28 and 29 connected together by a coupling 30. On the other end of the shaft 29 is a power take-off coupling 31 and the outer end of the shaft 28 is adapted to be connected with a clutch mechanism 32 which in turn is attached to the operating shaft of a starting motor 33. An operating lever arm 34 for the clutch mechanism 32 is pivoted on the base of the starting motor to make possible the engagement and disengagement of the clutch mechanism.

The resonant explosion power unit 22 comprises a tubular casing 35 which forms a chamber 36 having an explosion zone 37 located adjacent an end member 38 of the casing 35, and a housing 39 shown as being concentrically arranged around the casing 35 to form an air supply chamber 40 therebetween. Compressed air is conveyed from

2

the compressor to the supply chamber 40 by a conduit 41, from whence a part of the air passes through a port 42 in the member 38 into the explosion zone 37.

The flow of air through the port 42 is controlled by a pressure responsive valve 43 shown as being of the poppet type and having its stem 44 extending through an L-shaped projection 45 attached to the end member 38 of the casing 35. The valve 43 is normally held unseated by a spring 46 encircling the valve stem and acting against the projection 45 and the valve.

Fuel is injected into the compressed air in the explosion zone 37 by a spray nozzle 47, and the resulting explosive mixture is ignited by a spark plug 48 projecting through the housing 39 and into the casing 35 in the transverse plane of the fuel spray nozzle. The fuel is conveyed to the spray nozzle by a conduit 49 from a fuel pump 50 which may itself receive fuel, under pressure, through a main fuel line 51 from an outside source (not shown).

In order to convey the exhaust gases from the explosion chamber 36 to the inlet of the turbine 21 a discharge conduit 52 is adapted to extend through the housing 39 to an exhaust opening 53 situated in the casing at the intermediate portion of the explosion chamber. Means, other than the main valve 43, are provided to introduce cooling air into the explosion chamber along the length thereof. To this end, a plurality of ports 54 are arranged in the casing 35 between each end of the chamber 36 and the discharge conduit 52 to afford communication between the explosion chamber 36 and the supply chamber 40.

The flow of air through the ports 54 is controlled by pressure responsive valves 55, preferably in the form of reeds. Each valve is essentially a resilient member normally held seated over the inner end 56 of its annular valve housing 57 by a bolt 58 which clamps one end portion of the valve 55 between a washer 59 and the end 56 of the valve housing. Each housing 57 has a nice fit in its port 54 and is held fixedly therein by bolts 60. Thus, whenever a higher pressure exists in the supply chamber 40 than in the explosion chamber 36 the valves 55 will bend inwardly in the direction of the explosion chamber and allow air to pass thereinto through the annular housing 57. To make the valves readily accessible for replacement or repair, ports 61 are provided in the housing 39 opposite each of the ports 54 and said ports 61 are normally covered by plates 62.

The length of the chamber 36 is so chosen

3

and the frequency of the explosions in the chamber is so timed that, when a pressure wave from an explosion is at its peak in one end of the chamber, it will simultaneously be at its lowest value in the other end of the chamber and, to this end, the length of the chamber approximates one half a pressure wave length or an odd multiple thereof. Accordingly, in order to determine the proper frequency of explosions for any given length of the chamber 36—the natural frequency of the chamber being dependent on the velocity at which the pressure wave travels in the chamber 36 and the length of the chamber 36—it is merely necessary to vary the timing of the ignition and, of course, the injection of the fuel so that firing occurs when the peak of a pressure wave reflected from the opposite end of the chamber 36 reaches the explosion zone 43. When this timing relationship exists, the pressure at the explosion end will be at a maximum whereas the pressure at the opposite end of the container will be substantially at a minimum and the frequency of explosions will then be equal to, or an odd multiple of, the natural frequency of the chamber 36. Measurements of pressure at opposite ends of the container may be facilitated by any well known means (not shown). In furtherance of this cycle of operation, an end plate 63 of the casing serves as a reflecting member to reverse the direction of movement of the peak of the pressure waves in the chamber 36 on contact therewith. The timing of ignition of the explosive charges in the zone 37 by the spark plug 48 may be accomplished in any well known manner, such as illustrated in United States Patent 2,517,822.

At the beginning of an operating period of the plant, the starting motor 33 imparts rotary movement to the rotors 24 and 25 causing compressed air to flow into the supply chamber 40 and through the port 42 into the explosion zone 37. If then the fuel pump is put into operation, fuel will be injected into the air in the explosion zone 37 through the nozzle 47 and the resulting explosive mixture will then be ignited by the spark plug 48. This initial explosion forces the valve 43 to its seat, thereby cutting off the further flow of compressed air through the port 42, and the pressure wave of the explosion travels toward the opposite end of the chamber 36 causing a low pressure area to exist in front of the valve 43 which permits the valve to open and admit a new charge of air into the explosion zone 37. As the trough of the wave passes over the valves 55 near the explosion zone 37, they are forced open consecutively, starting with those nearest the point of explosion, at the instant the pressure of the wave drops below that of the air in the supply chamber 40. Cooling air is thus admitted over a large area into the explosion end of the chamber 36 to intermingle with the hot gases therein.

When the peak of the pressure wave hits the end plate 63 it is reflected back toward its point of origin but the trough of the original wave will continue to move along toward the reflecting end of the chamber 36 and will thus also pass over the valves 55 located near the reflecting end of the chamber 36 causing them to open consecutively and admit additional cooling air from the supply chamber 40 into the explosion chamber 36. The cooling air also intermingles with the explosion gases and reduces their temperature suitably for use in the turbine 21.

The peak of the reflected pressure wave mov-

4

ing toward the explosion zone 37 compresses the new charge of air therein and, at the instant when the peak of the wave reaches the explosion zone, fuel is injected through the nozzle 47 into the compressed air and this explosive mixture is ignited by the plug 48. Thus, another wave is started which continues through the same cycle as that just described but lags behind the preceding wave by approximately one wave length.

It will be readily understood that the exhaust gases will pass from the middle of the explosion chamber through the opening 53 at practically a constant pressure since the original pressure wave and its reflected wave move simultaneously in opposite directions in the chamber and the reflected wave originates at the instant the original wave has moved one-half wave length. Waves moving in this manner in a chamber whose length is approximately one-half of a pressure wave length will have the effect of neutralizing each other at a distance of one-quarter wave length from the points of origin and reflection which, in this case, is the middle portion of the explosion chamber 36.

From the foregoing description, it will be apparent to those skilled in the art to which the invention appertains that modifications and changes may be made without departing from the scope of the appended claims.

I claim:

1. A resonant explosion power unit, comprising a casing forming an explosion chamber, means for forming successive charges of an explosive mixture in only one end of the chamber, means for igniting the charges of explosive mixture, an end member on the casing approximately one-half of an explosion wave length from the point of explosion in the chamber for reversing the direction of movement of pressure waves at the instant of contact therewith, a plurality of valves arranged in spaced relation along the length of the end portion of the explosion chamber adjacent the end member and acting responsively to the pressure waves therein for introducing cooling air into the explosion gases, a plurality of valves arranged in spaced relation along the opposite end portion of the explosion chamber for admitting cooling air therinto, and an exhaust opening in the casing intermediate the end member and the point of explosion.

2. A resonant explosion power unit, comprising a casing having an explosion chamber having an explosion zone in only one end thereof, a housing arranged around the casing to form an air supply chamber therebetween, means for introducing the air and fuel constituents of successive charges of an explosive mixture into the explosion chamber, means for igniting the charges of explosive mixture at a frequency equal to the natural frequency of the chamber, end members on the casing serving to reverse the direction of movement of the pressure waves in the explosion chamber, a plurality of valves arranged in spaced relation along the length of the end portion of the explosion chamber opposite to the explosion zone and acting responsively to the pressure waves in the explosion chamber to allow cooling air to enter the explosion gases, and an exhaust opening in the casing and housing near the intermediate portion of the explosion chamber for removing

2,602,291

5

the exhaust gases at practically constant pressure from the explosion chamber.

GEORGE FARNELL.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date	
332,313	Wilcox -----	Dec. 15, 1885	10
2,480,626	Bodine -----	Aug. 30, 1949	
2,523,379	Kollsman -----	Sept. 26, 1950	
2,546,966	Bodine -----	Apr. 3, 1951	
2,550,515	Anderson -----	Apr. 24, 1951	15

Number
1,329
27,724
176,838
188,642
239,434
574,554
576,886

5

10

15

6

FOREIGN PATENTS

Country	Date
Great Britain -----	Jan. 24, 1905
Great Britain -----	Dec. 16, 1907
Great Britain -----	Mar. 6, 1922
Great Britain -----	Nov. 29, 1923
Great Britain -----	Sept. 10, 1925
Great Britain -----	Jan. 10, 1946
Germany -----	May 20, 1933