Dec. 16, 1930. W. G. NOACK ET AL 1,785,643

INTERNAL COMBUSTION POWER PLANT

Filed Sept. 15, 1927

Fig. 1

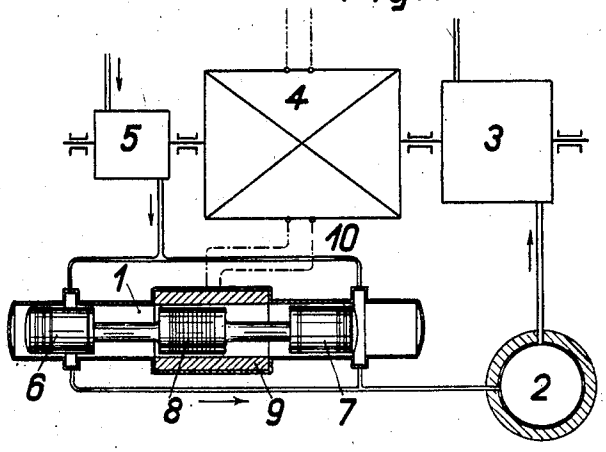
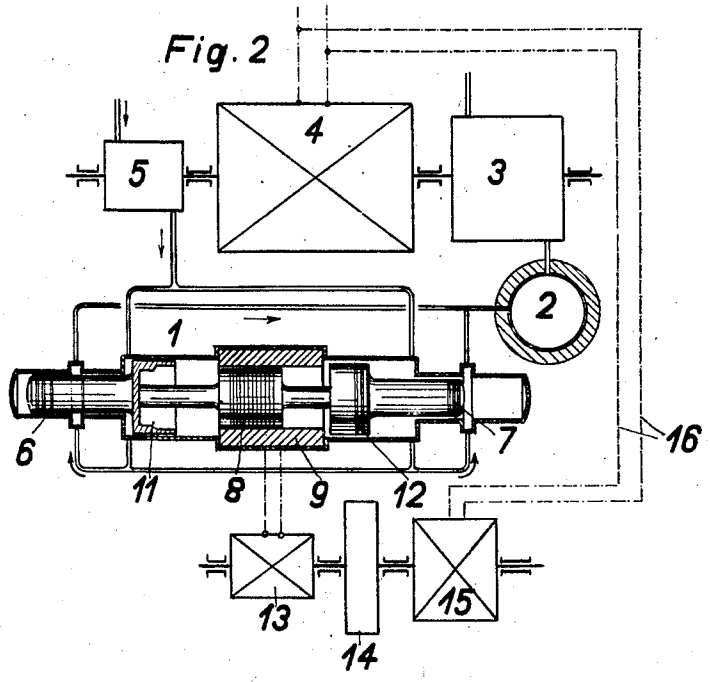


Fig. 2



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Patented Dec. 16, 1930

1,785,643

UNITED STATES PATENT OFFICE

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INTERNAL-COMBUSTION POWER PLANT

Application filed September 15, 1927, Serial No. 219,734, and in Switzerland April 25, 1927.

It has already been proposed to produce the working fluid for gas turbines in special machines in which the explosive mixture is given a certain amount of compression, exploded or burned and then partly expanded. These operations are conducted under high pressures and temperatures, and for this purpose the reciprocating engine has proved more suitable than the turbine. The production of the working fluid is therefore preferably carried out by reciprocating engines, of which the so-called free piston (or flying piston) engine is to be particularly recommended. Free piston engines have the advantage over the crank and connecting-rod type in having no connecting rod, crank shaft or bearings, and are in consequence cheaper and mechanically simpler, allowing higher piston pressures and piston velocities, and a higher stroke periodicity. These attributes are of particular importance in plants of the above description, since the production of the working fluid is an auxiliary function and the machine serving this purpose is only an auxiliary machine and should therefore be simple and inexpensive in design. The main engine in which the working fluid is made to do useful work is the gas turbine.

The ordinary type of free piston engine having no crank or flywheel is uneven in operation, has very little overload capacity and is easily stalled. In order to overcome these drawbacks it has already been proposed to couple the free-piston engine to a reciprocating electrical generator, which is connected either to a large electrical system or to a flywheel generator which takes over the equalizing functions of a flywheel and by virtue of its inherent synchronizing power ensures uniform running of the free piston engine. By suitably designing the electrical equipment it is also possible to increase the working periodicity of the reciprocating part of the machine above that obtainable when using the piston forces alone.

The present invention relates to an internal combustion power plant in which the working substance, consisting of very hot gas under high pressure, is produced in a reciprocating engine and expanded to do useful work in a gas turbine, the reciprocating engine being of the free piston type and coupled to a reciprocating electrical generator for the purpose of securing uniform running. The current obtained from this generator may be used to drive a motor for operating other auxiliary machines, or the two generators, i. e. the reciprocating generator and the rotary generator driven by the gas turbine, may be operated in parallel. In either case the primary object of electrically connecting the two machines is to ensure the uniform working of the free piston engine. Should the free piston engine fall out of step, or be in danger of stalling for example owing to ignition trouble or other reasons, then either the motor driving the auxiliaries (which would then work as a generator) or the main generator would act as a flywheel until proper working conditions had been restored.

To secure the necessary reliability for the gas turbine with the materials at present available, it is essential that the working fluid should not exceed a certain maximum temperature. The less the expansion in the first row of nozzles the lower will be this maximum temperature. In order that the allowable temperature for the blades shall not be exceeded it is necessary either to avoid using rich mixtures or to cool the exhaust gases as they leave the internal combustion engine by the addition of cold air. This may be performed in a mixing chamber immediately before the gas turbine. The same result is obtainable by an abundant use of scavenging air, particularly with the free piston engine working as a two-stroke engine. The high-pressure air necessary for this purpose may be conveniently obtained from a piston type compressor driven, together with the reciprocating generator, from the free piston engine. To keep the stroke volumes of the free piston engine and compressor as small as possible the air should be pre-compressed. For this purpose a so-called supercharging blower is employed which may be either driven by a motor which draws its current from the reciprocating generator, or coupled to the main generator or gas turbine.

The simplest arrangement of plant is obtained when no attempt is made to use the reciprocating generator for power supply purposes, its function being confined to that of a stabilizer for the free piston engine. In this case the whole of the power developed by the free piston engine is applied to the compression of air in the piston compressor, and the reciprocating generator, although electrically coupled either to the main electrical machine or to a special flywheel generator, runs practically unloaded. A transfer of electrical energy between the two machines takes place only if the strokes of the free piston engine commence to lead or lag on the uniform rotational motion of the main generator or aforesaid flywheel generator. Such an arrangement permits the reciprocating generator (and flywheel generator) to be designed for a mere fraction of the power developed by the free piston engine, since the full output is only required for extremely short periods of time, for example, during a few strokes or even a portion of a stroke, and under these conditions the electrical equipment may be safely loaded up to many times its normal rating.

The production of working fluid for a gas turbine would not ordinarily be carried out in a single free piston engine, but a number of such units would be installed. These units would be electrically coupled by means of their associated reciprocating generators and uniform working could then be ensured by a single rotary generator, or, in the event of power for driving purposes being required from the reciprocating generators, a single motor would suffice. It is then an advantage to design the rotary generator or motor as a polyphase machine and to connect each phase with one or more single-phase reciprocating generators. This will also ensure that the motions of the reciprocating parts of the free piston engines are in a definite phase relationship. For example by making the rotary generator or motor a three-phase machine the motions of the free piston engines are fixed at 120° apart and practically complete balance of the moving parts is obtained.

Two examples of internal combustion power plants embodying the present invention are illustrated diagrammatically in the accompanying drawings.

Figure 1 shows a plant in which the free piston engine which exhausts into and drives a gas turbine, supplies energy to a reciprocating generator, the current from which is passed to the main generator to which the compressor for scavenging and supercharging the free piston engine is also coupled.

Figure 2 shows a modified arrangement, in which the power developed by the free piston engine is employed to drive a piston type compressor, while the reciprocating generator is used simply to secure uniformity of working.

In the two figures the reference character 1 denotes the free piston engine, 2 an equalizing chamber for the exhaust gases, 3 the gas turbine, 4 the main generator, and 5 a blower for supplying scavenging air or air for combustion, which latter may be more or less pre-compressed. The pistons 6 and 7 are attached to the field magnet 8 of the reciprocating generator by means of piston rods. The reciprocating motion of the field generates an alternating current in the windings (not shown in the drawing) of the stator 9 and this current is led through the conductors 10 to the main generator 4, where it supplies the power for driving the blower 5.

In the plant shown in Fig. 2 the free piston engine drives a piston type compressor having pistons 11 and 12 carried on the same rods as the field magnet 8 of the reciprocating generator. This latter does not supply power for external purposes, but drives an auxiliary electrical machine 13 which is provided with a flywheel 14 to increase the inertia of the revolving masses. A blower 5 coupled to the main generator is used to pre-compress the air supplied to the piston compressor in order to permit a shorter stroke to be used. This air is further compressed by the said piston compressor and is then used as scavenging and combustion air in the free piston engine. The exhaust gases from the latter, which are still at a high pressure and temperature, are then passed on to the gas turbine 3.

The auxiliary machine 13 is coupled to electrical machine 15 which is electrically connected to the main generator by the leads 16. This machine 15 enables surplus energy to be transferred to or if necessary withdrawn from the main generator, even when the periodicities of the reciprocating and main generators are not the same. This condition would arise, for instance, if the stroke periodicity of the free piston engine were lower than the frequency of the system supplied by the main generator.

Instead of a single free piston engine there may be any number of such units, all connected to the aforesaid main or auxiliary generator. As before, uniformity of working is obtained by the action of the equalizing currents which are developed whenever the motions of the reciprocating generators are advanced or retarded with respect to the uniform rotational motion of the single main or auxiliary generator.

What we claim is:

1. Internal combustion power plant comprising, in combination, a gas turbine, an electric generator driven by said gas turbine, a reciprocating engine of the free or flying piston type the expanded working fluid of which operates the gas turbine, a reciprocating elec-

tric generator driven by the aforesaid reciprocating engine, and electric coupling means between the said reciprocating electric generator and the electric generator driven from the gas turbine, as and for the purpose set forth.

2. An electrical generating plant comprising a turbine, a rotary electrical generator driven thereby, a reciprocating engine, a reciprocating generator driven therefrom, electrical means coupling said generators, said coupling means including an electrical machine of the rotary type connected to the reciprocating generator, a fly wheel mechanically coupled to the said electrical machine, and a second electrical machine, the latter machine being electrically connected with the rotary generator.

3. An electrical generating plant comprising a turbine, a rotary generator driven by the turbine, a reciprocating engine, a reciprocating generator driven thereby, means for electrically coupling the generators, a blower coupled with the rotary generator, a compressor connected with the reciprocating generator, said coupling means including an electrical machine connected with the reciprocating generator, a second electrical machine, a fly wheel mechanically connected to the second machine, said second machine being electrically connected with the rotary generator.

In testimony whereof we have signed our names to this specification.

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