April 21, 1942. G. W. PEARCE, JR 2,280,447

JET COMPRESSOR FOR A POWER PLANT

Filed Oct. 13, 1939 2 Sheets-Sheet 1

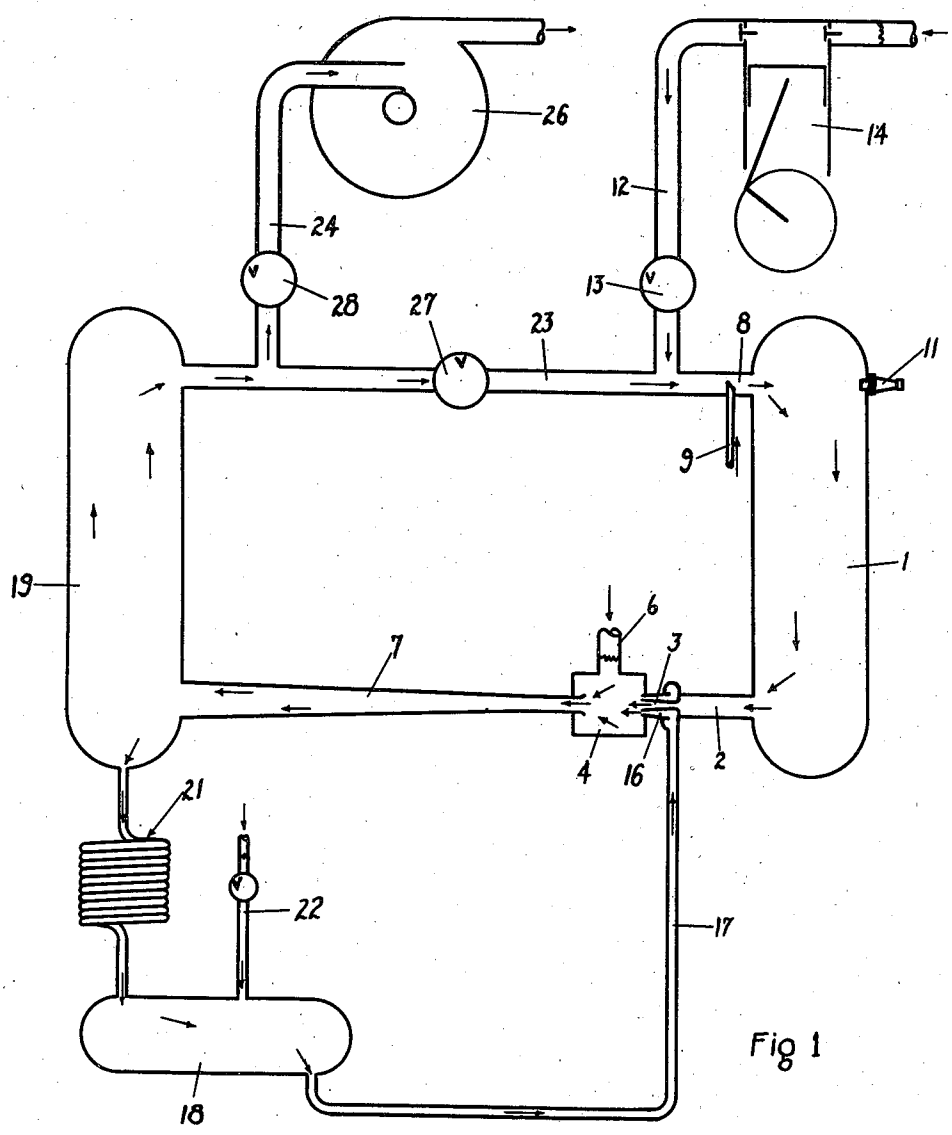


Fig 1

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JET COMPRESSOR FOR A POWER PLANT

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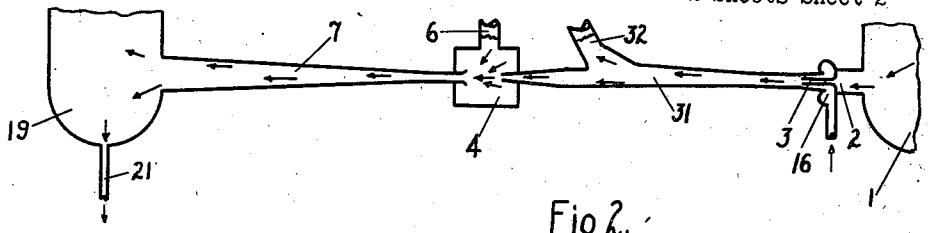


Fig 2.

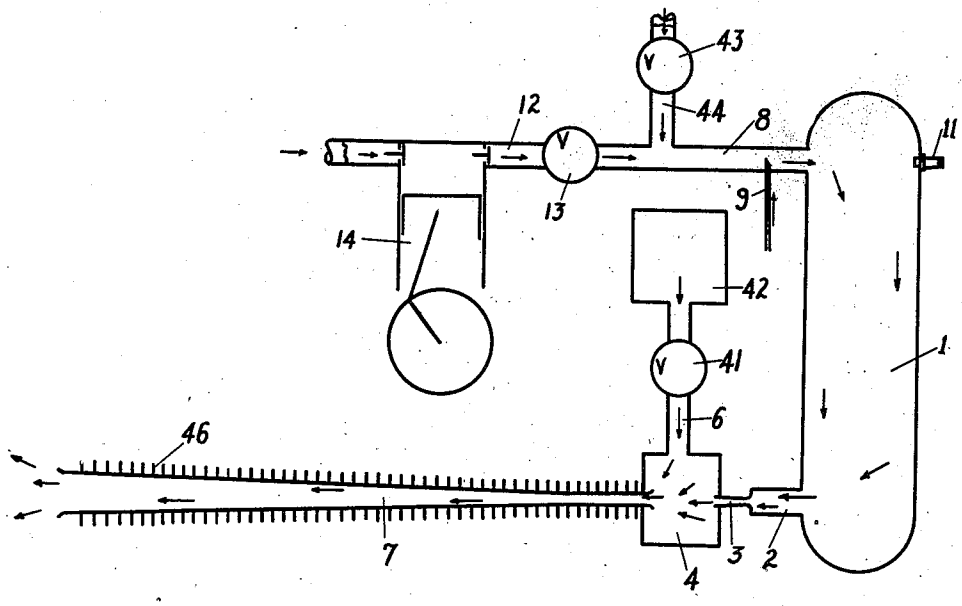


Fig 3.

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JET COMPRESSOR FOR POWER PLANTS

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6 Claims. (Cl. 230—102)

This invention relates to a method and apparatus for doing work, more particularly by a heat engine using gas as a working medium and referred to herein as a power plant.

It is among the objects of this invention to provide such a power plant which is highly efficient and economical in operation, and which is extremely simple in construction. Other objects are to provide a method for efficiently and economically introducing a fluid into a fluid system.

In accordance with this invention an injector forms a major feature of my power plant and comprises a mixing chamber and a jet. The jet is connected with the chamber, and the latter is provided with an outlet and with an additional inlet that is adapted to be connected with the atmosphere or to any source of fluid under a pressure less than that of the gas supplied to the jet. If the additional or second inlet of the mixing chamber is connected to a fluid at subatmospheric pressure, the inlet of the jet may be open to the atmosphere because the air will flow through the jet to the lower pressure zone in the mixing chamber. On the other hand, the inlet of the jet may be connected to a source of gas under pressure. In either case, as the gas flows through the jet it expands to a lower pressure and releases energy which is used to compress the mixture leaving the mixing chamber. The kinetic energy required to compress a gas through a given pressure range depends on the temperature rise during compression. In general, the smaller this temperature change the less energy required. Also, the lower the temperature at which the compression starts the smaller the temperature change.

According to this invention the injector is actuated by a gas whose temperature after expansion starts is lowered by a suitable cooling medium before or during compression of the mixture, wherefore less energy is required to handle a unit weight of the second fluid drawn into the injector, and more of it can be handled by a given amount of the actuating gas. Likewise, if the temperature of the actuating gas after expansion is above that of the second fluid, and the kinetic energy in the warm gas after expansion be transferred to a cool intermediate fluid which is used to aspirate the second fluid, less energy is required to handle a given amount of the second fluid. Thus, in both cases less of the heat in the actuating gas remains in the compressed gases delivered by the injector than in a conventional injector. Therefore, the compression of the gases is accompanied by a smaller temperature rise, and more of the second fluid can be compressed than heretofore.

In one of the many forms that this invention may take, the second inlet of the mixing chamber can be connected to a receptacle from which it is desired to remove a fluid. Or, this invention may be used to mix a plurality of fluids in which it is desired to have the resulting mixture at a pressure higher than could be obtained heretofore without cooling of the higher pressure gas after its expansion starts. In still another form of the invention this inlet may be open to the atmosphere and the outlet of the mixing chamber connected to a fluid actuated device, such as a turbine, which it is desired to operate.

The invention is illustrated in the accompanying drawings in which Fig. 1 is a diagrammatic view of my power plant connected to a turbine; Fig. 2 is a fragmentary diagrammatic view of a modified embodiment; and Fig. 3 is a view similar to Fig. 1 showing the power plant used for withdrawing a fluid from a receptacle.

Referring to Fig. 1 of the drawings, a combustion chamber 1 is provided near its bottom with an outlet 2 to which an injector is connected. The injector comprises a jet 3 leading from outlet 2 to a mixing chamber 4 having a second inlet 6 open to the atmosphere and having an outlet opposite the jet through which a delivery tube 7 extends. The combustion chamber is also provided with an inlet 8 through which air is introduced into the chamber wherein its temperature and pressure are raised. The heating of the air may be done by heating the chamber from the outside, or by introducing a suitable fuel with the air, such as through a fuel pipe 9 adjacent inlet 8, and igniting the combustible mixture by a spark plug 11 mounted in the wall of the chamber. After the combustion chamber wall reaches incandescence, burning will continue without the spark plug. To initially compress the gas in the combustion chamber to the desired pressure, inlet 8 is connected by a pipe 12 and valve 13 to an ordinary air compressor 14 driven in any suitable manner.

It is a feature of this invention that after the apparatus has been started in operation valve 13 may be closed and the compressor turned off, thereby saving the power required to operate the compressor. The combustion and pressure in the combustion chamber are maintained by only a portion of oxygen-containing gases that leave mixing chamber 4 and which are returned to the combustion chamber in a manner about to be

described. The rest of those gases are used, in this embodiment, to operate a turbine. In order to accomplish these novel results, means is provided for cooling the hot gases from the combustion chamber after expansion starts in the jet and before recompression in the delivery tube ceases so that the recompression will be accompanied by a smaller temperature rise than otherwise. Although this cooling may be done in various ways, it is preferred to do it by placing a cooling liquid, such as water, in direct contact with the hot gases as they leave the jet. For this purpose a nozzle **16** encircles the jet and is connected by a pipe **17** to a water storage tank **18**. To separate the water from the gases after the cooling operation has been completed, a separating tank **19** is connected to the outlet of delivery tube **7**. The water that settles to the bottom of this tank is led back to the water storage tank through a pipe **21** that is so formed as to cool the water flowing through it. The pressure of the gases above the water in the separating tank forces the water through the pipes and storage tank to nozzle **16**. Water that is lost in the system with the gases may be replaced through a supply pipe **22** connected to the storage tank.

The kinetic energy resulting from the expansion of a gas in a jet is sufficient to recompress it to substantially its original pressure and temperature. However, due to the cooling of the hot gases by the cooling liquid in accordance with this invention, the recompression starts in the delivery tube at a lower temperature than that at which expansion normally would have ceased, and consequently the gases are recompressed to substantially their original pressure at a much lower temperature and with a smaller temperature rise. Due to the recompression thus taking place in a lower and smaller temperature range, it requires less kinetic energy to recompress the gases than was released during their expansion. The excess energy delivers the air drawn in from the atmosphere through auxiliary inlet **6** of the mixing chamber against the higher pressure of the gases in the separating chamber. Consequently, more gas is recompressed than left the combustion chamber through the jet. A sufficient amount of this gas, containing oxygen, is conducted from the separating tank through a return pipe **23** to inlet **8** of the combustion chamber to support combustion in the latter and to maintain the desired pressure therein without the further use of air compressor **14**. The remainder of the gas, which is substantially equivalent to the volume of air drawn into the mixing chamber from the atmosphere, is led out of return pipe **23** through a pipe **24** to a turbine **26** which it operates in the usual manner.

Between pipes **12** and **24**, return pipe **23** is provided with a valve **27** that is closed while the compressor is operating so that it will pump air into the combustion chamber only. Turbine pipe **24** is provided with a throttling valve **28** which is adjusted to permit only gas in excess of the amount needed for the combustion chamber to be supplied to the turbine.

The apparatus shown in Fig. 2 has been modified to provide means for separating the products of combustion from the cooling or intermediate liquid before they reach the mixing chamber so that only the intermediate liquid passes into that chamber. Accordingly, jet **3** and the spray nozzle **16** are connected to the main inlet of the mixing chamber by a conduit **31** having a second outlet **32** near the mixing chamber. As the expanded gases and the liquid from nozzle **16** pass through this conduit, the gases separate from the liquid and pass out through outlet **32** to the atmosphere or to any other suitable place. However, the kinetic energy produced by the expanded gases is transferred to the liquid which passes on to the mixing chamber and draws the second fluid in through inlet **6**. If inlet **6** is open to the atmosphere the fluid that reaches separating tank **19** is composed largely of the liquid from nozzle **16** and air.

The power plant illustrated in Fig. 3 is used for withdrawing a fluid from a receptacle rather than for driving a turbine or the like. In this embodiment the second or auxiliary inlet **6** of mixing chamber **4** is connected through a valve **41** to a receptacle **42** from which it is desired to remove a fluid. This may be for the purpose of transferring the fluid to another receptacle or for creating a vacuum in receptacle **42**. To operate this apparatus valve **13** connecting compressor pipe **12** with inlet pipe **8** is opened, and a valve **43** in a pipe **44** that connects inlet pipe **8** with the atmosphere is closed. The compressor is set in operation in order to build up sufficient pressure in combustion chamber **1** to cause the gases issuing from jet **3** to expand to a pressure below that of the fluid in receptacle **42**. The compressor continues in operation until the gases issuing from the jet have withdrawn sufficient fluid from receptacle **42** to reduce its pressure below atmospheric. Valve **13** may then be closed and valve **43** opened because the products of combustion from the combustion chamber will continue to flow to the lower pressure area in the mixing chamber and thus continue to reduce the pressure in receptacle **42**.

In order that there will be sufficient energy in the mixing chamber to recompress the gases issuing therefrom through delivery tube **7** to atmospheric pressure or to the pressure of whatever receptacle may be connected to the tube, the gases issuing from the jet must be cooled after expansion starts and before recompression ceases. Although this cooling may be effected in the same way as shown in Fig. 1, another method of cooling is shown in Fig. 3. This consists of providing the delivery tube with means, such as cooling fins **46**, for dissipating the heat from the gases flowing therethrough.

Although this invention has been described in connection with a single stage injector, it will be understood that the same principles are equally applicable to multistage injectors.

According to the provisions of the patent statutes, I have explained the principle and method of practicing my invention and have illustrated and described what I now consider to represent its best embodiments. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

I claim:

1. In a power plant, the combination comprising a heating chamber member for heating gases therein, an outlet jet connected to said chamber for expanding the heated gases to increase their kinetic energy, a mixing chamber connected to the jet for receiving the expanded gases and provided with an opening through which a gas is drawn by said gases and mixed therewith, a gradually expanding delivery tube connected to the mixing chamber for receiving all of the gases therefrom and in which said kinetic energy is

used to compress the mixture of gases, means for restricting the temperature rise of said mixture during said compression whereby said kinetic energy is sufficient to compress the mixture to a pressure greater than that of the gases in the heating chamber, and a conduit member for conducting enough of said compressed mixture back to the heating chamber member to replace the gases escaping through the jet, one of said members being provided with an outlet for the rest of said compressed mixture so that power can be furnished thereby.

2. In a power plant, the combination comprising a heating chamber member for heating gases therein, an outlet jet connected to said chamber for expanding the heated gases to increase their kinetic energy, a mixing chamber connected to the jet for receiving the expanded gases and provided with an opening through which a gas is drawn by said gases and mixed therewith, a gradually expanding delivery tube connected to the mixing chamber for receiving all of the gases therefrom and in which said kinetic energy is used to compress the mixture of gases, means for cooling said gases after expansion starts whereby said kinetic energy is sufficient to compress the mixture to a pressure greater than that of the gases in the heating chamber, and a conduit member for conducting enough of said compressed mixture back to the heating chamber member to replace the gases escaping through the jet, one of said members being provided with an outlet for the rest of said compressed mixture adapted to be connected to a gas-operated device for actuating it.

3. In a power plant, the combination comprising a heating chamber member for heating gases therein, an outlet jet connected to said chamber for expanding the heated gases to increase their kinetic energy, a mixing chamber connected to the jet for receiving the expanded gases and provided with an opening through which a gas is drawn by said gases and mixed therewith, a gradually expanding delivery tube connected to the mixing chamber for receiving all of the gases therefrom and in which said kinetic energy is used to compress the mixture of gases, means for cooling said gases with a liquid after expansion starts whereby said kinetic energy is sufficient to compress the mixture to a pressure greater than that of the gases in the heating chamber, means for separating the liquid from said mixture after said compression, and a conduit member for conducting enough of said compressed mixture back to the heating chamber member to replace the gases escaping through the jet, one of said members being provided with an outlet for the rest of said compressed mixture so that power can be furnished thereby.

4. In a power plant, the combination comprising a heating chamber member for heating gases therein, an outlet jet connected to said chamber for expanding the heated gases to increase their kinetic energy, a mixing chamber connected to the jet for receiving the expanded gases and provided with an opening through which a gas is drawn by said gases and mixed therewith, a gradually expanding delivery tube connected to the mixing chamber for receiving all of the gases therefrom and in which said kinetic energy is used to compress the mixture of gases, means for introducing a liquid into said gases to cool them after expansion starts and before compression ceases whereby said mixture is compressed to a pressure greater than that of the gases in the heating chamber, a separating tank member connected to the outlet of the delivery tube for separating the liquid from said mixture, and a conduit member connecting said tank member with said heating chamber member for conducting enough of said compressed mixture back to the heating chamber member to replace the gases escaping through the jet, one of said members being provided with an outlet for the rest of said compressed mixture so that power can be furnished thereby.

5. In a power plant, the combination comprising a heating chamber member for heating gases therein, means for initially pumping air into the chamber, an outlet jet connected to said chamber for expanding the heated gases to increase their kinetic energy, a mixing chamber connected to the jet for receiving the expanded gases and provided with an opening through which a gas is drawn by said gases and mixed therewith, a gradually expanding delivery tube connected to the mixing chamber for receiving all of the gases therefrom and in which said kinetic energy is used to compress the mixture of gases, means for restricting the temperature rise of said mixture during said compression whereby said kinetic energy is sufficient to compress the mixture to a pressure greater than that of the gases in the heating chamber, and a conduit member for conducting enough of said compressed mixture back to the heating chamber member to replace the gases escaping through the jet, one of said members being provided with an outlet for the rest of said compressed mixture so that power can be furnished thereby, and means for stopping said air pumping means as soon as enough of said compressed mixture is conducted by said conduit back to the heating chamber to replace said escaping gases.

6. The method of obtaining power from a combustible fuel, comprising burning the fuel under pressure, expanding the gaseous products of combustion in a jet to increase their kinetic energy, entraining air in the expanded gases, using said kinetic energy to compress the mixture of gases and air, restricting the temperature rise of said mixture during said compression whereby said kinetic energy is sufficient to compress the mixture to a pressure greater than that of said fuel under pressure, returning a portion of said mixture to said fuel under pressure to supply thereto the oxygen for combustion, and bleeding off the rest of said mixture to be used as power.

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