

S. Z. DE FERRANTI.
TURBINE ENGINE.
APPLICATION FILED NOV. 12, 1904.

1,045,961.

Patented Dec. 3, 1912.
4 SHEETS—SHEET 1.

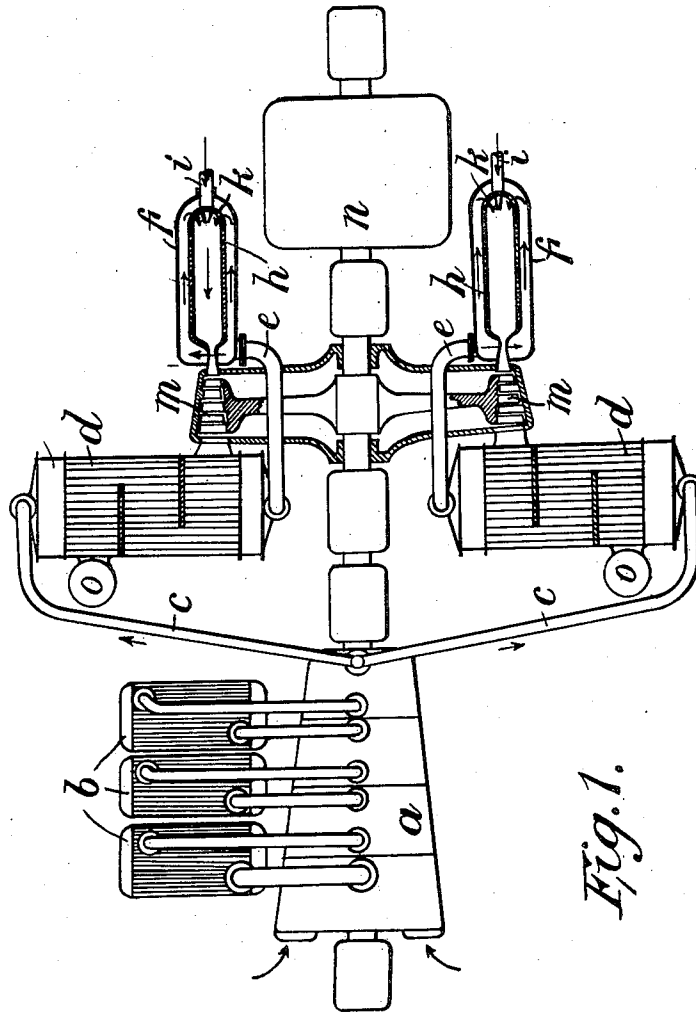


Fig. 1.

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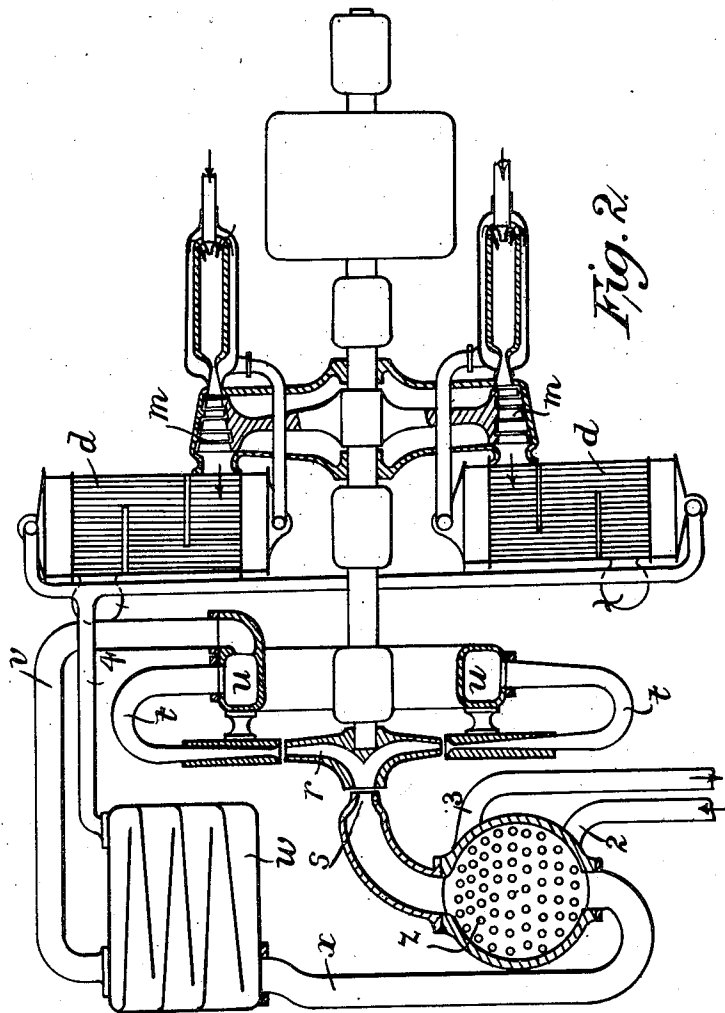


Fig. 2.

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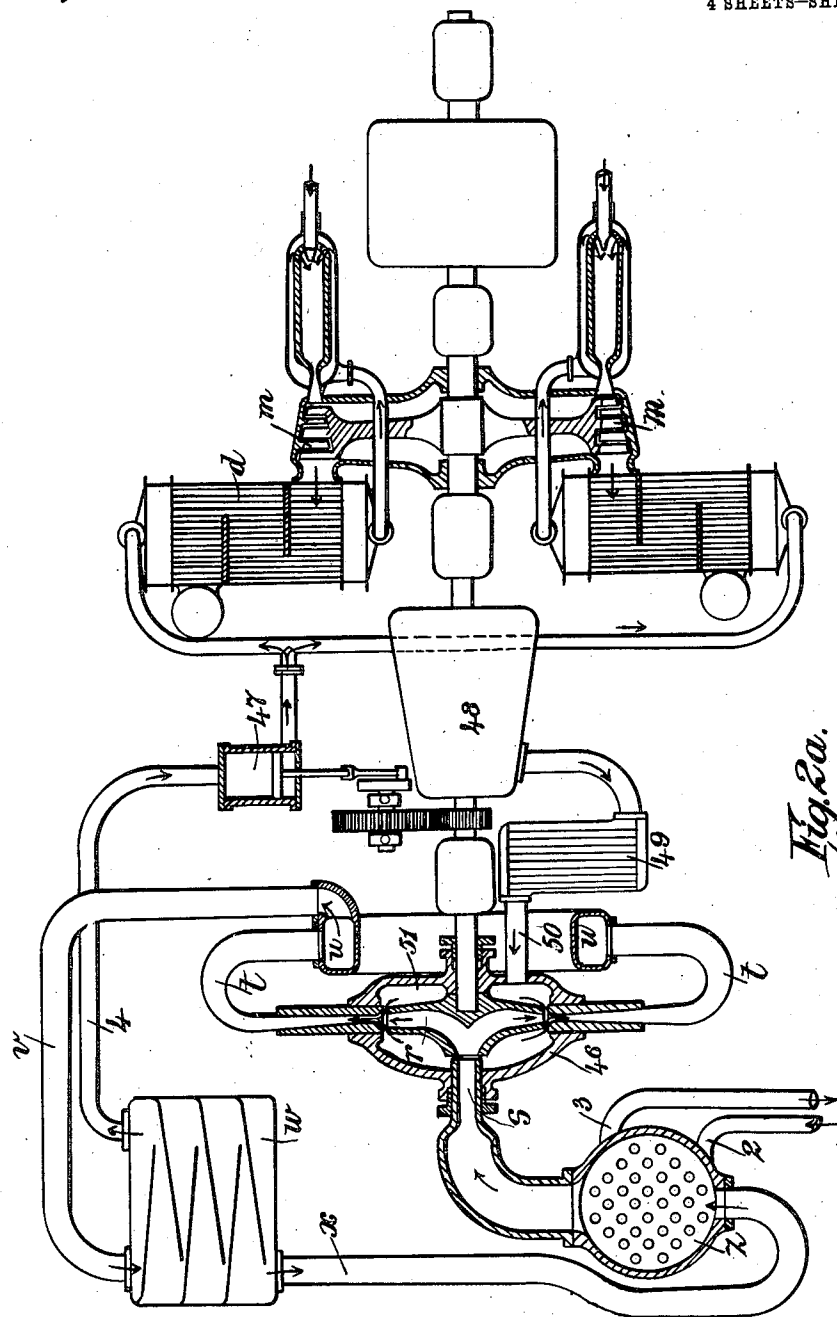


Fig. 2a.

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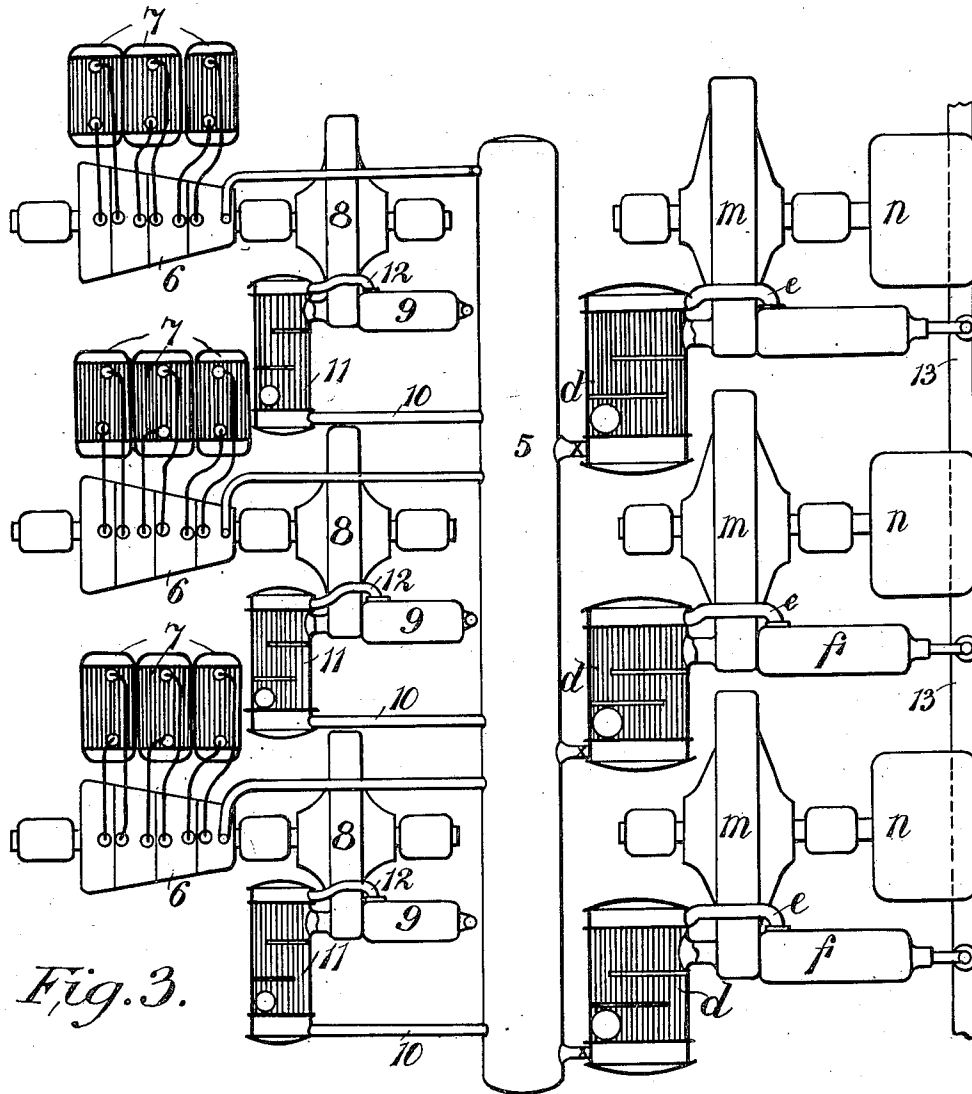


Fig. 3.

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UNITED STATES PATENT OFFICE.

SEBASTIAN ZIANI DE FERRANTI, OF LONDON, ENGLAND.

TURBINE-ENGINE.

1,045,961.

Specification of Letters Patent.

Patented Dec. 3, 1912.

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To all whom it may concern:

Be it known that I, SEBASTIAN ZIANI DE FERRANTI, a subject of the King of Great Britain and Ireland, residing at 31 Lyndhurst road, Hampstead, London, N. W., England, have invented certain new and useful Improvements in or Relating to Turbine-Engines, of which the following is a specification.

10 This invention relates to power installations in which a turbine is supplied with air and products of combustion as the working fluid, the constituent elements of this working fluid having been first necessarily compressed to a high pressure in order to secure a good economy.

It is found that to achieve commercial success in power installations of the type in question, great care has to be taken to reduce the cost and complexity of the compressing plant to a minimum and at the same time to lessen as far as possible the negative work spent in the compressing operation.

Various combinations of elements to form the complete power installation and various cycles of operations have been proposed heretofore in this art but the present invention differs from all previous attempts inasmuch as it includes at the same time the following essential and salient features as component elements of the complete installation, viz.: (a) multiple stage compression of the elastic fluid medium in a low cost apparatus with cooling between the stages, so that compression is practically isothermal; (b) imparting of the heat to the fluid at the maximum pressure of the cycle by internal combustion; (c) expansion in a single stage down to a temperature workable in the blades of the turbine and (d) extraction of the velocity due to the expansion in a multiple stage impact turbine.

It will be understood that when describing the compression stage above, I intend the term "practically isothermal" to include the case of a series of adiabatic compressions with cooling between stages, thus being on the whole substantially isothermal it may include the case in which the last stage alone of the compression is adiabatic.

Referring to the accompanying drawings which form part of the specification, I will now describe various arrangements of apparatus for carrying my invention into effect.

Figure 1 shows a turbine, the combustion

chamber of which is supplied with compressed air from a stage compressor; Fig. 2 shows a similar installation but provided with a compressor using liquid as the medium of compression; Fig. 2^a shows a similar installation to that shown in Fig. 2, but provided with a rotary blower for the primary and a reciprocating compressor, for the final stage of the compression. Fig. 3 shows a series of turbine driven compressors feeding into a common reservoir from which the turbines doing useful work draw their supplies.

All the drawings are of a diagrammatic nature, individual pipes, for example, being in many instances represented by a single line; where desirable, similar parts of the apparatus in the different figures are denoted by the same reference symbols.

In carrying the invention into effect according to one form, the compressor, as one element of the complete power generator, may take any of the different forms mentioned above or a stage turbo-compressor, *a*, *i. e.*, a reverse turbine with blades modified to form a compressor (see Fig. 1) with coolers, *b*, disposed between stages so as to give a substantially isothermal compression may be used with or without the addition of a reciprocating piston compressor for the final stage. The compressed air passes by way of the pipes, *c*, through the regenerators, *d*, and thence through the pipes, *e*, to the combustion chamber. This part of the apparatus is preferably duplicated, as shown in the figure, though for convenience only one operative set of the different elements will be described. The combustion chamber consists of an outer shell, *f*, and an inner shell, *h*, from which at one end the nozzle (or nozzles) issues and to which at the other end fuel is supplied through the pipe, *i*. This fuel may be either gas or liquid or solid fuel in a finely divided state. Holes, *k*, are also formed in the inner shell at this end to allow the compressed air after passing between the outer and inner shells to enter the latter and supply oxygen for the combustion of the fuel.

The combustion chamber may be water jacketed or lined with refractory material or both or again it may be lined and lagged and is preferably arranged in such relation to the adjoining turbine that the expanding nozzle (or nozzles) branches directly out from same, expanding the high temperature

products of combustion down to a low temperature before impact on the turbine wheel. The nozzles preferably expand from the throat outward or are of expanding section so as to give the suitable drop of pressure and temperature.

The turbine *m*, itself, which is shown in the figure as driving its own compressor, *a*, and a dynamo, *n*, may consist of impact wheels with such a suitable number of actions as will enable it to deal with the issuing velocity, the whole of the expansion however being carried out in a single stage in the nozzle. Or a single wheel may be used with the fluid thrown back on it the necessary number of times or a combination of both forms.

The turbine may with advantage be of the type described in my Patent No. 2565 of 1895.

The system thus includes a rotary multiple compression stage isothermal compressor together with a single expansion stage turbine. The products of combustion after giving up energy to the turbine pass through the regenerator, *d*, to the exhaust, *o*, thereby raising the temperature of the compressed air on its way to the combustion chamber to as nearly that of the exhaust gases as possible. Structurally, the regenerator may be of any convenient tube pattern as indicated or otherwise. Where gas is used as a fuel, a separate compressor and regenerator of any of the above forms may be used for the gas as distinct from the air. It will be seen that in carrying my invention into effect, the component elements of the complete generator may take other forms than those described above by way of example without departing from the essence of the invention.

According to a modified form of the invention, as shown in Fig. 2, a rotary air compressor of the type in which liquid is used as the medium of compression and energy is imparted to the liquid by a rotary device, is substituted for the stage turbo-compressor indicated in Fig. 1. Such an air compressor may be of the type for which a British patent, No. 22846/02 has been granted, or again, it may be of the well known hydraulic type in which a stream of water moving under gravity entrains and compresses air but modified in so far as the water is circulated by and receives energy from a rotary device.

One form of such a suitable compressor will be described by way of example.

A rotary thrower, *r*, having for example, two hollow arms and shown as driven by the turbine, *m*, receives water through the nozzle, *s*. As the thrower rotates at a high speed, the solid jets of water issuing therefrom are caused to pass over the open ends of a series of compressing tubes, *t*, which

in end view are arranged in a complete circle surrounding the thrower. The inlet ends of these tubes being as close as possible together and separated only by thin partitions or dividing walls with sharpened edges; the effect of this high velocity jet of water passing over them is to shoot plugs of water into the tubes, *t*, the air to be compressed being entrained between these plugs. The compressing tubes lead into a hollow annular chamber, *u*, from which a pipe, *v*, passes to the air and water separator chamber, *w*. The water separated in this chamber passes by way of the pipe, *x*, to a cooler, *z*, whence it is returned to the thrower through the contracting nozzle, *s*. Pipes, 2 and 3, are provided, by means of which cold water is circulated through the cooler, *z*. The compressed air from the separator, *w*, passes through the pipe, 4, which branches into two parts leading respectively to the regenerators, *d*. In some cases however I may inclose the thrower *r* (Fig. 2^a) in a casing, 46, and deliver to the chamber 51 air which has been already compressed in a rotary blower 48, by way of a cooler, 49, and a pipe 50. The air then passes to the separator *w*, as above described, from thence to a reciprocating compressor 47, where it receives its final compression after which it is led to the regenerators *d* by the pipe 4. From this point the cycle of operations is as described above, the same reference symbols being used to denote similar parts.

In some cases the turbine which gives out the power for useful work may not itself drive any compressor at all; but in this case it is fed from a reservoir which is supplied by a separately driven compressor as above. Or again, a plurality of turbines doing useful work may be fed in parallel from a common reservoir which is itself supplied by one or more separately driven compressors.

Thus, referring to Fig. 3, a common compressed air reservoir, 5, is shown fed by, for example, three multi-stage compressors, 6, each supplied with coolers 7, between stages so as to give a substantially isothermal compression; each of these compressors is driven by a turbine, 8, of the type described above, air being supplied to the combustion chamber, 9, from the common reservoir, 5, by way of the pipe, 10, regenerator, 11, and pipe, 12. This part of the apparatus constitutes the compressor system.

Where gas is used as the fuel there is a corresponding system for the gas to that already described for the air, the combustion chamber being fed from the gas main. Oil can in like manner be stored under pressure, (the pressure if necessary being obtained from the air reservoir,) and forced into the combustion chambers.

The motor system, as shown by way of ex-

ample in the figure comprises three turbines, *m*, each driving a dynamo, *n*. Each turbine is, as above, supplied with working fluid from the combustion chamber, *f*, which is fed on the one hand with compressed air drawn from the common reservoir, *5*, by way of the regenerator, *d*, and on the other hand with fuel from the fuel main, *13*, which is itself fed from a separate compressor system, or if desired by pressure from the air reservoir in the case of oil.

It will be understood that although certain elements have been described above in relation to one system of working only, nevertheless I may adapt such elements if desirable, to form component parts of other systems described in this specification, without going beyond the limits of the invention.

From the above description it will be seen that the essential features of my invention are; multiple stage compression of the elastic fluid medium in a low cost apparatus with cooling between the stages, so that compression is practically isothermal; imparting of the heat to the fluid at the maximum pressure of the cycle by internal combustion; expansion in a single stage down to a temperature workable in the blades of the turbine and extraction of the velocity due to the expansion, in a multiple stage impact-turbine.

Again, although I have described the turbine as having a regenerator this may be omitted if the compression pressure be raised to such a point that the expansion to the exhaust pressure is sufficient to absorb practically all the heat in the working fluid so that it discharges at practically atmospheric pressure.

Having thus described my invention what I claim as new and desire to secure by Letters Patent is:

1. A power installation comprising in combination a combustion turbine and means for absorbing the power developed thereby; a second combustion turbine and an air compressor driven thereby; an air reservoir into which said compressor delivers, combustion chambers operatively connected to each of said turbines together with means for delivering air from said reservoir to the combustion chambers of each of the above mentioned turbines.

2. A power installation comprising in combination, a combustion turbine driving an air compressor; a second combustion turbine with means for absorbing the power developed thereby; combustion chambers operatively connected to said turbines, means for delivering air from said compressor to the combustion chamber of said second turbine, said means including as part of it a regenerator together with means for passing exhaust gases from said second turbine through said regenerator.

3. A power installation comprising in combination a combustion turbine driving an air compressor; a second combustion turbine and means for absorbing the power developed thereby; combustion chambers operatively connected to said turbines, means for delivering air from said compressor to the combustion chamber of said turbine driving it, said means including as part of it a regenerator together with means for passing exhaust gases from said compressor-driving turbine through said regenerator.

4. A power installation comprising in combination, a combustion turbine driving an air compressor; a second combustion turbine and means for absorbing the power developed thereby; combustion chambers operatively connected to said turbines, means for delivering air from said compressor to the combustion chamber of one of said turbines, said means including as part of it a regenerator together with means for passing exhaust gases from one of said turbines through said regenerator.

5. A power installation comprising in combination a combustion turbine driving an air compressor; a second combustion turbine and means for absorbing the power developed thereby; combustion chambers operatively connected to said turbines, means for leading compressed air from said compressor to the combustion chambers of each of said turbines said leading means having parts in duplicate with a regenerator in each of said parts together with means for passing exhaust gases from said turbines through said regenerators.

6. A power installation comprising in combination, a combustion turbine driving an air compressor; a second combustion turbine and means for absorbing the power developed thereby; combustion chambers operatively connected to said turbines, means for leading compressed air from said compressor to the combustion chambers of each of said turbines said leading means including ducts connected respectively to each of said turbines and a regenerator in each of said ducts, together with means for passing exhaust gases from each of said turbines through the regenerator disposed in the duct connected thereto.

7. A power installation comprising in combination a combustion turbine driving an air compressor; a second combustion turbine mechanically independent of said first mentioned turbine and means for absorbing the power developed thereby, combustion chambers operatively connected to said turbines; together with means for leading air from said compressor to the combustion chambers of each of said turbines said leading means including regenerative means for heating said fluid.

8. A power installation comprising in com-

5 bination, a plurality of combustion turbines and means for absorbing the power developed thereby; a second plurality of combustion turbines and air compressors driven thereby; combustion chambers operatively connected to each of said turbines; together with a common reservoir into which all said air compressors deliver and connections between said reservoir and each of the com-

bustion chambers of the individual turbines 10 of both said pluralities.

In witness whereof I have hereunto set my hand in presence of two witnesses.

SEBASTIAN ZIANI DE FERRANTI.

Witnesses:

ROBERT MORRISON NEILSON,
WILLIAM CASTLE.