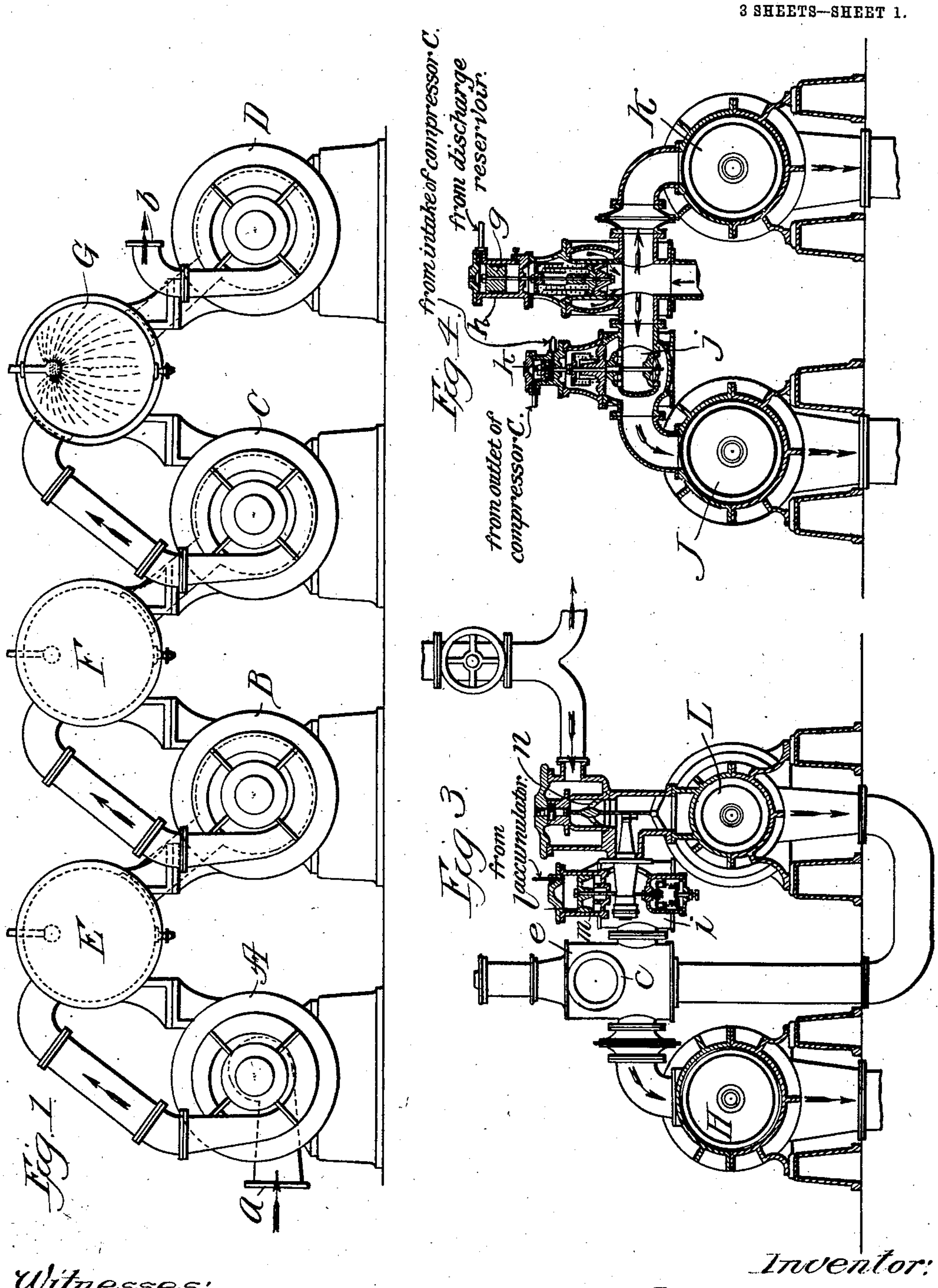
A. C. E. RATEAU.

HIGH PRESSURE COMPRESSOR OR OTHER POWER ABSORBING MACHINE.

APPLICATION FILED MAY 3, 1906.

961,317. Patented June 14, 1910.

3 SHEETS—SHEET 1.



Witnesses:

Geo. C. Dawson.

G. E. Falk.

Inventor:

Auguste C. E. Rateau,

By Barton & Tanner

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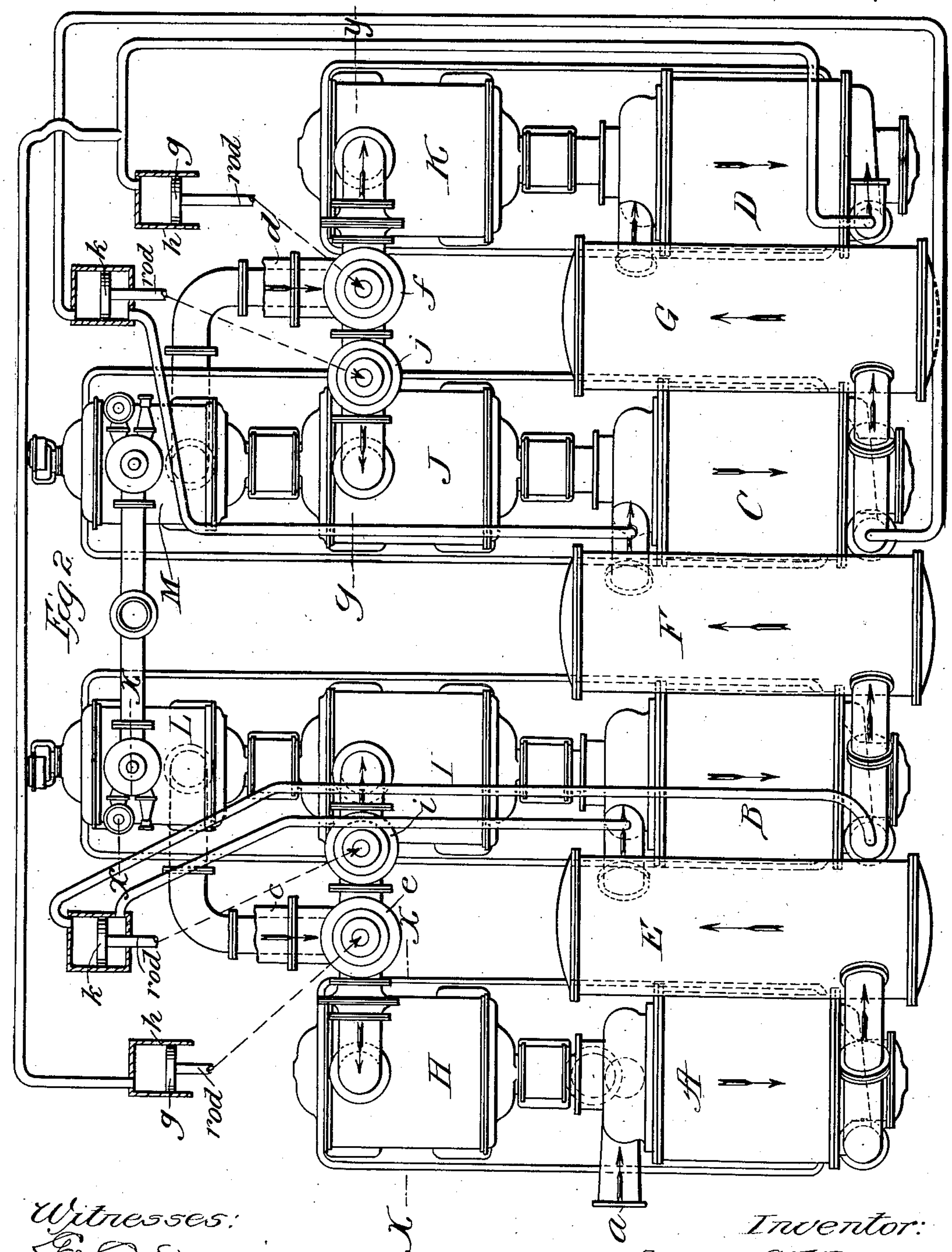

Fig. 2

Witnesses:

Geo. C. Dawson

J. E. Folk

Inventor:

Auguste C. E. Rateau,

By Barton & Tanner

Attys.

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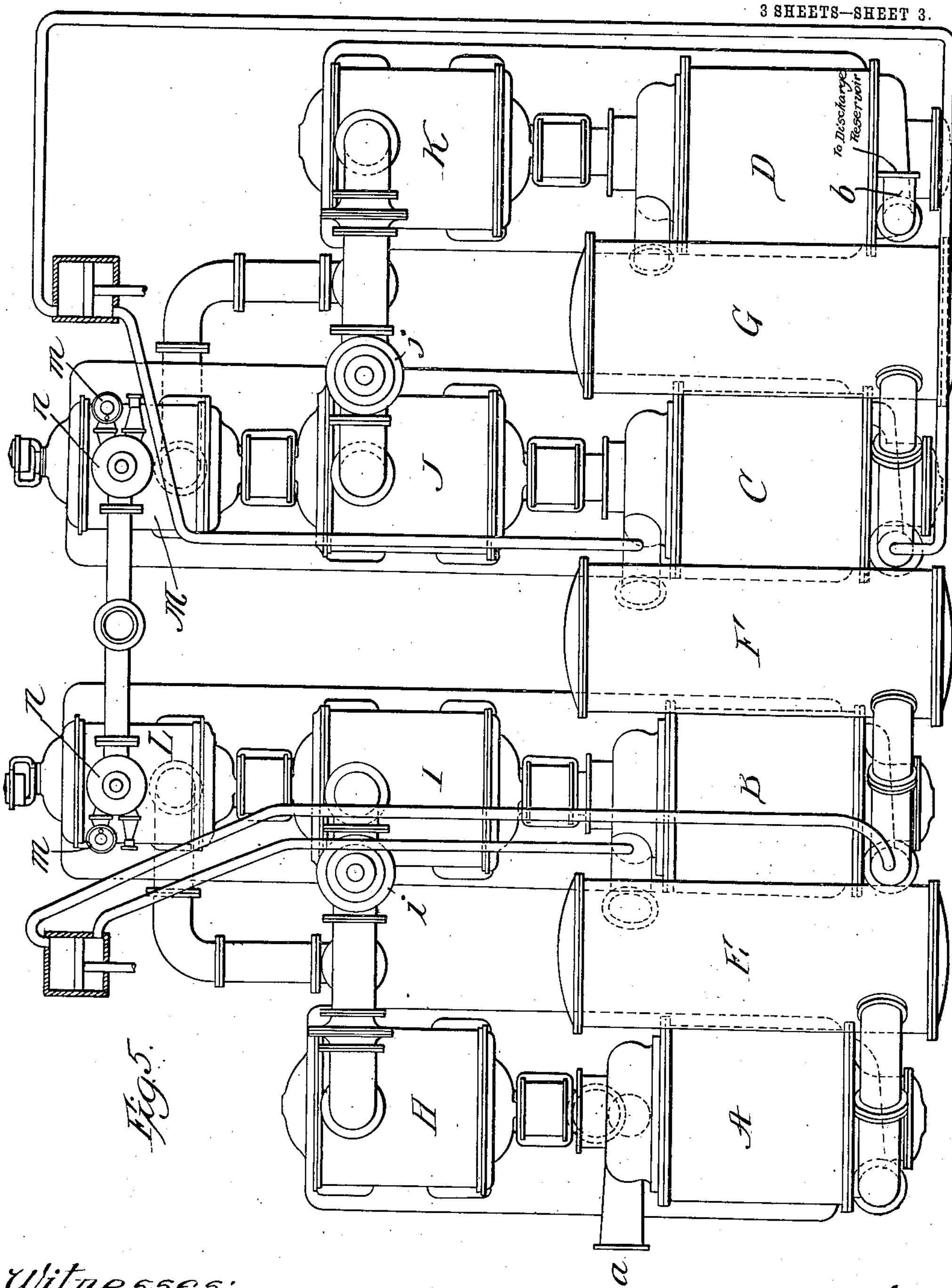

Fig. 5.

Witnesses:

Fd. C. Davison

Maurice Goldberger.

Inventor:

Auguste C. E. Rateau

By Barton & Folk,

Att'ys.

UNITED STATES PATENT OFFICE.

AUGUSTE C. E. RATEAU, OF PARIS, FRANCE, ASSIGNOR TO RATEAU TURBINE COMPANY, OF CHICAGO, ILLINOIS, A CORPORATION OF WEST VIRGINIA.

HIGH-PRESSURE COMPRESSOR OR OTHER POWER-ABSORBING MACHINE.

961,317. Specification of Letters Patent. Patented June 14, 1910.

Application filed May 3, 1906. Serial No. 315,047.

To all whom it may concern:

Be it known that I, AUGUSTE C. E. RATEAU, a citizen of France, residing at Paris, in the Department of Seine, have invented a certain new and useful Improvement in High-Pressure Compressors or other Similar Power-Absorbing Machines, of which the following is a full, clear, concise, and exact description.

This invention relates to the driving of compressors or other power absorbing machines by turbines or other engines operated by steam, gas, or similar motive power. Its object is to provide an improved construction and arrangement of said engines and the power absorbing machines driven thereby.

In general the invention contemplates a plurality of power absorbing machines connected in series with respect to the delivery of their output, these machines being driven by engines which are connected in parallel or series-parallel with respect to the passage of motive fluid.

This invention, though not limited thereto, is especially applicable to a system of compressors for fluids such as gas or steam, and provides means whereby such fluids may be readily compressed to high pressures such as six or seven atmospheres. This may be accomplished by the employment of centrifugal compressors operated by steam turbines. This application of my invention contemplates a system of several compressors arranged so that they are traversed successively by the fluid undergoing compression, these compressors being driven by turbine engines which are connected in parallel or series-parallel with respect to the passage of motive fluid.

It is well-known that in the compression of gases, the pressure increases very rapidly with the number of compressor wheels or impellers acting in series. In fact the characteristic feature of centrifugal fans or compressors is that they furnish an increase of pressure proportional to the square of the peripheral speed and to the density of the gaseous fluid. As this density increases nearly proportionally to the pressure, it results that the values of the absolute pressures at the discharge outlets of the successive impellers form approximately a geometrical progression. Very high pressures are rendered possible by this means. For example, suppose that a compressor furnishes a pressure equal to a column of air of 5000 meters. If it receives the air from the atmosphere at a pressure of one kilogram per square centimeter, the air discharged will have a pressure of 1.6 kilograms per square centimeter. A second similar compressor, receiving this air, will carry its pressure to $1.6^2=2.6$ kilograms approximately, and so on. But this is so only in so far as the compression is effected at a constant temperature. In reality, the gas is heated by compression, for it receives the heat resulting from the work lost in the machine, due to friction, eddy-currents, etc., and the temperature would increase still more quickly if the operation were accomplished according to the adiabatic method. As a result of this elevation of temperature, the density no longer increases proportionally to the pressure, and, in consequence, the final pressures obtained are lower than those which the preceding reasoning would indicate. To obviate this inconvenience, I propose to cool the air either during the compression or between the successive phases of compression, in such a manner as to bring the air back to its initial temperature, and so to increase its density.

The invention may be more readily understood by reference to the accompanying drawings, showing a particular embodiment of the invention, in which—

Figure 1 represents in elevation a system of compressors; Fig. 2 is a plan view thereof; Figs. 3 and 4 are sectional views on lines X—X and Y—Y respectively of Fig. 2; and Fig. 5 is a plan view of a modified system.

Like parts are designated by similar letters of reference throughout the several views.

The system shown in the drawings involves the use of turbo-ventilators, that is to say, of multicellular fans or compressors driven by steam turbines. The compressors are connected in series, while the turbine motors are supplied with fluid in parallel or series-parallel. Two bases support the casing of the compressors. One of these bases carries the fluid inlet pipe and a volute distributer; the other carries the volute collector and the discharge pipe.

In Fig. 1 may be seen the assembly of the four compressors A, B, C, D, mounted upon four different shafts and traversed in series by the fluid to be compressed. The disposition of the compressors upon distinct shafts is not indispensable. They may be in groups of two or three upon the same shaft, provided that the fluid traverses them in series. Between consecutive compressors are refrigerators E, F, G, connected between the discharge-outlet of one compressor and the inlet of the compressor following. The air leaving one compressor traverses this refrigerator before passing to the next compressor. The refrigerators comprise metal reservoirs, in one part of which the air to to be cooled is received, and in the other part cold water. The cooling may be accomplished either by mixture or by conduction. In the first case the water is injected into the air, in the form of a jet as finely divided as possible in order to increase the surface of contact. It is then indispensible to take special precautions so that this water may not be entrained into the compressors. On the other hand, in the process of cooling by conduction, the water and the air are separated. A group of tubes placed in the reservoir is traversed by cold water and the heated air coming in contact with the conducting walls of the tubes is cooled thereby. Cooling may also be accomplished during compression by causing cold water to circulate in a casing surrounding the compressor itself.

In Fig. 1, the path of the air is traced by means of arrows. The air enters at *a* and leaves at *b* after having traversed successively the compressors and the refrigerators. In order to obtain high pressures, if a great number of wheels of large diameter is to be avoided, very high speeds of rotation must be resorted to. In this respect steam turbines are the only machines which permit of obtaining good results.

In Figs. 1 and 2, it is seen that the compressors A, B, C, D are driven by low-pressure and high-pressure turbines H, I and L, J and M, and K respectively, mounted upon their shafts. But it should be noted that in order to obtain high speeds of rotation, the wheels of the steam turbines must be of small dimensions. It follows that the passages also will be very restricted, and will only allow a small quantity of steam to pass. If, notwithstanding, great power is to obtained, it becomes indispensable to provide several turbines, connected in parallel and arranged to reinforce each other. Sometimes it may be desirable to group a certain number of turbines in series, the different groups thus constituted being connected in parallel.

The system above described is characterized by the employment of multicellular compressors mounted in series upon one or several shafts and driven by turbines which are supplied with motive fluid in parallel or series-parallel. In addition to these general dispositions, certain particular features assure a proper operation of the system. The first has for its object to automatically obtain the stopping or starting of the compressors A, B, C, D, according to the pressure existing in the discharge reservoir. For this purpose valves *e* and *f* are provided upon the pipes *c* and *d* which conduct the steam to the turbines. Each of said valves is governed by a piston *g* which is arranged to move in a cylinder *h*; or a membrane may be used instead of the piston. One of the faces of the piston is subjected to the pressure of the discharge reservoir, and the other face thereof to atmospheric pressure. This arrangement is indicated diagrammatically in Fig. 2. When the pressure of the discharge becomes too strong the piston moves downward and closes the valve; and the turbines and compressors slow down, or even stop. If, on the contrary, the pressure falls below a certain limit, the piston opens the valve, the speed of rotation of the turbines is increased, and the compressors again continue their operation. A second feature has for its object to divide or equalize the power between the different turbines. For this purpose upon each turbine, or upon certain ones of the turbines, is a valve *i* or *j* regulating the passage of steam thereto. This valve is controlled by a piston *k* the opposite faces of which are subjected to the pressures at the inlet and at the discharge respectively. This arrangement is indicated diagrammatically in Fig. 2. If the power of the turbine becomes too great or too feeble, the pressure produced by the compressor varies in the same manner, the piston is operated and opens or closes the valve until the pressure of the turbine returns to a suitable value.

The exhaust from intermittently driven engines stored in accumulators may be utilized as a source of supply of the motive fluid for the low pressure turbines H, I, and J, K, the steam from said accumulators being conducted thereto by pipes *c*, *d* respectively. In such case it becomes necessary to provide against an insufficient supply of steam from said accumulators, due to a protracted stoppage of said intermittently driven engines. In order to obtain, in such event, a continued operation of the compressors, I provide each group of compressors with high pressure turbines L, M, which are furnished with live steam. Under normal conditions, these high pressure turbines are inactive, the compressors being driven merely by the turbines H, I, J, K. When the pressure in the accumulator becomes lowered a piston *l* which has one of its faces subjected to the pressure in said accumulator and its other face to atmospheric pressure is moved in the cylinder m and opens the valve n, which admits live steam into the high pressure turbine. The exhaust steam from the high pressure turbines passes into the passage which supplies the steam to the low pressure turbines.

Under the conditions just described, in order to equalize the power with which the different compressors are driven, it is necessary to diminish the power of the low pressure turbine which is mounted on the same shaft with the high pressure turbine. Figs. 2, 3 and 4 represent in plan and in section a structure for accomplishing this. As there shown, the compressors A, B, C, D are mounted upon separate shafts, driven by the low pressure turbines H, I, J, K, respectively. The shafts of the turbines I, J, are also provided with high pressure turbines L, M, respectively. Referring to Figs. 3 and 4, it will be seen that the increased pressure at the outlet of compressor C due to the added driving action of the turbine M will operate the piston k to close the valve j, thus cutting off the supply of steam to the low pressure turbine J, thereby increasing the amount of steam delivered to the low pressure turbine K. By this means equilibrium is restored. The structure shown in Figs. 2, 3, and 4 can also be adapted to an installation for high pressure only. In this case the valves e and f and the pipes c and d may be omitted and the cylinder m subjected to the pressure of the exhaust reservoir instead of the accumulator. This furnishes an example of an arrangement in series parallel, in which two parallel groups comprise each a high pressure turbine in series with two low pressure turbines, these two last being themselves in parallel.

Having thus described my invention, I claim:—

1. The combination with a plurality of power-absorbing machines connected to act in series with respect to the delivery of their output, of a corresponding number of engines connected in parallel and arranged to drive said machines, valves controlling the supply of motive fluid to the individual engines, and regulators, each responsive to the power developed in a corresponding power absorbing machine, for controlling said valves.

2. The combination with a plurality of low pressure engines, of a power absorbing machine driven by each engine, a high pressure engine arranged to supplement the driving of one of said power absorbing machines, means for delivering the exhaust steam from said high pressure engine into a chamber communicating with said low pressure engines in parallel, and means controlled by said power absorbing machines for controlling the distribution of said exhaust steam in said low pressure engines.

3. The combination with two or more low pressure engines and corresponding power-absorbing machines driven thereby and connected to act together with respect to the delivery of their output, a source of low-pressure motive fluid supplying said engines in parallel, a high pressure engine mechanically coupled to one of said low pressure engines and arranged to deliver its exhaust to the other low pressure engine, an independent source of high pressure motive fluid, and an automatic regulator, responsive to a diminution of said low pressure fluid, adapted to admit high-pressure fluid to said high-pressure engine.

4. The combination with a plurality of low-pressure engines and corresponding power absorbing machines driven thereby, a source of low pressure motive fluid supplying said engines in parallel, a high pressure engine arranged to supplement the driving of one of said power absorbing machines and arranged to deliver its exhaust to the low pressure engines in parallel, an independent source of high pressure motive fluid, an automatic regulator responsive to a diminution of said low pressure fluid for admitting high-pressure fluid to said high-pressure engine, and an automatic regulator responsive to the power developed in said power absorbing machines for controlling the distribution of said exhaust steam to said low-pressure engines.

5. The combination with a number of compressors connected in series, of steam turbines connected in parallel, arranged to drive said compressors, valves controlling the supply of motive fluid to the individual turbines, and a regulator for operating each valve, responsive to the discharge pressure of the corresponding compressor, whereby the power delivered to the several compressors is equalized.

6. The combination with a series of centrifugal compressors having the discharge of the first connected to the inlet of the second, and so on throughout the series, of a number of engines connected in parallel with respect to the passage of motive fluid, a valve governing such supply, and a piston controlled by the discharge from the series of compressors, adapted to control the operation of said valve; whereby the speed of the compressors is varied automatically to maintain the discharge pressure approximately constant.

In witness whereof, I, hereunto subscribe my name this sixth day of April A. D., 1906.

AUGUSTE C. E. RATEAU.

Witnesses:

P. J. A. CHALEIL,

AUGUSTUS E. INGRAM.