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Fig:1

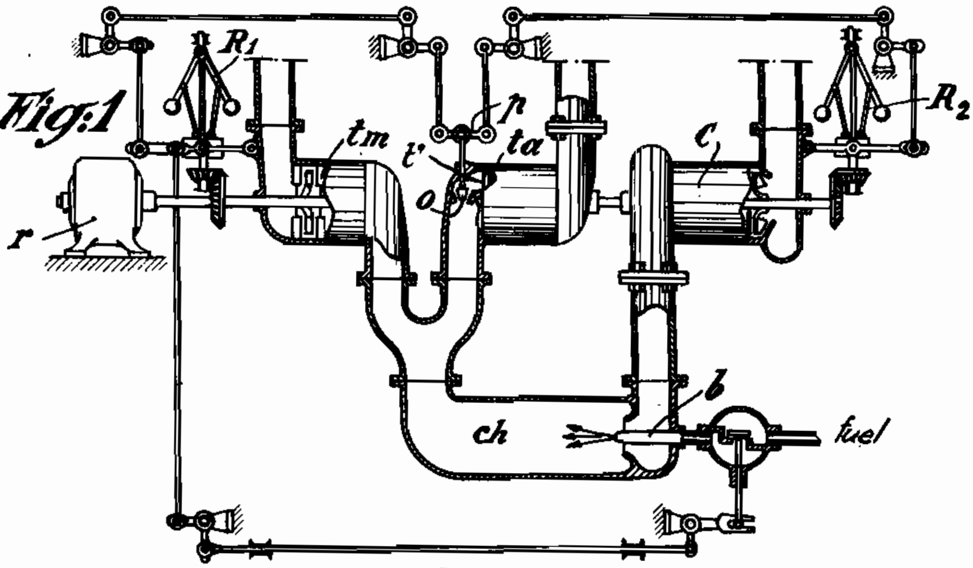
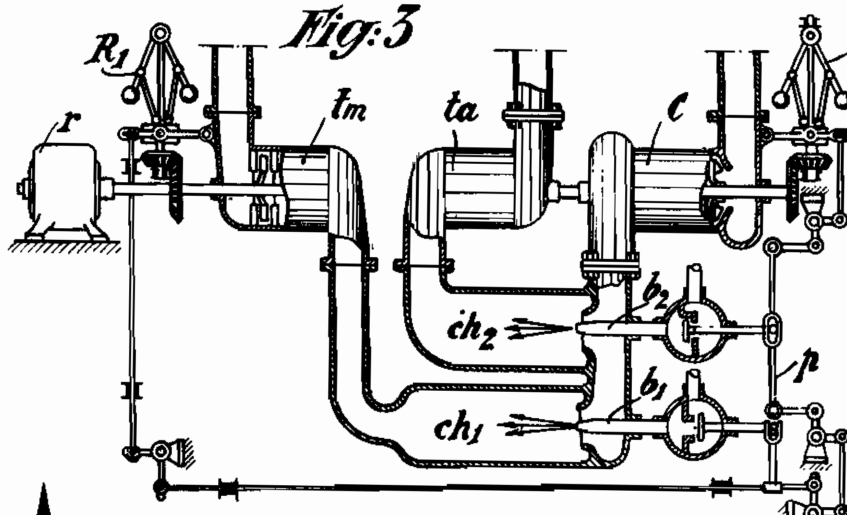


Fig:3



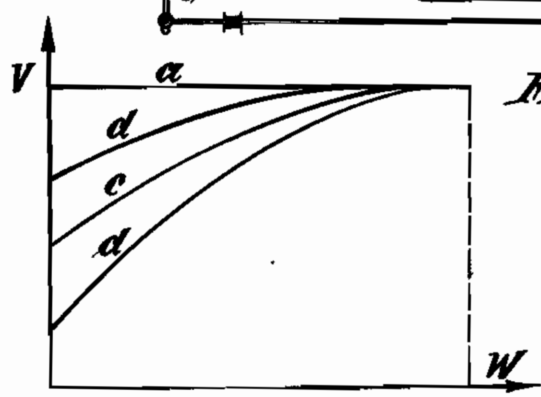


Fig:5

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Fig: 2

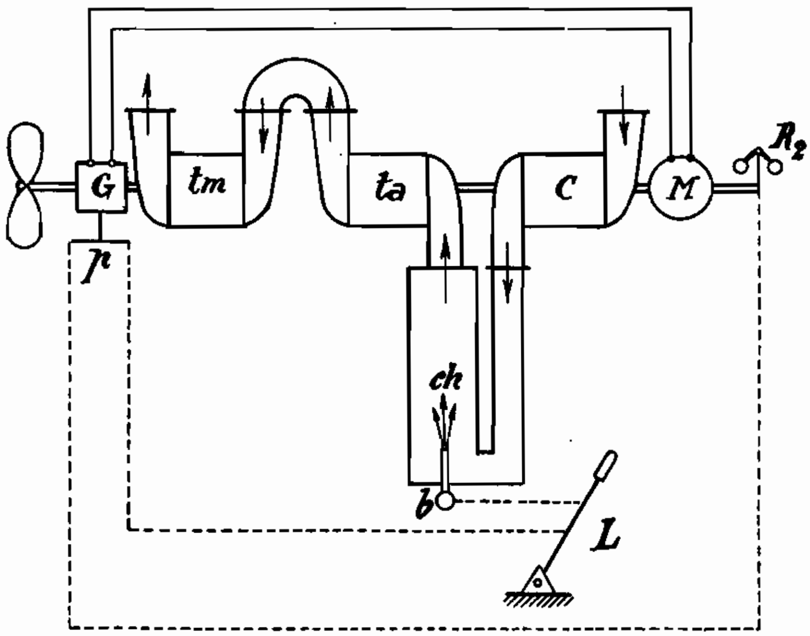
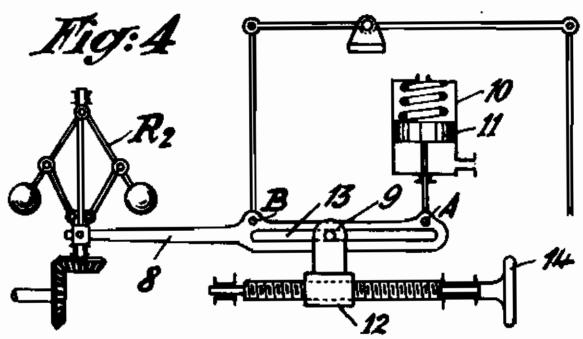


Fig: 4



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ALIEN PROPERTY CUSTODIAN

GAS TURBINE MOTOR PLANTS

Louis Armand Hermitte, La Courneuve, France; vested in the Alien Property Custodian

Application filed January 26, 1942

The present invention refers to gas turbine motive systems the object of which is to generate power or to drive any receiving apparatus whatever. The composition of the motive system may be of any kind and comprise, for example, one or more compressors, in series or in parallel, with or without intermediary refrigeration, one or more combustion chambers, one or more motive or auxiliary turbines, with or without intermediary reheating, with or without one or more heat exchanges which, by means of the heat of the exhaust gases, warm the air supplied by the compressor or compressors. The driven apparatus may be an electric generator or any other apparatus having or not a constant speed.

My invention applies more particularly to those gas turbine motive systems in which the compressor or compressors are driven by one or more auxiliary turbines which are mechanically independent of the motive turbines.

In what follows, it will be supposed for the sake of simplicity that there is only one motive turbine driving a receiving apparatus and only one auxiliary turbine driving an air compressor.

Such a system may be controlled in different ways all of which amount to acting on the supply of fuel by adapting it to the load borne by the receiving apparatus. The auxiliary turbo-compressor set then assumes a speed which is a function of this load.

The speed with which the power furnished by the motive turbine can be increased is in relation with the mechanical inertia of the auxiliary set and with the inertia of the fluid columns involved, the latter being always negligible.

It might be imagined that it is sufficient, in order to furnish a power supplement to the motive turbine, to instantaneously burn a superabundant quantity of fuel, which is possible as a result of the excess of air with which all these sets operate; the temperature would thus be increased, consequently also the available thermic drop on the motive turbine, with only a negligible delay due to the inertia of the fluid columns involved and without waiting for the acceleration of the auxiliary turbo-compressor. This however would lead one to alloy, for gas turbines, an increase in temperature which, although momentary, is incompatible with the proper bearing of the materials composing the turbines, this temperature having already been chosen or brought by adjustment to as high a value as possible for all speeds, so as to obtain a maximum yield. It is consequently necessary to increase the quantity of burnt fuel only progressively, in relation with the increase in the supply of air given by the progressive acceleration of the auxiliary set. The speed with which the motive turbine can furnish power is consequently limited by the time necessary for this acceleration, that is to say by the mechanical inertia of the auxiliary set.

The object of the present invention is to do away wtih this inconvenience.

According to one embodiment of the invention, the speed of the auxiliary set is maintained constant so that this set is capable of supplying at any time the volume of air necessary for the rapid loading of the motive turbines, the loading speed then depending only on the inertia of the fluid columns involved which are practically negligible.

This adjustment is suitable in those cases where the variations of speed are important and can not be foreseen. For reduced loads, the yield of a gas turbine motor thus adjusted is inferior to that of a motor in which the speed of the auxiliary set is free or is adjusted in order to obtain at the turbines that maximum temperature compatible with their good mechanical behaviour.

Whenever periods of load variation are separated by rather long periods of operation at rated load and that in the course of these periods it is possible to foresee the coming variations of load, it is advantageous to be able to momentarily suppress the action of the constant speed control of the auxiliary set, it being necessary to have recourse again to this constant speed control only when load variations are expected.

Along the same line of thought, when load variations are slight or when the conditions under which acceleration are to take place are less rigorous, it is interesting to be able to temper the action of the speed governor of the auxiliary set and to maintain between its speed and that which it would have under maximum yield conditions, only that difference which is strictly necessary.

In its second embodiment, the invention comprises a system which allows to effect these operations and which is superadded to the speed control of the auxiliary set.

The applying of the invention to that case where the motive turbine and the auxiliary turbine are fed by one and the same combustion chamber, whether these turbines be in parallel or in series requires a device which allows to vary the distribution of power between these turbines.

Whatever be the connection of the turbines (parallel or series), the distribution of power between the turbines can always be modified by varying the cross-section of the inlet tuyeres of the turbines, which is a particularly advantageous method as far as the yield is concerned. It is also possible to transfer power from one shaft to another by means of an electric motor set on the auxiliary shaft and of a generator on the shaft of the motive turbine.

When the turbines are in parallel, it is possible to vary the power distribution by a gas supply reducing organ set above or below one of them. With turbines mounted in parallel an other advantageous embodiment consists in supplying them by means of two distinct combustion chambers, the fuel supply to each of these chambers being adjusted for each turbine, according to the respective powers.

The device for distributing power to the turbines can depend upon a speed governor mounted on the auxiliary set; the organ for controlling the load of the set which, according to the case, can be speed governor (case where the motive turbine is a part of a constant speed motor generator set) or any other governor, or be a hand operated control organ (case of a motive set for marine, aeronautical or terrestrial propulsion) then controls the supply of fuel to the burners.

In the case where two distinct combustion chambers are utilised, the speed governor of the auxiliary set controls the supply of fuel to the combustion chamber of the auxiliary turbine, while the control organ for the load acts on the fuel supply to the combustion chamber of the motive turbine.

With a view to increasing the speed with which the new state of equilibrium corresponding to any load variation whatever can be attained, it is interesting that the control organ for the load of the set, while acting on the supply of fuel to the burners, also obtains an approximate adjustment of the power distribution to the two turbines. The speed governor of the auxiliary set has then only to perfect this latter adjustment.

The passing over from the control with the auxiliary set operating at constant speed (first embodiment) to the control allowing a reduction in the speed of this auxiliary set during intervals between load variations (second embodiment) can be obtained by means of a mechanical device acting on the adjustment of the speed-governor of the auxiliary set, for example by means of a spring scale or by any other similar means.

The description which follows, with reference to the appended drawing, given by way of non-limitative example, will allow a thorough understanding of how the invention can be embodied, those characteristics which appear in the drawing as well as in the text being a part, of course, of the invention.

Figures 1, 2 and 3 are non-limitative examples of embodiments of the invention and correspond to the first mode of realization of the invention.

Figures 4 and 5 refer to an organ which may be added to the control means of the preceding examples and which allow to obtain the second way of putting the invention into practice.

Figure 1 represents a gas turbine motive system in which the motive turbine *tm* and the auxiliary turbine *ta* are mounted in parallel a single combustion chamber *ch* being utilized. The receiving apparatus *r* is supposed to be a constant speed electric generator. The load controlling organ is the speed governor R_1 of the motive turbine *tm*; it acts directly on the supply of fuel to the burner *b*. The organ which allows to vary the power distribution between the two turbines is supposed to be an obturator O controlling the passage of the gases to a section of the tuyeres *t'* on the inlet end of the auxiliary turbine *ta*. It is made to depend upon, by means of a swingle-tree *p*, the speed governor R_2 of the auxiliary turbine, and upon the governor R_1.

If it supposed, for example, that an increase in the load of the receiving apparatus occurs, the speed of the motive turbine *tm* will have a tendency to fall, and immediately the governor R_1 will increase the fuel supply to the burner *b* and close the obturator O. The temperature which was inferior to the maximum allowable, since the compressor maintained at a constant speed discharges a superabundant air supply, rises the thermal fall and the supply of warm gases in the motive turbine increase and the latter, as a result furnishes an increased power. The thermal fall available for the auxiliary turbine also increases, but the supply of warm gases passing through the latter decreases; the auxiliary turbine will consequently have a tendency to accelerate or to slow down according to the amplitude of the approximate adjustment obtained and the governor R_2 then acts to reestablish a constant speed by adjusting, by means of the swingle-tree *p*, the position of the obturator O.

Figure 2 represents another embodiment of the invention, in which both turbines are in series and where the control of the speed of the auxillary set is effected electrically. The driven organ is, for example, a marine propeller. An electric generator G is set unto the shaft of the motive unit and an electric motor M is mounted on the shaft of the auxiliary turbine. The power supplied by the generator G is controlled by the governor R_2, by means of a swingle-tree *p*, and, for approximate adjustment, by the control lever L of the ships speed. The latter also acts of course on the burner *b*.

In case of an increase in the load, the supply of fuel to the burner is admitted by the lever L. The temperature, which was inferior to the maximum allowable, rises, the thermal fall to the motive turbine increases and consequently the power it supplied also. Simultaneously, the lever L reduces the power furnished by the generator G (the control means of the generator G are well known and do not need other explanations) and the power developed on the shaft of the motive turbine increases to that extent. The auxiliary turbine has a tendency to accelerate, since its thermal drop increases and to slow down, since the motor M is unloaded. The governor R_2 maintains its speed by adjusting the electric regulation of G.

In the case where the gas turbine should control an electric generator, the power supplied to M could be taken directly from the main generator.

Figure 3 represents another embodiment of the invention, in which two combustion chambers ch_1 and ch_2 are utilized, respectively connected to the motive turbine and to the auxiliary turbine which are in parallel. The governor R_1 then acts on burner b_1 of the motive turbine *tm* while the burner b_2 of the auxiliary turbine *ta* is dependent upon the two governors R_1 and R_2.

The governor R_2 maintains the speed of the auxiliary set constant; the latter consequently furnishes to the combustion chamber of the motive turbine an air supply which is constant for all loads. The fuel supply being reduced for small loads, the temperature reaches the maximum allowable only under full-load conditions.

When the load is increased, for example, the regulator R_1 increases the fuel supply to the burner b_1. The temperature of the gases which was inferior to the maximum allowable increases as well as the thermal drop available and the power developed by the motive turbine *tm* increases. Simultaneously, as a result of the increase in temperature at the turbine *tm*, the resistance which it offers to the passage of the gases increases and the discharge of the compressor then has a tendency to preferably enter the auxiliary combustion chamber, which condition would result in a speed variation of the auxiliary set. To maintain it, a new adjusting of the burner b_2 is necessary. The governor R_1 allows to obtain an approximate adjustment, so that the governor R_2 then only has to perfect it. The two governors act on the burner b_2 by means of a swingle-tree *p*.

The three embodiments which have just been described refer to the first mode of realisation of the control system consistent with the invention. (Compressor maintained at constant speed). In order to pass on to the second mode of realization, that is which consists in reducing the speed of the compressor during those periods where the load does not vary, it is necessary to act on the adjustment controlled by the governor R_2. In order to do this, a device such as the one represented in fig. 4 by way of non-limitative example, may be utilized. In this device, the speed governor R_2 of the auxiliary set rests on the extremity of a balance-lever 9 having a fixed fulcrum 9, a spring 10 bearing on the other extremity of the said balance lever, the tension of the said spring being adjusted by an organ depending upon any characteristic factor whatever of the load, for example by a piston 11 which is subjected to a pressure proportional to the fuel supp'y passing through the burner.

The fixed fulcrum 9 can be displaced in a slot 13 of the balance lever between the extremities A and B of this slot by means of a nut 12 controlled by a screwed fly-wheel 14.

When the fixed fulcrum 9 is at A, the spring balance lever is non-effective and the control of the constant speed auxiliary set is obtained (first embodiment). When the fixed fulcrum is displaced from A to B, the further the fulcrum is from A, the greater will the speed of the auxiliary set vary with the load. Practically, it is possible, by displacing this fixed fulcrum, to obtain all the curves such as those drawn on fig. 5 by laying off as abscissae the load values W of the receiving unit and as ordinates the speed V of the auxiliary set. The straight line *a* represents constant speed operation and the limiting curve *b* shows operating conditions obtained when the fixed fulcrum is at B. (In this case, the action of the governor and of the spring balance-lever are both nil). Curves *c* and *d* represent intermediate operating conditions when the fixed fulcrum occupies intermediate points between A and B.

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