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Filed March 16, 1942

Serial No. 434,985

2 Sheets-Sheet 1

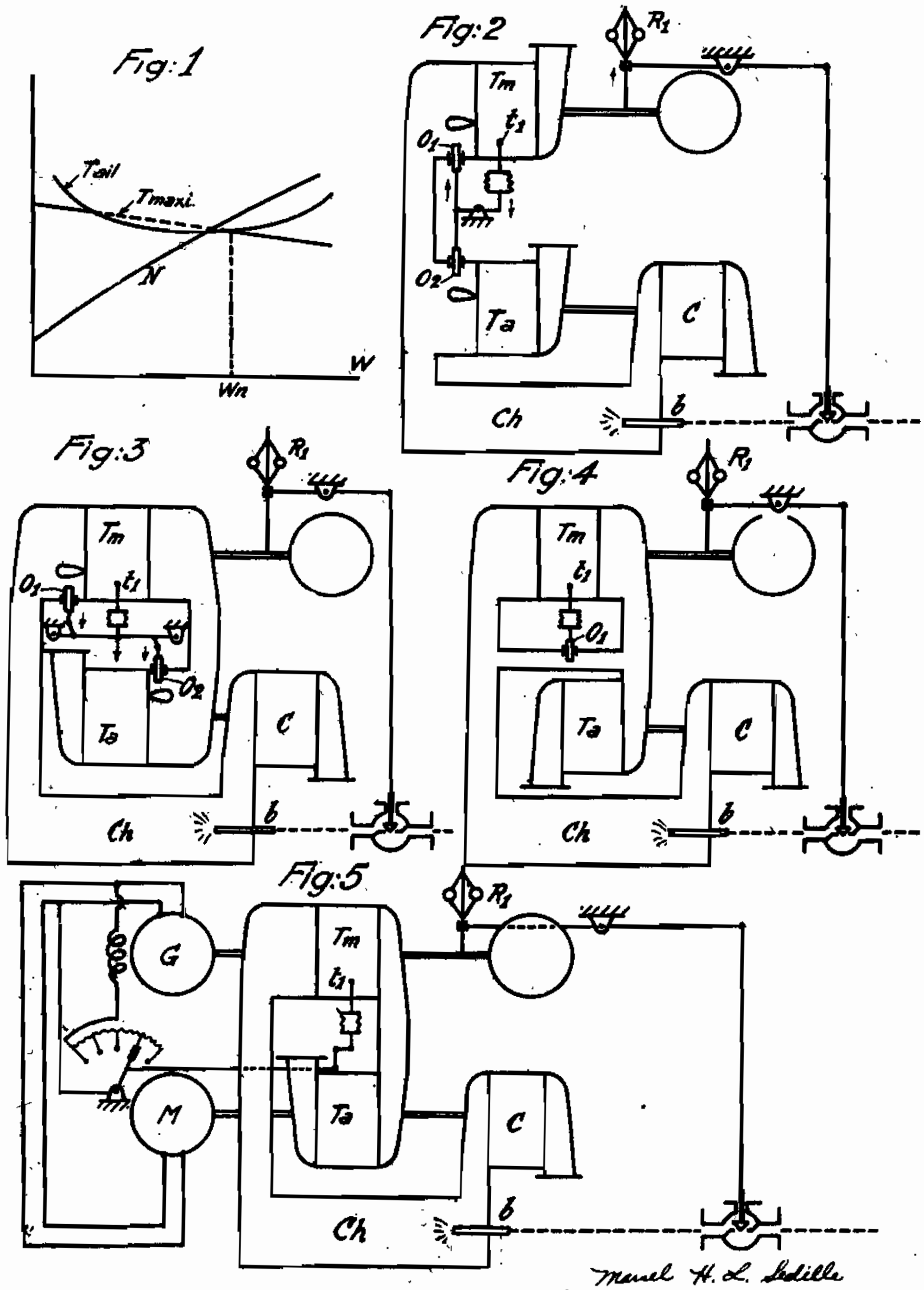

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Fig:6

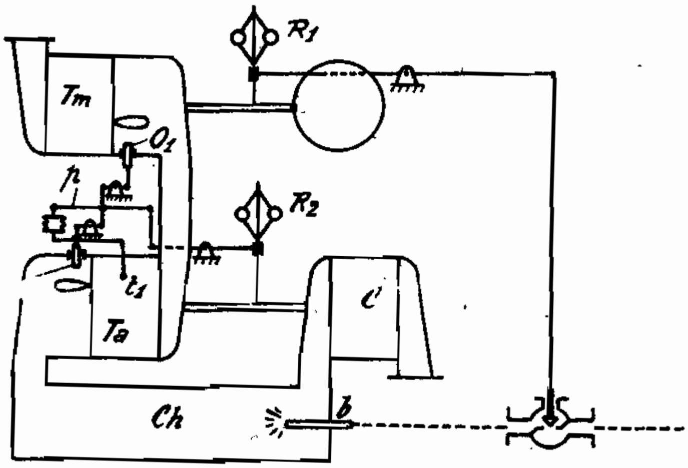


Fig:7

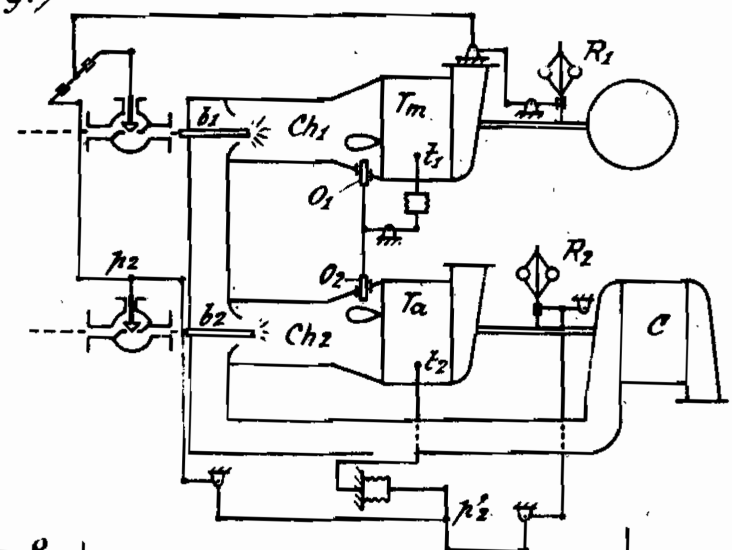
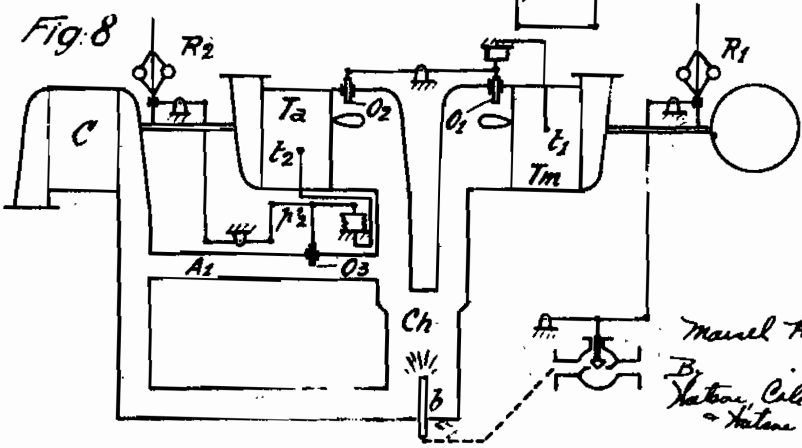


Fig:8



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ALIEN PROPERTY CUSTODIAN

SYSTEM AND DEVICES FOR CONTROLLING THERMAL GAS TURBINE MOTIVE UNITS

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Application filed March 16, 1942

The present invention relates to gas turbine motive units the object of which is to supply power or to drive any receiving apparatus whatsoever. The motive unit may be constituted in any manner and comprise for example, one or several compressors connected in series or in parallel, with or without intermediary refrigeration, one or several combustion chambers, one or several motive or auxiliary turbines with or without intermediary reheating, with or without several heat exchangers; the driven apparatus may be an electric generator or any other apparatus having or not a constant speed.

The invention relates to motive sets having two or more shafts at least one of which is used to drive the air compressor or compressors.

In what follows, it will be supposed for the sake of simplifying the exposition, that there are only two shafts, one of which drives the receiving apparatus, the other driving the air compressor, that there is no regenerator, nor any intermediately reheater between the turbines, nor any air refrigerator, these suppositions affecting in no way the scope of the invention which can be applied also to more complex motive sets.

The object of the present invention is a system for controlling the temperature in turbines, according to which system the temperature of the gases on leaving the first row of mobile blading is maintained constant, or between two limits or inferior to a given limit, dependent or not on the speed, the said temperature being, in practice, sufficiently close to the average temperature of the mobile blades themselves and, in any case, dependent on it.

In order to act on the said temperature, while maintaining the power delivered by the set at the required value, the invention provides for an increase in the power supplied by the auxiliary turbine, so that the compressor operating at a higher speed delivers more air and the temperature of the gases falls; moreover the fuel supply is simultaneously adjusted to maintain the power delivered.

From the viewpoint of yield, it is desirable that the operating point of the compressor remain as close as possible to the maximum yield for each speed; certain devices which also constitute the object of the present invention obtain this result.

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

Fig. 1 is a diagram of curves for the understanding of the invention.

Figs. 2, 3, 4, 5, 6, 7 and 8 give a few non limitative embodiments of the invention.

Whenever the load of a motive unit of the type considered varies, the temperature at the turbines varies according to a law similar to the one shown on Fig. 1 by curve T_{a1}; it is generally a minimum for the nominal power W_n or for a neighbouring point; for partial loads and for overloads, the temperature rises.

For partial loads or for overloads, this temperature may attain inadmissible values as far as the operating security of the machine is concerned; the most exposed organ of a gas turbine is the first row of mobile blading receiving the hottest gases. The speed of the corresponding rotor may be constant or assume in relation to the load values such as those represented by the curve N. Mechanical stresses can then diminish for partial loads and the maximum allowable temperature is, in general, a curve such as T_{max}, and in a particular case, may be a horizontal line.

In what follows a few embodiments of devices allowing to put the control system according to the invention into practice will be described. It will be supposed, in the first place, that a constant speed motor is concerned regardless of the load value (N is then a horizontal line).

Fig. 2 represents a turbine motive unit in which the motive turbine T_m and the auxiliary turbine T_a are arranged in parallel. The unit comprises only one combustion chamber Ch, the load regulator of the motive turbine, which is in this case supposed to be a speed governor R_1 but which could be a regulator of any other kind, acts on the supply of fuel furnished to burner b. It being supposed that the turbine the most exposed to rises in temperature is the motive turbine T_m, a thermostat t_1 maintains at a constant value the temperature of the gases leaving the first row of mobile blading of this turbine by simultaneously acting on the obturators O_1 and O_2 which affect only a fraction of the gas current passing through each one of the turbines T_a and T_m.

If, for example, the temperature, after the first row of mobile blading of the turbine T_m, has a tendency to increase, the thermostat t_1 opens O_2 on the feed end of the auxiliary turbine and shuts O_1 on the feed end of the motive turbine; the auxiliary turbine accelerates and the compressor furnishing a greater air supply, the temperature of the gases falls. The respective simultaneous positions of the obturators O_1 and O_2 can be calculated or determined experimentally in order to maintain the compressor C at its maximum yield for its new equilibrium speed. The load governor R_1 maintains the power delivered by the unit at the required value by acting on the fuel supply.

In the embodiment shown in Fig. 3, the turbines Tm and Ta are set in series, it being supposed that the motive turbine Tm is the high pressure turbine. The governor R_1 acts as before on burner b, and the thermostat t_1 on the obturators O_1 and O_2 which affect only a portion of the gas current passing through each turbine. When the temperature of the gases leaving the first row of mobile blading of the turbine Tm has a tendency to rise, the thermostat closes the obturator O_2 and opens the obturator O_1. The thermal drop in the turbine Tm has a tendency to diminish and that in the turbine Ta a tendency to increase; the compressor accelerates and thereby delivers a greater air supply and the temperature of the gases diminishes. As before, the governor R_1 controls the fuel consumption by maintaining the power delivered by the turbine Tm at the required value. The respective simultaneous positions of the obturators O_1 and O_2 may be experimentally calculated or determined in order to maintain the compressor C at its optimum yield for its new equilibrium speed.

In the embodiment shown in Fig. 4 the constituent parts of the motive unit have the same layout as in the preceding figure; the control is effected by by-passing a certain quantity of gas to the turbine Tm, quantity which is controlled by the obturator O_1 dependent upon the thermostat t_1.

Of course the same devices can be provided if the high pressure turbine is the auxiliary turbine and the low pressure turbine the motive turbine.

In the embodiment shown in Fig. 5 where the turbines are, by way of example, connected in series, the control is obtained by an electric, hydraulic or pneumatic generator G mounted onto the shaft of the motive turbine Tm and by an electric, hydraulic or pneumatic motor M mounted onto the auxiliary shaft and receiving its power from the generator G by means of a regulator (device for varying the excitation of the generator G for example) controlled by the thermostat t_1. If the temperature reaches an inadmissible value in the turbine Tm, the generator G, as a result of the action of the thermostat t_1, supplies more power to the motor M which condition results in an increase in the air supply delivered by the compressor; simultaneously the governor R_1 reestablishes the power at the required value; of course this arrangement can also be used if the high pressure turbine is the auxiliary turbine and if the turbines are connected in parallel.

In all the preceding examples, it has been supposed that the maximum allowable temperature was constant in relation to the load.

When the speed of the turbine wheel which is the most exposed to thermal deteriorations varies with the load (curve N, Fig. 1), the maximum allowable temperature also varies with the latter, that is to say that the curve T_{maxi}, Fig. 1, is no longer a horizontal line. The regulation may then be exercised by a thermostat the regulation temperature of which is readjusted by means of a speed detector or any other organ sensitive to a value varying with the load of the unit, such as for example, the quantity of fuel fed to the burner.

Fig. 6 represents an embodiment in which the turbines are connected in series; the thermostat t_1 and the speed detector R_2 both act on the position of the obturators O_1 and O_2 by means of a swingle-tree p. Of course this variable temperature control may be applied to all the arrangements already mentioned hereabove.

In all the above examples, the motive unit has only one combustion chamber.

In the embodiment shown in Fig. 7, two motive and auxiliary turbines are connected in parallel and each fed by a combustion chamber Ch_1 and Ch_2. The burner b_2 is operated by a swingle-tree p_2. The load governor R_1 of the main unit acts on the burner b_1 and on one of the branches of this swingle-tree p_2. A thermostat t_1 placed at the delivery end of the first mobile blading of the motive turbine Tm acts on both obturators O_1 and O_2. A thermostat t_2 placed at the delivery end of the first mobile blading of the auxiliary turbine and combined, for example by means of a swingle-tree p'_2 with an organ R_2 sensitive to the speed of the auxiliary group, actuates the other branch of the swingle-tree p_2.

When the load diminishes, for example, the governor R_1 reduces the feed of fuel to the burners b_1 and b_2; the auxiliary group slows down and the temperature at both turbines varies.

If the said temperature has a tendency to rise beyond the limit allowable after the first expansion stage of the turbine Tm, the thermostat t_1 closes O_1 and opens O_2 thus causing the auxiliary unit to accelerate, which unit delivers more air and causes the temperature of the gases to drop; likewise, the thermostat t_2 and the organ R_2 sensitive to the speed simultaneously act on the fuel supply to the burner b_2 in order to maintain the temperature, after the first expansion stage of the turbine Ta, at a value which is a function of the speed. If this temperature rises, t_2 closes b_2 and the governor R_1 reestablishes the power delivered by opening b_1; the temperature at the turbine Tm thereby increases, which condition actuates the regulation controlled by the thermostat t_1. When t_2 acts, it is possible to have it obtain only as approximate adjustment of b_1 and of O_1 and O_2 so that R_1 and t_1 need only then to perfect this adjustment.

Naturally, one of the temperature adjustments may exist without the other, in the case where the latter should prove unnecessary.

The turbine Tm, if its speed varies with the load, may also be provided with an organ sensitive to speed which organ corrects the action of the thermostat t_1.

In the embodiment shown in figure 8, the two turbines connected in parallel are fed by the same combustion chamber and their operating temperatures may be rendered different by means of a conduit A_1 feeding supplementary fresh air onto one of them, the said conduit being provided with a regulating valve or damper O_3.

The governor R_1 acts on the burner b, the thermostat t_1 of the motive turbine acts on both the obturators O_1 and O_2; the thermostat t_2 of the auxiliary turbine the action of which is, for example, corrected by the organ R_2, sensitive to speed, by means of a swingle-tree p'_2, controls the valve O_3; when the load drops, for example, the governor R_1 reduces the fuel feed to the burner b; if the temperature at the turbines then has a tendency to rise, the thermostat t_1 opens

O_2 and closes O_1 which causes the auxiliary unit to accelerate and lowers the temperatures.

If in spite of this, the temperature at the turbine T_a is still too high, the thermostat t_2 opens O_3, which lowers the temperature at the auxiliary turbine but simultaneously raises the temperature at the motive turbine; the thermostat t_1 then enters into action to bring it back again. This action may be limited to a small measure if t_2 and R_2 act on O_1 and O_2 in parallel with T_1 in order to obtain an approximate adjustment. The respective simultaneous positions of the three valves O_1, O_2 and O_3 may be calculated so that the compressor yield be substantially a maximum for all loads; naturally the turbine T_m may also be provided with an organ sensitive to speed if its speed diminishes with the load; finally, only one of the two temperature controls can exist.

In all of the above examples, as in all similar examples falling within the scope of the invention, one and only one position of the control organs utilized corresponds to each load; the said organs are controlled by the thermostats but can be controlled by the load organ of the main unit itself, that is to say for example by its speed governor when the unit is at a constant speed, on condition that the position of the control organs which maintain the temperature considered constant can be calculated or noted experimentally; it is then possible to completely suppress the automatic control or to keep it as a safety measure by having it act only as a limiting device; the load regulator of the motive turbine can also obtain only an approximate adjustment of the regulation organs described (organs O_1, O_2, O_3) the thermostats then having only to perfect this adjustment.

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