

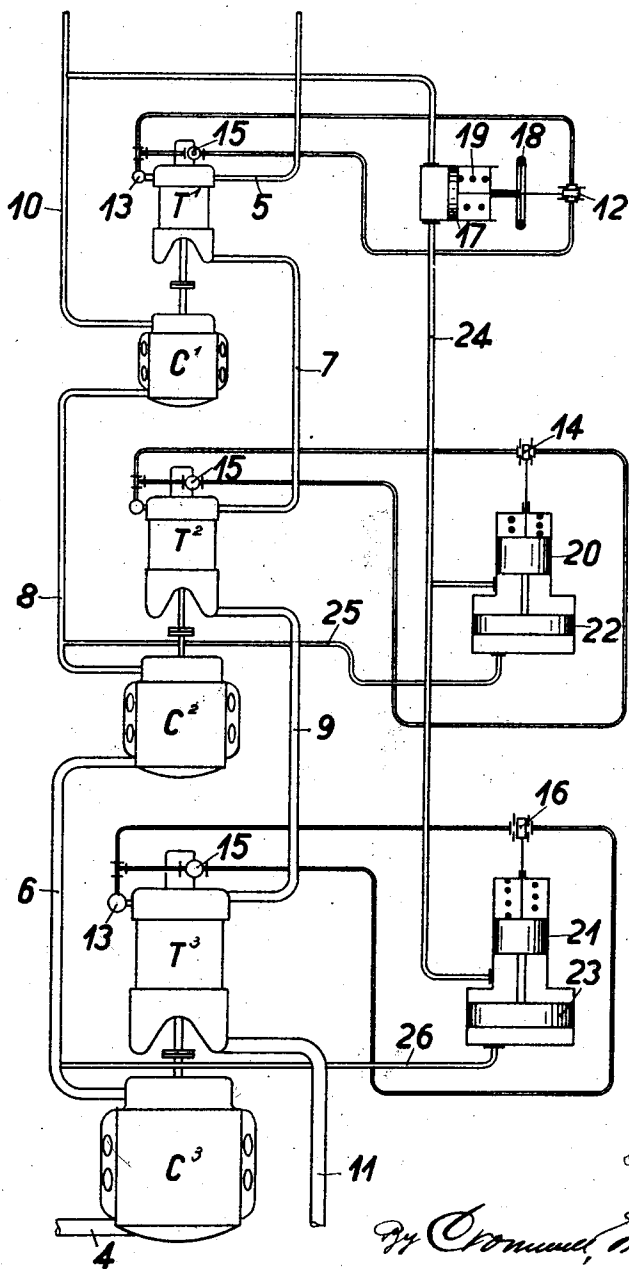
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COMPRESSOR APPARATUS

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UNITED STATES PATENT OFFICE.

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COMPRESSOR APPARATUS.

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This invention relates to installations for the progressive compression of gases and the like, and pertains particularly to multi-stage compressors driven separately by respective turbines or the like. The invention has to do primarily with the regulation of the several turbines for most efficient operation.

The general purpose of the invention is the provision of apparatus whereby regulation to constant output pressures or the like may be accomplished with facility and without imposing undesirable speed variations on the respective turbines.

Another object is the provision of apparatus whereby the loads on the several units may be held to approximately uniform ratio for different final output pressures.

Other and further objects will be pointed out or indicated hereinafter or obvious to one skilled in the art upon an understanding of the invention.

In the drawing forming a part of this specification I illustrate diagrammatically one arrangement of apparatus embodying the invention, but it is not intended that the claims are limited to this arrangement alone.

In the drawing, the diagram represents a three unit set of turbine driven compressors with regulating apparatus.

It is a desirable arrangement to divide high pressure rotary compressors into two or more casings or separately driven stages. When the drive is by steam turbine it is of advantage to subdivide the turbine in the same way to drive the respective compressors, the steam being passed through the various turbine sections in succession. Besides other advantages, this arrangement allows the adoption of the most favorable speeds for both turbine and compressor sections and thus, for example, the low pressure compressor driven by the low pressure turbine may run at the lowest speed and the high pressure compressor driven by the high pressure turbine may run at the highest speed.

As I have explained in a copending application, when the steam at the H. P. end alone is governed, a reduction of the total load caused by a change in the quantity of the medium passing through the compressors results in a redistribution of the load between the various turbine sections, the H. P. turbine taking an increased percentage of the load and the L. P. turbine taking a de-

creased percentage. Now if, for example, the final compression pressure and the speed remain constant, the individual compressors tend to maintain their original output in spite of the change in the load. Thus the balance of energy between turbine and compressor momentarily is destroyed but is automatically restored by an appropriate change in speed so that the H. P. set will run faster owing to its taking a higher proportion of the load. The following table shows the approximate output and speed variations for various loads.

Load.	1/1	3/4	1/2	1/4
Variation in output (%)-----	0	±10	±30	±50
Variation in speed (%)-----	0	±5	±14	±22.5

Thus for small variations of load the speed variation is comparatively small, the reason being that the power required by a rotary compressor working with constant quantity, varies with the square of the speed. Plants subject to small load variations may therefore be governed at the H. P. steam inlet alone with satisfactory results. When the delivery quantities and hence the load are subject to wide variations, however, the divergencies in speed become so great that the pressure ratios in the individual compressor casings differ so greatly from the normal that the working becomes unsatisfactory. As a result of the percentage increase in output of the H. P. turbine the speed at 1/4 load, for example, will be raised by about 22.5%, and the L. P. turbine will run correspondingly slower. This change of speed and accompanying change in the pressure ratio leads to a variation of the cooling effect, especially when intercoolers are used, and also to an unfavorable change in the specific volumetric loading of the impellers, i. e., the grading of the impellers chosen for normal working conditions is unsuitable for fractional loads owing to the radical changes in speeds. Such widely diverging speeds are also unsuitable for the turbines, as the H. P. turbine normally runs at a high speed and if this is raised by a considerable amount, the stresses in the compressor impellers may exceed the allowable limits. Also a greatly reduced speed of the L. P. turbine means considerably reduced efficiency.

The present invention provides a means for governing such multi-stage compressors without the disadvantages pointed out above. The means employed consist in governing the steam admission to all the turbines of the H. P. turbine alone. When this latter method is adopted, a variation in load results in a redistribution of the load between the various turbines, but if, for example, the admission pressure of the H. P. and I. P. units is raised by cutting out corresponding nozzle sections, the heat drop will be distributed among the individual turbines in such a way that either the original load distribution is maintained or is altered according to definite laws to suit the purpose in view.

An arrangement in accordance with the present invention is shown in the drawing, wherein T^1 designates the high pressure turbine connected to drive the high pressure compressor C^1 , T^2 an intermediate pressure turbine connected to drive the intermediate pressure compressor C^2 , and T^3 the low pressure turbine driving the low pressure compressor C^3 . The steam is supplied to the H. P. turbine at 5, passes from that turbine to the I. P. turbine through the pipe 7, and from the I. P. turbine to the L. P. turbine through pipe 9, and is exhausted through 11. The medium for compression enters the L. P. turbine through 4, passes to the I. P. turbine through 6, to the H. P. turbine through 8, and to the service line through 10. Regulating devices are provided for the respective turbines, that for turbine T^1 being designated 12, for the turbine T^2 being designated 14, and that for T^3 being designated 16. These regulators control the steam supply to the respective units through governing devices 13 operated in suitable fashion, as by oil pressure furnished by the pumps 15. The H. P. regulator is responsive to variations in the pressure in output line 10, so that it will regulate the H. P. turbine to constant output pressure. The line pressure is effective on the piston 17 to vary the operating oil supply through the regulating device 12 to the governor 13. The output pressure to which regulation is effected may be varied by hand adjustment of the screw 18 to vary the compression of spring 19, against which the line pressure is exerted through piston 17. While the arrangement of the other regulators may be such as to give constant pressure output from their respective units, in the arrangement illustrated they are coupled so as to maintain a constant ratio between the output pressure of their units and that of the H. P. unit. This is preferable on account of the fact that it effects a distribution of the work among the several units more or less in accordance with any change in the critical output pressure, rather than requiring the H. P. unit to as-

sume a condition of operation to effect the entire change itself. Thus, when the critical final pressure is changed, as by adjustment of the pressure determining device 18, an accommodation of all the units to the change is accomplished automatically, so that the ratio between the final and preliminary pressures is maintained substantially constant. To accomplish this, the regulating devices 14 and 16 are under the control of differential pistons 20—22 and 21—23, the space between the pistons is connected to the final compression pressure through the line 24, and the final pressure of the respective unit is applied beneath the larger piston through the pipes 25 and 26 in the respective instances.

With regulation in this fashion the load is distributed among the turbines in a constant ratio, although the output pressures of all are allowed a variation in accordance with varying demands, and this is accomplished without disproportionate or undesirable divergence in speed.

What I claim is:

1. Compressor apparatus comprising, in combination, a plurality of compressors connected in series, a plurality of turbines connected for passage of operating fluid there-through in series, the high pressure turbine connected to drive the high pressure compressor and lower pressure turbines connected to drive respectively the lower pressure compressors, means for regulating the fluid supplied to the high pressure turbine, and means responsive to the end compression pressure and intermediate compression pressures for regulating the fluid supplied to the lower pressure turbines.

2. Compressor apparatus comprising, a plurality of different staged compressors, a plurality of different staged turbines each connected to drive the respective compressor of corresponding stage, means for regulating steam supply to the high pressure turbine and means operating automatically to regulate steam supply to the other turbines in constant ratio.

3. Compressor apparatus comprising, in combination, a plurality of different staged compressors, a plurality of different staged turbines, the turbines being connected to drive respective compressors of corresponding stage, means for regulating the high pressure turbine to constant output pressure of its compressor and means for regulating the other turbines to maintain a constant ratio between the final pressure and the output of their respective compressors.

4. Compressor apparatus comprising, in combination, a plurality of compressors of different stage, a plurality of turbines of different stage, each turbine driving a respective compressor, means for varying the steam supply to the high pressure turbine, said

means responsive to the final compression pressure, and means responsive to the final pressure and output pressure of respective compressors for controlling the speed of the
5 lower pressure turbines.

5. Compressor apparatus comprising, in combination, a plurality of compressors of different stage connected in series, a plurality of turbines of different stage connected in series, the respective turbines
10 driving respective compressors, a regulating device for the high pressure turbine, said

regulating device responsive to the final output pressure, and a regulating device for each lower pressure turbine, each of said
15 last mentioned regulating devices being responsive to the output pressure of the corresponding compressor and final compression pressure.

In testimony whereof I have hereunto subscribed my name at Zurich, Switzerland, on
20 the 3rd day of March, A. D. 1926.

KARL FREY.