

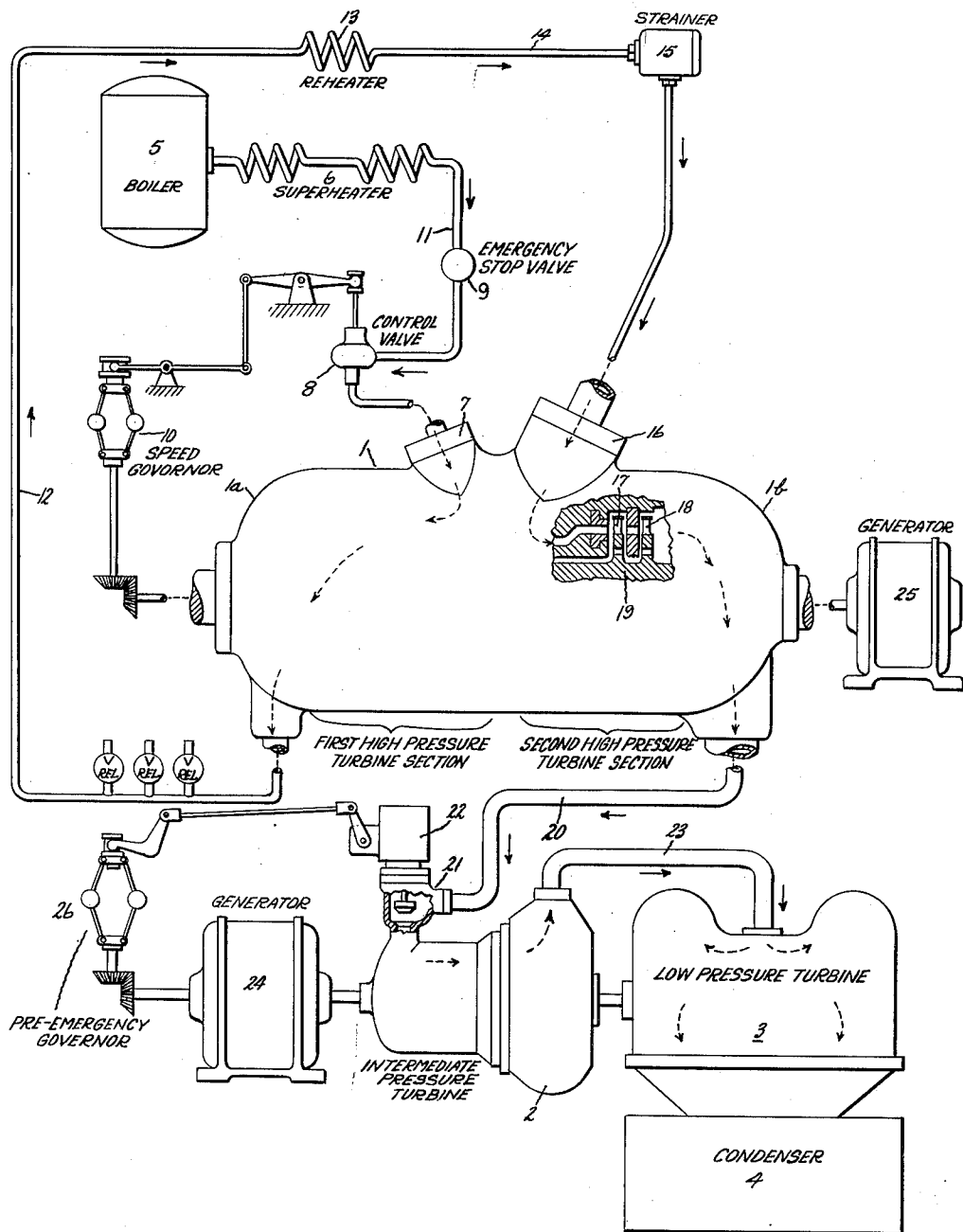
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COMPOUND TURBINE POWER PLANT WITH INTERCEPT VALVE

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## UNITED STATES PATENT OFFICE

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COMPOUND TURBINE POWER PLANT WITH  
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This invention relates to elastic fluid turbines, particularly to compound steam turbine plants having in series a first high pressure turbine section, a reheater for increasing the temperature of the motive fluid, a second high pressure turbine section, and one or more lower pressure turbines exhausting into a condenser.

In elastic fluid turbine plants of the type described, the control problem is complicated by the fact that the various turbine sections may be connected by steam conduits of diameters on the order of 18 inches and from 50 to 300 feet in length. The flow of motive fluid is primarily controlled by suitable regulating valve means at the inlet to the first high pressure section. To prevent unsafe overspeed conditions, one or more emergency stop valves are arranged to be actuated by suitable speed responsive devices, as will be well understood by those skilled in the art. However, with such powerplants it has been found that an additional valve is required in order to prevent overspeeding of the lower pressure turbine sections by the action of the very substantial amount of steam stored in the high pressure turbine casings, reheat boiler, and the long conduits connecting them. This additional valve is known as an "intercept" valve, and previous practice has been to locate it between the reheater and the next lower pressure turbine element to which the reheater supplies steam. Ordinarily, this intercept valve is located immediately adjacent the entrance to such lower pressure turbine.

As initial steam conditions have risen to the neighborhood of 2400 pounds per square inch gage pressure and 1100° F. temperature and with high resuperheat temperatures, the previously used intercept valve arrangements have been found inadequate to prevent overspeeding and costly to build because of the special materials required by the high temperatures to which the intercept valve is subjected. The present invention relates to a novel arrangement which greatly enhances the efficacy of the intercept valve in preventing such overspeeding, and should reduce the cost of the valve, as compared with the previously used practice of placing the intercept valve between turbine and reheater.

Accordingly, the object of this invention is to provide an improved compound turbine plane characterized by a novel location for the intercept valve to produce more effective speed control action when the load on the plant is suddenly disconnected and the speed of the turbine-generator increases;

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Other objects and advantages will become apparent from the following description taken in connection with the accompanying drawing in which the single figure represents diagrammatically a compound turbine plane having an intercept valve arranged in accordance with the invention.

Generally stated, the invention is practiced by arranging the reheater in series between two high pressure turbine sections and locating the intercept valve at the inlet to the intermediate pressure turbine so that at least one high pressure turbine section is interposed in series between the reheater and the intercept valve.

Referring now more particularly to the drawing, the invention is shown applied to a compound turbine plant including a two-section high pressure turbine indicated generally at 1, and, on a separate shaft, an intermediate pressure turbine 2 and a low pressure turbine 3, exhausting into a condenser 4.

Steam is generated in the boiler 5 and a superheater 6, which may supply motive fluid at pressures as high as 2400 lb. per sq. in. and temperatures in the neighborhood of 1100° F. The flow of motive fluid to the inlet 7 of the first high pressure turbine element 1a is regulated by suitable valve means in a steam control chest indicated generally at 8. As will be understood by those skilled in the art, the chest 8 may have a number of separate poppet or other type valves, each controlling the flow of steam to one of several steam inlets similar to that designated 7. The details of this governing valve mechanism are not material to an understanding of the present invention and are therefore not described in more detail.

In order to prevent dangerous overspeed conditions, an emergency stop valve 9 is interposed between the superheater 6 and the governing valve 8. It will of course be appreciated that this valve is intended to be closed automatically by a suitable over-speed governor (not shown). Such emergency overspeed governor arrangements are well-known in the art, one such being disclosed in United States Patent 2,524,552, issued October 3, 1950 on an application of L. B. Wales et al. and assigned to the same assignee as the present application.

As will be readily appreciated by those skilled in the turbine art, high temperature high pressure motive fluid is supplied from the superheater 6 through conduit 11 through the normally open stop valve 9 to the control valve chest 8. From the valve chest, motive fluid flows to the

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high pressure inlet 7 of the first turbine section 1a. The motive fluid flows to the left through the first high pressure turbine section 1a, as indicated by the arrows, and by way of a conduit 12 to a reheater indicated generally at 13. The reheater raises the steam temperature from about 750° F. to approximately its initial value, in the neighborhood of 1100° F. From the reheater, the motive fluid passes through a conduit 14 containing a strainer 15 to the inlet 16 of the second high pressure turbine section 1b. From inlet 16, the motive fluid flows to the right as indicated by the arrows in the drawing through the second high pressure section 1b, which of course has a plurality of bucket-wheels, only two of which are shown at 17, 18 as being forged integral with the turbine rotor 19. The second high pressure section 1b may have in the neighborhood of four bucket-wheels, while the first high pressure section 1a may have about ten stages. After passing through both high pressure sections 1a, 1b, the motive fluid passes through conduit 20, having at this point a temperature on the order of 925° F. and a pressure on the order of 280 lb. per sq. in.

As will be understood by those familiar with large capacity compound turbine plants, the conduit 20 may be of very substantial length, perhaps as much as 150 feet, and of a diameter on the order of 18 inches. In accordance with the invention, the intercept valve 21 is located at the inlet to the intermediate pressure turbine 2, as contrasted with the prior practice of providing such a valve at the inlet 16 to the high pressure turbine 1b. The intercept valve 21 has a suitable motor, indicated at 22, interconnected with the "pre-emergency governor" 26 for causing the valve to close automatically when the pre-emergency governor is tripped by a preselected rise in speed of the generator 24. The governors 10 and 26 are arranged to effect simultaneous closing of valves 8 and 21 respectively.

From the intermediate pressure turbine 2, motive fluid flows through the cross-over pipe 23 to the double-flow low pressure turbine 3. Spent steam from the low pressure turbine is exhausted into the condenser 4.

As will be seen from the drawing, the intermediate pressure turbine 2 and low pressure turbine 3 are coupled together to drive a suitable load, represented by an electric generator at 24. Similarly, the rotor 19 of the high pressure turbine 1 is arranged to drive a suitable generator 25.

The high pressure turbine 1 is described in more detail in my application, Serial No. 62,678, filed November 30, 1948, abandoned and published in the Official Gazette of May 23, 1950.

It will now be apparent from the above description of this plant that, if the intercept valve 21 were located at the inlet 16 to the high pressure section turbine 1b, then, upon simultaneous closing of the intercept valve 21, stop valve 9, and governing valve 8, the very substantial quantity of high pressure steam contained in the casing 1b and long conduit 20 would tend to cause overspeeding of the intermediate pressure turbine 2. However, with the intercept valve 21 located as shown in the drawing, this motive fluid is trapped between the control valve 8 and the intercept valve 21. This has a triple effect in preventing overspeeding of the turbines.

In the first place, there is a smaller quantity of high pressure motive fluid left free to expand through the lower pressure turbines 2, 3. That is, only the comparatively small amount of steam in

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the intermediate pressure turbine 2 and the cross-over pipe 23 will expand through the low pressure turbine 3. The resulting energy delivered to the low pressure turbine rotor will not be sufficient to produce excessive overspeed. As soon as the intercept valve 21 closes, the flow of motive fluid through the comparatively long interconnecting conduit 20 and through the high pressure turbine is stopped, so that there is no further delivery of energy to the high pressure turbine rotor. In the second place, the number of turbine stages through which the trapped steam is permitted to expand is considerably reduced. And thirdly, the comparatively dense high pressure steam trapped upstream from the intercept valve 21 produces a substantial "hydraulic braking" effect on the high pressure turbine rotor 19. This will be apparent from the fact that, as soon as the intercept valve 21 closes, the pressure throughout the conduit 20, low pressure turbine 1b, and high pressure turbine 1a becomes equalized at a pressure on the order of 500 to 600 lbs. per sq. in. This steam is sufficiently dense that rotation of the high pressure bucket-wheels 17, 18, etc. in this fluid produces a very substantial braking effect, which may be equivalent to a braking load on the order of 800 to 900 horsepower.

Thus, by reducing the volume of trapped steam, reducing the number of turbine stages through which this trapped steam is free to expand when the intercept valve closes, and by reason of the above-described hydraulic braking action, the problem of preventing overspeed when the stop valve and intercept valve are tripped is greatly simplified.

Another important advantage of this intercept valve arrangement lies in the fact that the temperatures to which the valve is subjected are only on the order of 900° F., whereas it would have to withstand temperatures continuously on the order of 1100° F. and pressures of 500 pounds per square inch if located in accordance with prior art practice at the inlet to the high pressure section 1b. This is a matter of substantial importance, as it makes possible the use of much lower cost and more readily available alloys, a matter of significance in the light of the fact that the intercept valve may be on the order of 40" to 50" in diameter and may weigh in the neighborhood of 15,000 pounds.

While the invention has been specifically described herein as applied to a compound turbine having rotors arranged on two mechanically independent shafts, it will be appreciated by those skilled in the art that the invention may also be applied to plants in which all the turbine elements are on a common shaft. Such an arrangement may be readily visualized by assuming that the generator 24 in the drawing is relocated to coincide with generator 25. In such a case, the pre-emergency overspeed governor 26 is relocated near the speed governor 10, and is arranged, as described above, to effect closing of the intercept valve 21 in synchronism with the stop valve 9 and throttle valve 8.

It will be apparent to those skilled in the art that many other changes might be made. For instance, the intercept valve might conceivably be located at the inlet to the low pressure turbine 3, so as to still further reduce the volume of trapped steam and the temperatures at which the valve has to operate. At the same time, this would mean that steam trapped in the inter-

mediate pressure turbine 2 would produce the above-described hydraulic braking effect on the low pressure turbine rotor. This might be carried one step further by locating the intercept valve at the exit of the low pressure turbine 3; although this probably would not be feasible in most cases because of the tremendous size of the valve which would be required to handle the volume flow at that point. The entrance to the intermediate pressure turbine 2, as illustrated in the drawing, appears to be the best compromise between utilizing a valve of reasonable size, but yet attaining the advantages described above.

It is of course intended that the appended claims shall cover all such modifications and changes as fall within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In a turbine powerplant having a vapor generator supplying motive fluid to a first high turbine section, a reheater for increasing the temperature of motive fluid received from the first high pressure section and delivering it to a second high pressure turbine section, and a comparatively long cross-over conduit supplying motive fluid from the second high pressure turbine section to the inlet of an intermediate pressure turbine, the combination of a high pressure turbine control valve located between the vapor generator and the high pressure turbine, an intercept valve located in said cross-over conduit adjacent the entrance to the intermediate pressure turbine, and governing means for simultaneously closing said control valve and intercept valve whereby, upon closing of said valves, the motive fluid trapped in the high pressure turbine and cross-over conduit are prevented from expanding through the intermediate

pressure turbine and the high pressure fluid remaining in the high pressure turbine exerts a braking effect on the high pressure turbine rotor.

2. In a compound turbine powerplant having a vapor generator supplying motive fluid to a first high pressure turbine section, a reheater for increasing the temperature of motive fluid received from the first high pressure section and delivering it to a second high pressure turbine section, and a comparatively long cross-over conduit supplying motive fluid from the second high pressure section to the inlet of a lower pressure turbine section, the combination of a control valve located between the vapor generator and the first high pressure section, an intercept valve located in said cross-over conduit at the entrance to said lower pressure section, and speed responsive means for simultaneously closing said valves, whereby elastic fluid trapped in the high pressure turbine and cross-over conduit upstream from the intercept valve is prevented from expanding through the lower pressure turbine, and the high pressure fluid remaining between said valves exerts a hydraulic braking effect on the high pressure turbine rotor.

GLENN B. WARREN.

#### REFERENCES CITED

The following references are of record in the file of this patent:

#### UNITED STATES PATENTS

| Number    | Name                 | Date          |
|-----------|----------------------|---------------|
| 1,759,452 | Hartmann et al. .... | May 20, 1930  |
| 1,774,974 | Hilgers et al. ....  | Sept. 2, 1930 |
| 1,920,781 | Caughey .....        | Aug. 1, 1933  |
| 2,504,640 | Bryant .....         | Apr. 13, 1950 |