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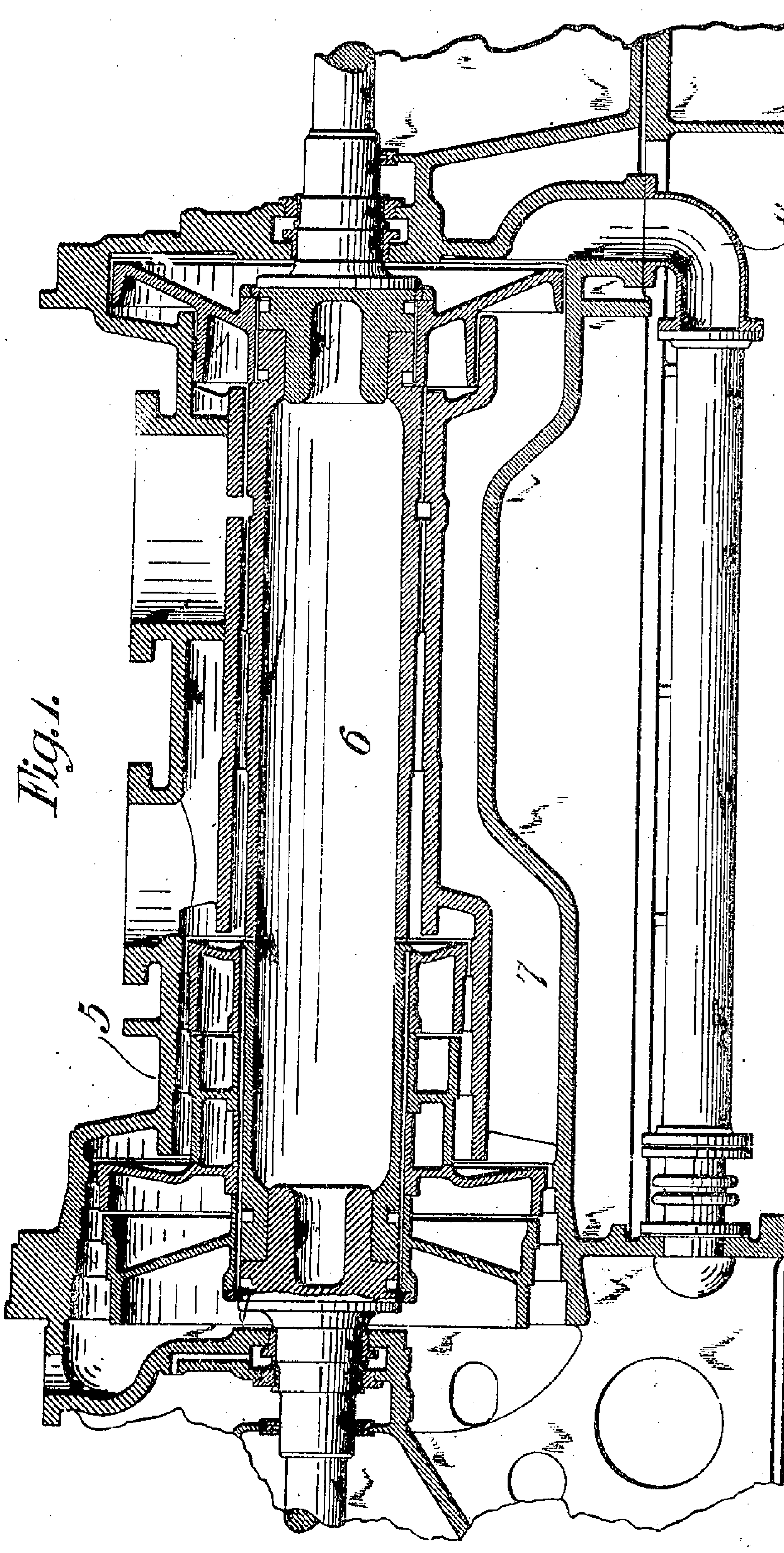
ELASTIC FLUID TURBINE.

APPLICATION FILED APR. 12, 1905. RENEWED JUNE 7, 1909.

934,915.

Patented Sept. 21, 1909.

4 SHEETS—SHEET 1.



Witnesses
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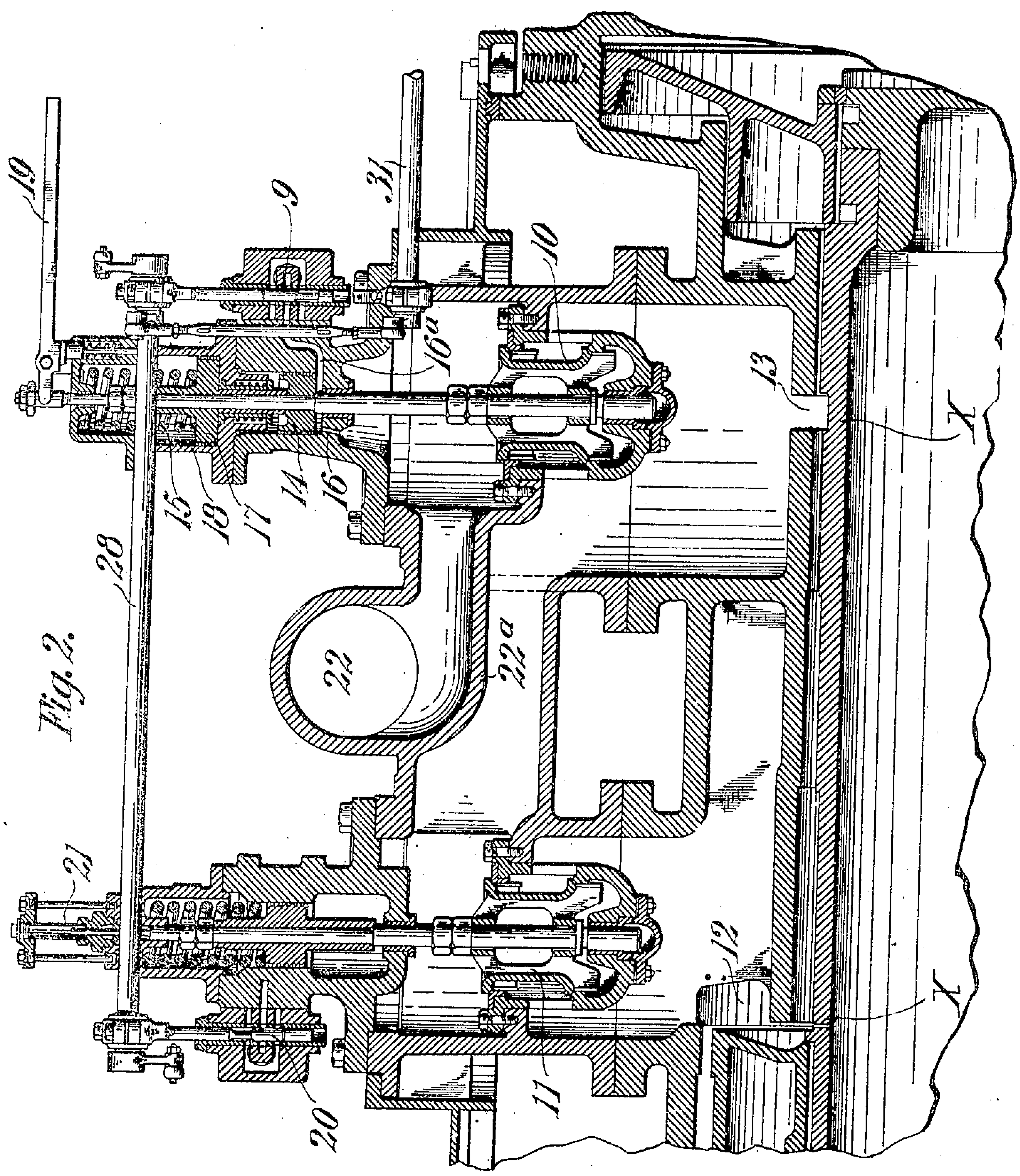

Fig. 2.

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Fig. 4.

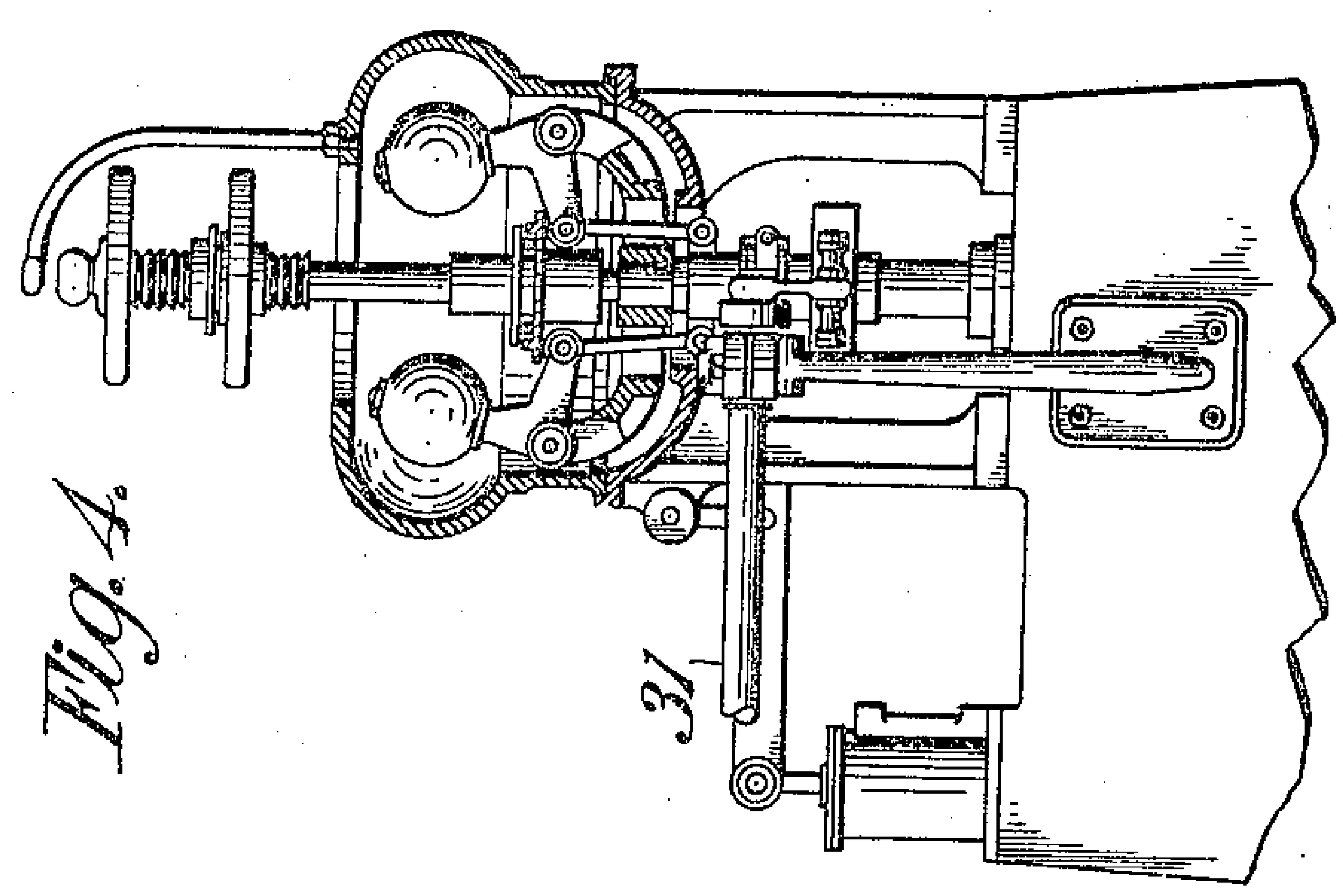

Fig. 3.

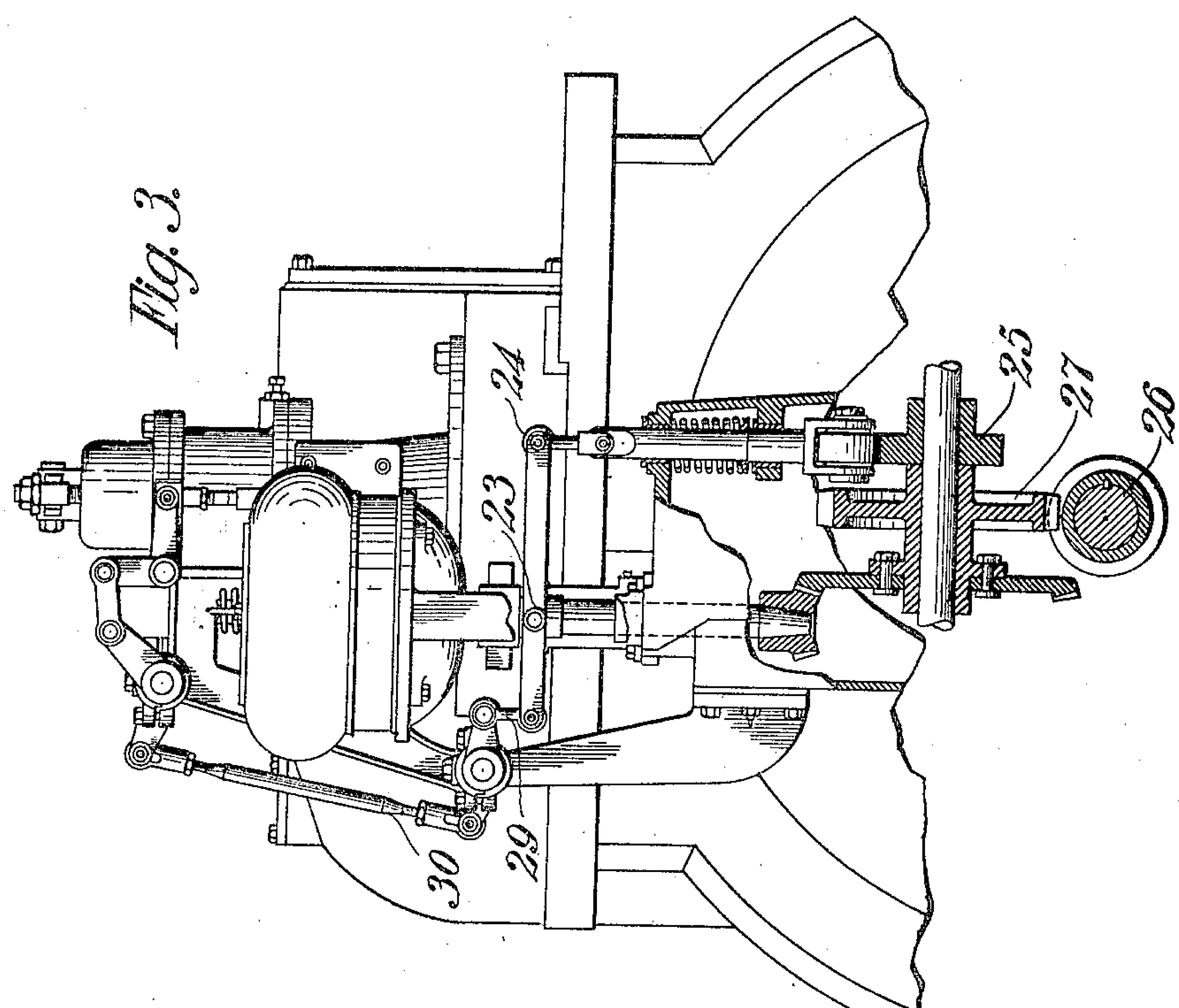

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Fig. 5.

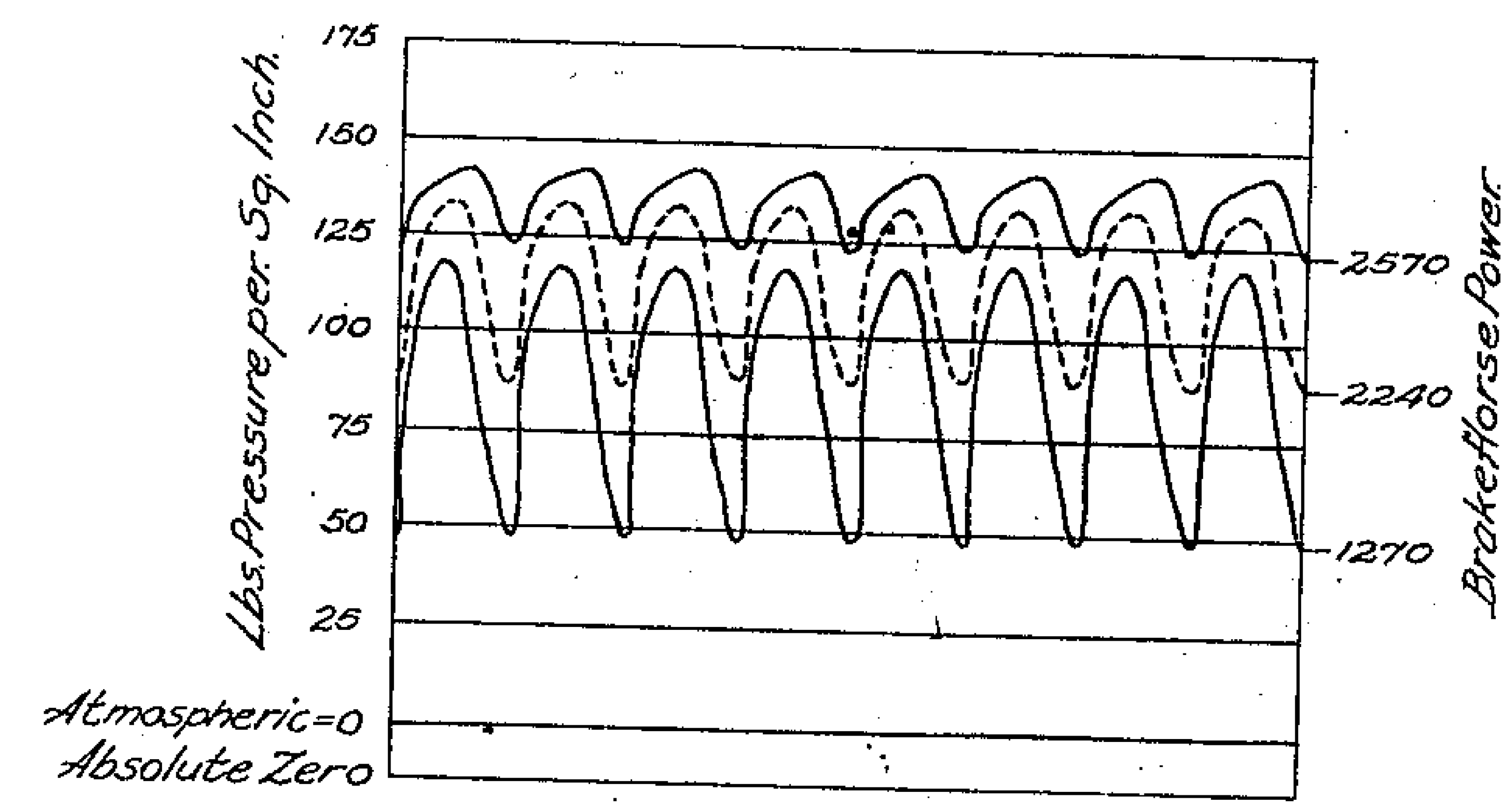
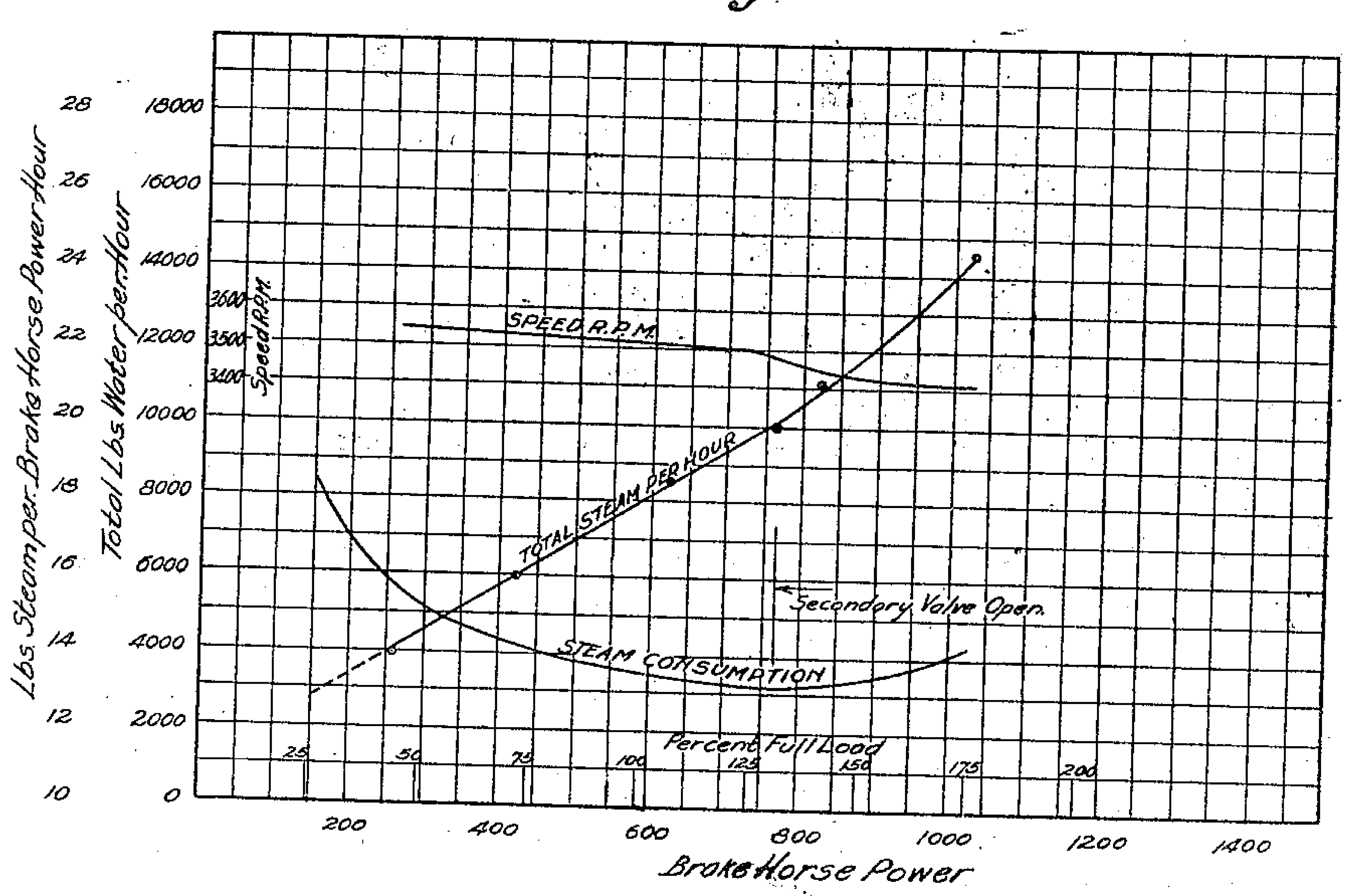


Fig. 6.



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ELASTIC-FLUID TURBINE.

934,915. Specification of Letters Patent. Patented Sept. 21, 1909.

Application filed April 12, 1905, Serial No. 255,113. Renewed June 7, 1909. Serial No. 500,737.

To all whom it may concern:

Be it known that I, FRANCIS HODGKINSON, a subject of the King of Great Britain and Ireland, residing at Edgewood Park, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Elastic-Fluid Turbines, of which the following is a specification.

This invention relates to elastic fluid turbines, and more especially to governing means therefor.

An object of this invention has been to provide effective governing means for steam or other elastic fluid turbines, whereby a substantially uniform speed may be maintained through a wide range of load variations. This, as well as other objects which will be apparent to those skilled in this particular art, I attain by means of the mechanism described in the specification and illustrated in the accompanying drawings in conjunction with a particular type of steam turbine.

It will be understood that this invention is not limited in its application to any particular style or type of turbine, and a particular type is here shown only for the sake of illustration.

Hereinafter the working fluid will be referred to as steam, with no intention, however, of limiting the appended claims to steam turbines.

In the drawings, Figure 1 is a longitudinal sectional view of a steam turbine to which this invention may be applied: Fig. 2 is a longitudinal sectional view of the inlet's portion of the turbine illustrated in Fig. 1, showing the automatic valve forming a part of this invention, in position: Fig. 3 is an end view in elevation of a portion of a turbine equipped with this invention, and Fig. 4 is a detail view of a governor which may be utilized with this invention: Figs. 5 and 6 are diagrams hereinafter described.

The turbine proper, as illustrated, consists of two essential elements, a casing or stator 5 and a rotor or rotating part 6.

The rotor is built up of blade supporting drums mounted on shaft ends which project through the casing ends and are journaled within suitable bearings. The drums, for reasons of manufacture, are stepped and of increasing diameters to provide for proper steam expansion.

Opposed to the blade drums, the rotor is provided with balance-pistons rendered effective by means of steam passages 7, one only of which is illustrated, and by a passage 8 subjecting the reverse sides of the balance-pistons to the exhaust pressure.

The internal portions of the casing correspond to the several dimensions of the rotor and its parts, and its inner surface is adapted to carry rings of fixed blades to alternate with the blades with which the rotor is adapted to be provided.

The governing mechanism is constructed and arranged so that the steam enters the turbine in puffs, and not in a continuous blast. Speed regulating is, therefore, accomplished by proportioning the duration of the puffs to the load. This is done by means of a small pilot-valve 9, actuated directly by the governor which thereby controls the steam passing through the main puppet-admission-valve 10.

When the turbine is in operation, the main or primary puppet-valve 10 is continually opening and closing at uniform intervals, but the periods during which the valve is allowed to remain open are proportioned to the load on the turbine. At light load, the valve opens for a very short period and remains closed during the greater part of the interval. As the load increases the period lengthens until finally, at about full load, the valve does not reach its seat at all, and approximately continuous pressure is obtained in the high pressure end of the turbine, or between the points $x—x$ in Fig. 2. On the load becoming further increased, an auxiliary or secondary valve 11 begins to open and to admit steam to the annular space 12 at the beginning of the intermediate drum of the rotor where the steam working areas are greater; this increases in proportion the total power of the turbine.

The operation of the secondary puppet-valve 11 is the same as that of the main admission valve, so that the governor automatically controls the power and speed of the turbine from no load to such overloads as are usually beyond the limits of the generating apparatus with which they are generally utilized. With this method of governing, the turbine operates at its best efficiency at or near full rated load, although possessing at the same time large overload capacity with remarkably high efficiency.

The primary admission valve.—The main admission valve 10, which controls the steam admitted through an annular port 13 at the beginning of the high pressure section, is raised from its seat during its reciprocations by means of a motor connected to its stem which motor consists of a steam-piston 14 and a spring 15. The piston is single-acting and the steam is admitted to its underside through a port or channel 16 and exhauster through the channel 16^2 under the control of pilot-valve 9. The channel 16 is materially smaller than the channel 16^a and when the channel 16^a is open to the exhaust, steam admitted through the channel 16 is negligible. The seating of the valve is accomplished by means of the spring 15 acting in conjunction with a dash-pot or timing device formed by piston 17 located within a cylindrical portion 18 of the valve stem chamber. A hand-lever 19 is provided for opening the valve during the warming up operation.

The secondary admission valve.—The construction of the secondary admission valve is similar to the primary admission valve in most respects, and its operation is controlled by a pilot-valve 20. For the sake of visibly indicating the operation of the secondary valve, the end of its stem is reduced and reciprocates within a sight-glass 21 provided for that purpose.

Any desirable kind of a throttle-valve in the steam-line between the boiler and the turbine may be utilized to control the flow of steam through the admission port 22. During normal load and all loads below normal, the secondary admission valve 11, as before said, remains closed. During all loads above normal, the steam passing through the secondary admission valve, passes first through the primary admission valve, which remains open.

If desired, a partition similar to the one indicated by dotted lines in Fig. 2 could separate the two valve-chests and partition 22^a would be cut away, so that the secondary admission valve would be supplied with steam direct from the admission port 22 without first passing through the primary admission valve. The construction shown, however, it is believed is preferable, owing to the fact that all of the steam passing to the turbine can be shut off by the primary admission valve, which would not be the case with the alternative construction.

The governor, which is here shown of the fly-ball type merely for the sake of illustration, raises and lowers the fulcrum 23 of the lever 24, which lever causes both of the pilot-valves to regularly reciprocate.

The lever 24 is regularly reciprocated synchronously with the rotation of the turbine rotor by means of a cam 25 driven from the turbine-shaft 26 through suitable gearing 27. The stems of both pilot-valves, by means of suitable links and lever connections, are reciprocated by a rock-shaft 28, operated by lever 24 through links 29 and 30 and the rock-shaft 31.

It will be seen that as the lever 24 is regularly reciprocated, and as the position of its fulcrum is dependent upon the position of the fly-balls, the planes of reciprocation of the two pilot-valves will vary as the position of said fulcrum varies.

The connecting mechanism between the lever 24 and both of said pilot-valves is such that the pilot-valve controlling the secondary admission valve 11 will reciprocate between ineffective limits during normal load and all loads under normal and the secondary admission valve will therefore remain closed. When the speed of the turbine drops below normal and the fulcrum 23 is lowered, the pilot-valve 20 for the secondary admission valve will reciprocate between effective limits, and thereby cause the secondary valve to operate and to open at regular intervals.

The operation of the primary admission valve is shown in Fig. 5, which represents some indicator cards taken on a 1250 k. w. turbine at various loads, the indicator being attached to the admission port 13, and the indicator barrel revolving at constant speed by suitable means. It is seen that at light loads the valve opens for very short periods and remains closed during the greater part of the interval. As the load increases, the valve remains open longer until finally continuous full pressure is obtained in the high pressure end of the turbine, and it will be seen that at this time the valve does not reach its seat at all, but is merely pulsating without sensibly reducing the pressure of steam in the turbine. On the load being still further increased, the secondary admission valve will begin to open and admit high pressure steam to the annular inlet 12 to the intermediate section, and the operation of this secondary valve while the primary valve is admitting continuous full pressure, would be the same as the operation of the primary valve as indicated in Fig. 5.

The performance of a turbine equipped with a secondary valve embodying this invention is illustrated in Fig. 6, which shows an economy test on a turbine where tests were made up to 76 per cent. overload. The economy, it will be observed, drops off slightly as the secondary valve opens, but, on the other hand, the range of load at which the turbine may be economically operated is greatly extended, in this case from 400 to over 1,000 B.H.P., with the steam consumption varying from 13.2 to 14.3, or but slightly over 8 per cent. from that of maximum efficiency.

It will be understood that various changes in the mechanism may be made without departing from the spirit of this invention. The governor may be materially modified, and, if desired, a different type of governor may be utilized. For the primary and secondary admission valves, Corliss valves may be substituted for the puppet valves, and the valve motors changed to suit. Both the primary and secondary valves may be operated electrically, or either may be operated directly from the governor through suitable mechanism, but

Having thus described my invention, what I claim as new and useful and desire to secure by Letters Patent is:

1. In a multi-stage elastic fluid turbine, a fluid inlet to the high pressure stage, a supplemental fluid inlet to an intermediate stage, valves regulating said inlets, means dependent on the turbine speed whereby said valves are automatically controlled, and mechanism whereby said valves are caused to give pulsations to the entering fluid.

2. In a multi-stage elastic fluid turbine, a fluid inlet to the high pressure stage, a supplemental fluid inlet to an intermediate stage, independent motor moved valves regulating said inlets, means dependent on the turbine speed whereby said valves are automatically controlled, and mechanism operatively connected to said means whereby the operation of the valve motors is such that the fluid passing said valves is caused to pulsate.

3. In a multi-stage elastic fluid turbine, a primary fluid inlet to the high pressure stage, a secondary fluid inlet to an intermediate stage, independently operating valves regulating said inlets, mechanism whereby at light loads the secondary fluid inlet valve is held closed and the primary fluid inlet valve is caused to pulsate at constant intervals, the periods of which are proportional to the turbine speed, and means whereby when the primary fluid inlet valve remains constantly open the secondary fluid inlet valve is caused to pulsate.

4. In an elastic fluid turbine, a main fluid inlet at the high pressure end, a pulsating valve controlling said inlet, a high pressure inlet intermediate of the main fluid inlet and the low pressure end, a pulsating valve controlling said inlet, a speed governor and means between said governor and said valves whereby the pulsations of said valves are independently and automatically controlled by said governor.

5. In an elastic fluid turbine, a main fluid inlet at the high pressure end, a supplemental fluid inlet nearer the low pressure end, a valve between the main inlet and the supplemental inlet for controlling the latter inlet, a valve controlling the fluid admitted to the main inlet and that passing the valve for the supplemental inlet, agents for causing said valves when in operation to pulsate, a governor and means dependent thereon for automatically operating said valves.

6. In an elastic fluid turbine, a secondary motor operated inlet valve and means movable within a transparent housing for visibly indicating the operation of said valve.

7. In an elastic fluid turbine, a fluid inlet to the high pressure stage, a supplemental fluid inlet to an intermediate stage, a pulsating valve controlling said latter inlet, and means whereby the operations of said latter valve is visibly indicated.

8. In a turbine having a plurality of inlet-ports, separate valves for said ports, and means operatively connected with the valves for opening and closing one at constant intervals while the other remains closed and for allowing the first to remain open continuously while the second is open; said means including a governor device.

9. The combination with a turbine-engine having a plurality of inlet-ports, of separate valves for said ports, means connecting with the valves and adapted to open and close one of said ports at intervals, and means to open and close the other port and permit the first-mentioned port to remain open continuously.

10. The combination with a turbine-engine having a plurality of inlet-ports, of separate valves for said ports, means connecting with the valves for opening and closing one of the valves regularly, and a governor device for controlling the position of said means so as to regulate the time and degree of the valve-opening.

11. The combination with a turbine-engine having a plurality of inlet-ports, of separate valves for said ports, means for opening and closing one of said valves regularly, a variable fulcrum for said means, means for determining the position of the fulcrum, and means for opening and closing a second valve while allowing the first valve to remain open continuously.

12. The combination with a turbine-engine having a plurality of inlet-ports, of separate valves for said ports, means for opening and closing one of said valves at intervals, a variable fulcrum for said means, and a governor controlling the position of the fulcrum and operating to open the second valve when the first valve remains open.

13. The combination with a turbine-engine having a plurality of inlet-ports, of separate valves for said ports, a vibrating lever for regularly opening and closing one of said valves, said lever having a variable fulcrum, constantly-acting means for vibrating said

lever, and a governor device controlling the position of the fulcrum so as to regulate the time and degree of the opening and closing of the valve.

14. The combination with a turbine-engine having a plurality of inlet-ports, of separate valves for said ports, a vibrating lever having a variable fulcrum and operating to open and close one of the valves, constantly-acting means vibrating the lever, a governor controlling the position of the fulcrum to regulate the time and degree of the opening of the valve, and means for opening and closing a second valve and allowing the first to remain open continuously, said means including a lever operated by the same governor device.

15. The combination with a turbine-engine having two inlet-ports, of separate valves therefor, a lever having a variable fulcrum and operating to regularly open and close the first valve, a governor device controlling the position of the fulcrum, a lever for opening and closing the second valve at such times as the opening-lever for the first valve becomes ineffective, and means whereby the same governor controls the action of the opening-lever for the second valve.

16. In a governor device for engines, the combination with an engine organized to receive steam at two points, of a steam-chest having a fixed port at each end of such points and connected with a source of supply, separate valves for said ports, means for opening and closing one of said valves at intervals and for allowing it to remain continuously open at times, and means for opening the second valve.

17. In a multi-stage elastic fluid turbine, a primary admission valve for the high pressure stage, a secondary admission valve for an intermediate stage, means whereby each of said valves when in operation is caused to pulsate the fluid passing it, a governor and mechanism whereby the governing function is placed upon one or the other of said valves according to the turbine speed.

18. A turbine divided into stages, with blades or buckets for the stages, in combination with a fluid-actuated valve controlling the passage of motive fluid through one stage and a fluid-actuated valve controlling the passage of motive fluid through a lower stage, said lower stage valve receiving its operating fluid when said first valve moves from its seat.

19. A turbine divided into stages, with blades or buckets for the stages, in combination with a valve capable of automatic and hand regulation for controlling the passage of motive fluid through one stage and a fluid-actuated valve controlling the passage of motive fluid through a lower stage, the lower stage valve receiving its operating fluid when said first valve moves from its seat.

20. A turbine divided into stages, with blades or buckets for the stages, in combination with an automatic fluid actuated valve capable of hand regulation for controlling the passage of fluid through one stage, and a valve for automatically by-passing motive fluid around one or more stages.

21. A turbine divided into stages, with blades or buckets for the stages, in combination with an automatic valve capable of hand regulation for controlling the passage of motive fluid through one stage, and a fluid-actuated valve for automatically by-passing motive fluid around one or more stages.

22. A turbine divided into stages, with buckets for the stages, and a governor responsive to speed changes, in combination with a valve capable of movement independent of said governor controlling the passage of motive fluid through the first stage, a fluid-actuated valve for by-passing motive fluid around one or more stages, and means for causing said by-pass valve to operate under predetermined conditions.

23. A turbine divided into stages and provided with a speed-responsive governor, in combination with a fluid-actuated valve controlling the passage of motive fluid through the first stage, and a fluid-actuated valve for automatically by-passing motive fluid around one or more stages.

24. A turbine divided into stages and provided with a speed responsive governor, in combination with a fluid-actuated valve controlling the passage of motive fluid through a stage, and a fluid-actuated valve for automatically by-passing fluid around one or more stages under predetermined conditions.

25. A method of operating a multi-stage turbine consisting in admitting a substantially constant supply of motive-fluid to the high-pressure stage, in admitting a relatively high-pressure supply of motive-fluid to an intermediate or low-pressure stage and in pulsating the relatively high-pressure supply to the intermediate or low-pressure stage.

26. A method of operating a multi-stage turbine during overloads consisting in admitting a substantially constant supply of motive-fluid to a high-pressure stage, in admitting relatively high-pressure motive-fluid to an intermediate or low-pressure stage and in varying the relatively high-pressure motive-fluid admitted to the intermediate or low-pressure stage with the variations in the overload.

27. A method of operating a multi-stage turbine during overloads which consists in admitting a substantially constant supply

of motive-fluid to all of the stages, in impressing a supply of relatively high-pressure motive-fluid upon the motive-fluid which has done work in a plurality of stages and in varying the impressed supply as the overload varies.

In testimony whereof I have hereunto subscribed my name this tenth day of April, 1905.

FRANCIS HODGKINSON.

Witnesses:
DAVID WILLIAMS,
JNO. S. GREEN.