No. 766,921. PATENTED AUG. 9, 1904.

J. WILKINSON.

GOVERNING MECHANISM FOR TURBINES.

APPLICATION FILED APR. 8, 1904.

NO MODEL. 3 SHEETS—SHEET 1.

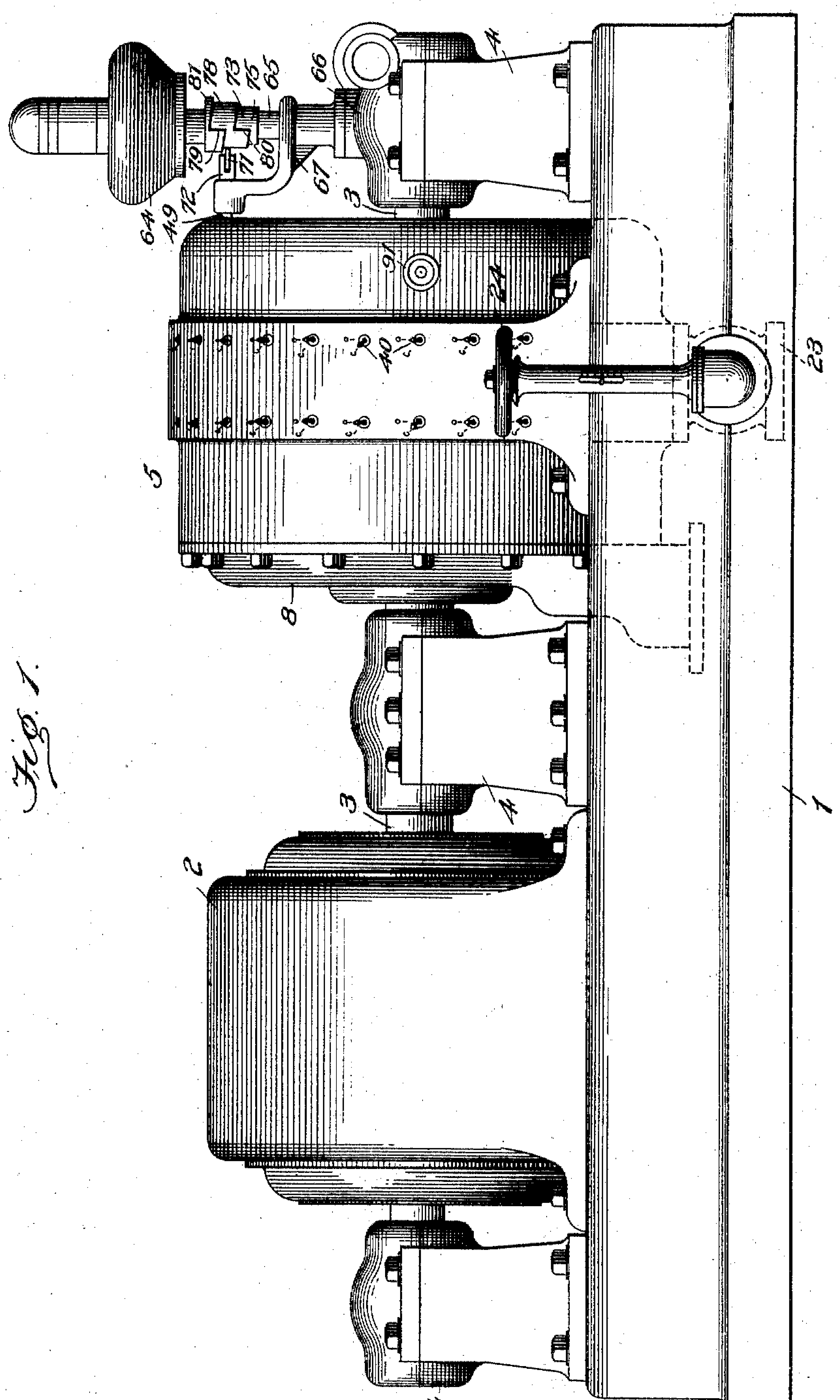

Fig. 1

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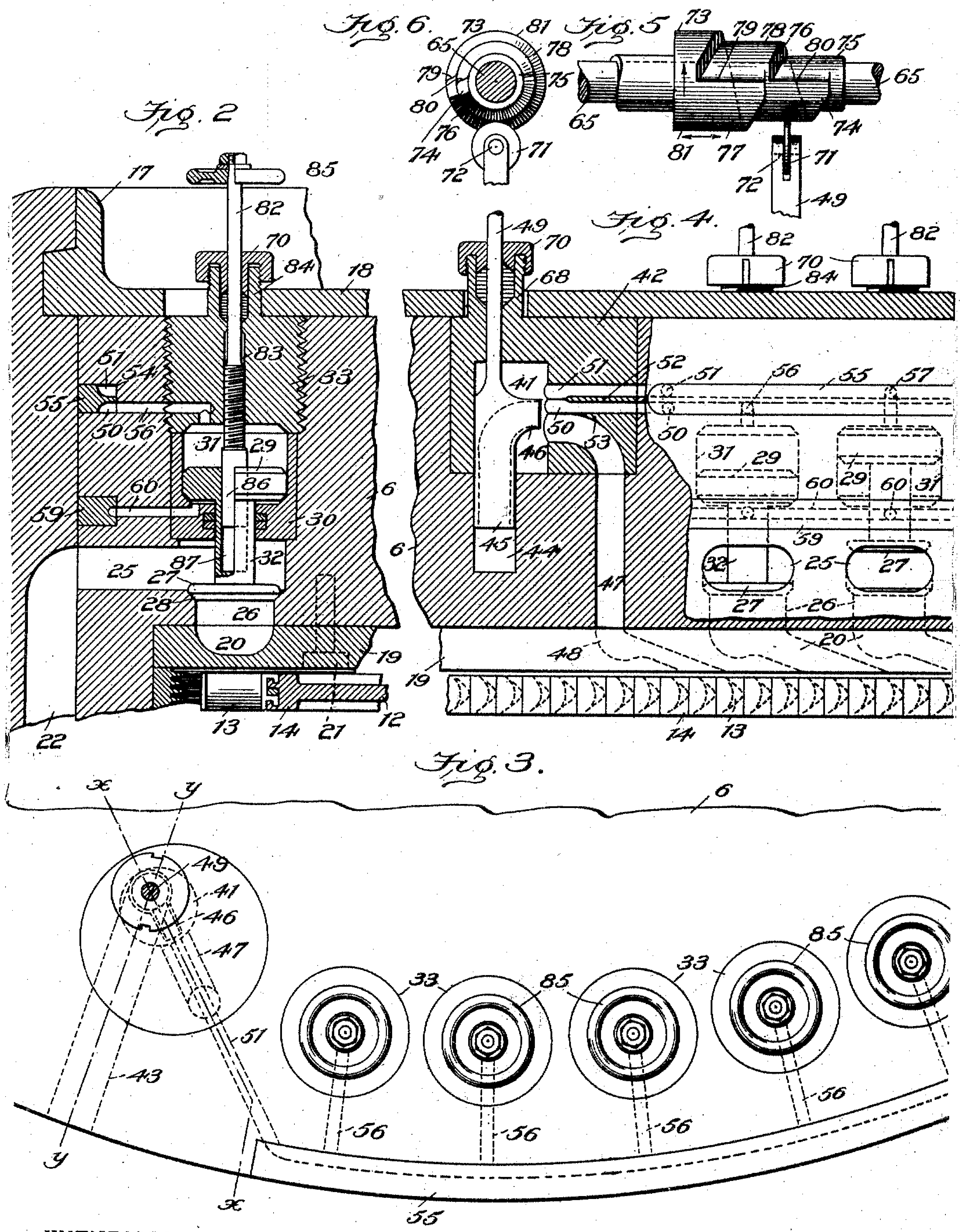
NO MODEL. 3 SHEETS—SHEET 2.



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NO MODEL. 3 SHEETS—SHEET 3.

Fig. 7.

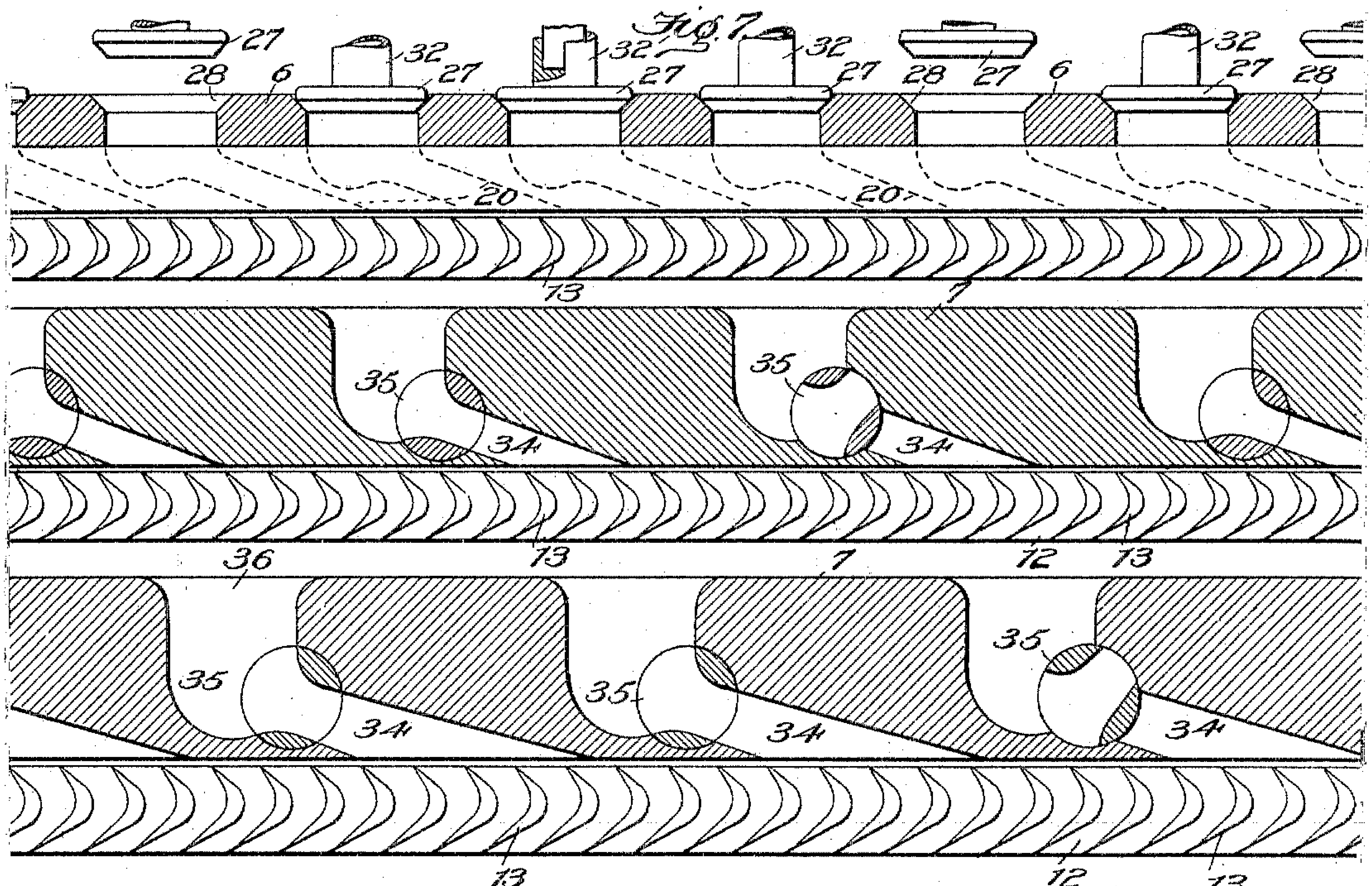


Fig. 8.

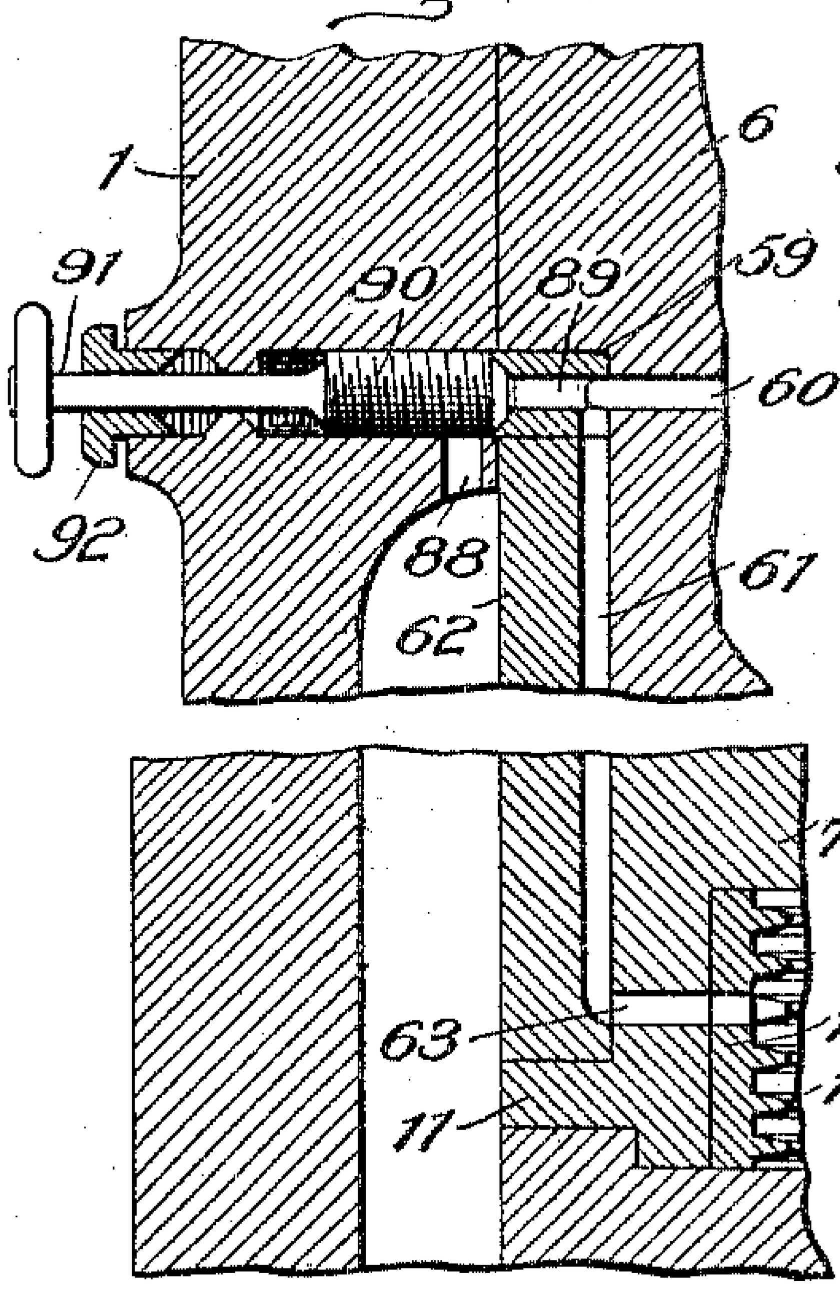


Fig. 9.

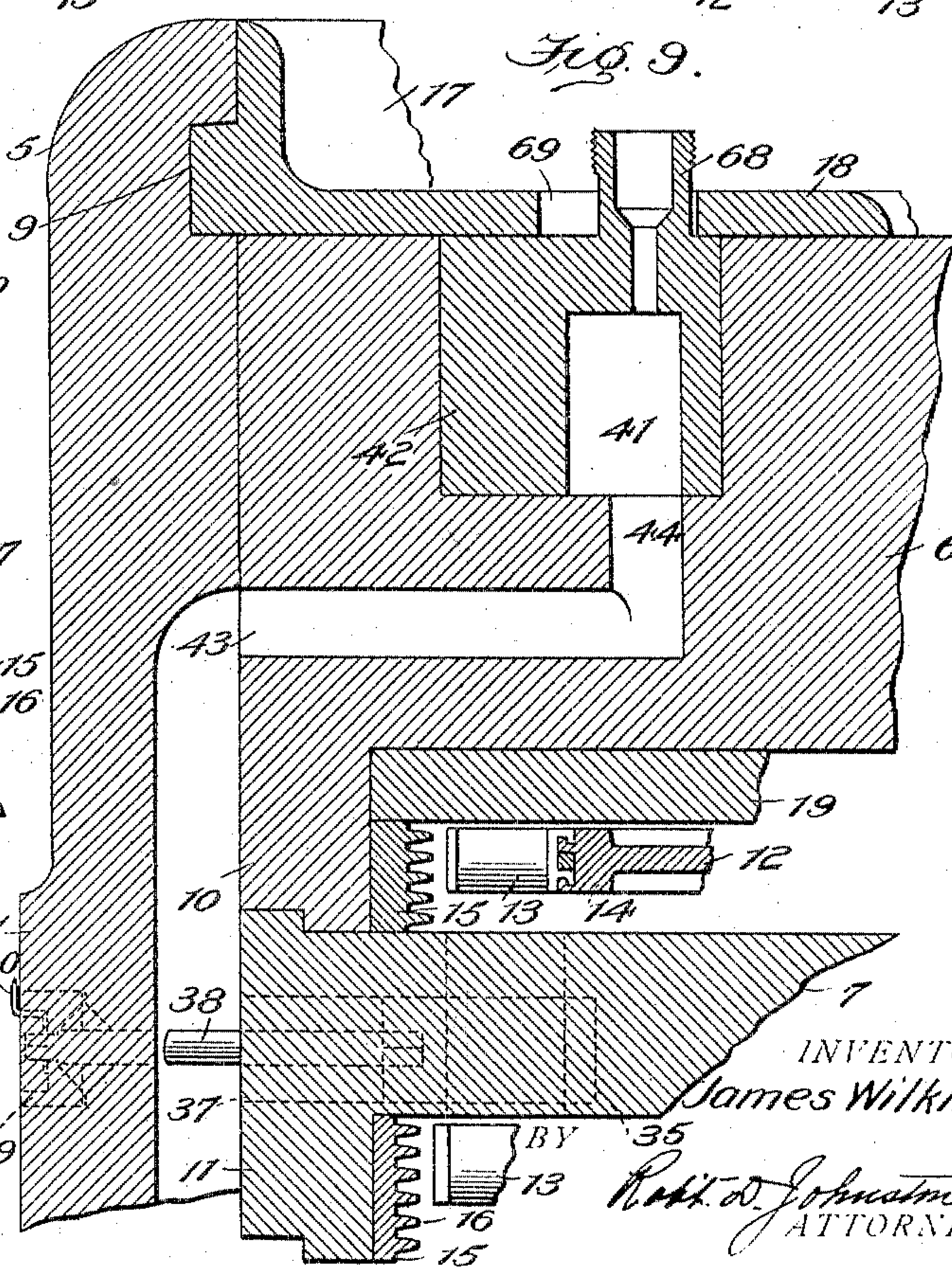
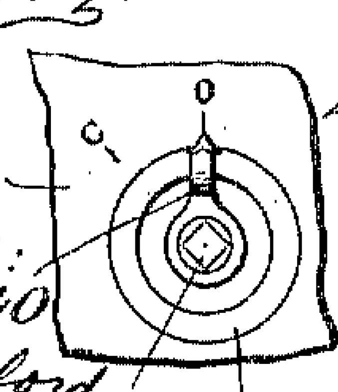


Fig. 10.



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UNITED STATES PATENT OFFICE.

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GOVERNING MECHANISM FOR TURBINES.

SPECIFICATION forming part of Letters Patent No. 766,921, dated August 9, 1904.

Application filed April 8, 1904. Serial No. 202,245. (No model.)

To all whom it may concern:

Be it known that I, JAMES WILKINSON, a citizen of the United States, residing at Birmingham, in the county of Jefferson and State of Alabama, have invented new and useful Improvements in Governing Mechanism for Turbines, of which the following is a specification.

My invention relates to improvements in elastic-fluid turbines of the impact and the reaction type, and has for its object to perfect a controller mechanism for the supply of motor fluid which will enable the turbine to operate with high efficiency under normal load variations and at the same time avoid the serious loss in economy which attends the operation of the present turbines under an overload. The additional motor fluid required to drive the turbine when its load is greater than can be carried by the full normal supply of pressure has heretofore been introduced into a low-pressure stage in multiple-stage impact-turbines and at an intermediate point in the working passage of reaction-turbines. This practice is attended by two serious objections, first of which is that the introduction of the highly-heated motor fluid into the turbine at a point where the active fluid therein will have given out most of its heat and be at a low temperature causes an excessive initial condensation, the water of which not only represents loss of energy, but also constitutes a serious detriment in that it creates friction and is difficult to dispose of. The other objection is that by introducing the overload supply at an intermediate point in the working passage of either type of turbine but a fraction of its energy of pressure will be converted into velocity, for the succeeding vanes are not designed nor intended to abstract all of the velocity from the motor fluid. To obviate these objections in connection with multiple-stage impact-turbines and reaction-turbines having relatively short working passages, I provide a plurality of overload-nozzles leading through the supply-head and provide valves therefor which are controlled and operated from the governor for the normal-load valves. In this manner when the load becomes excessive all the overload-valves are intermittently opened and admit the additional supply of motor fluid to the first stage. Since this supply will be greater than that which can normally flow through the second-stage nozzles of an impact-turbine, the first stage will practically constitute a supply-chamber for the second stage, which thus becomes the first. Though this may have a tendency to decrease the efficiency of the turbine by shortening its working passage, the loss resulting therefrom will be small compared with the present practice. In reaction-turbines having short working passages the effect of this increased initial supply will be to move the maximum temperature-line forward in the working passage, practically shortening its length.

My invention further embodies material improvements in governing the normal fluid-supply by providing means to vary by hand the area of the working passage, so that when operating at constant underloads the effective power of the turbine is proportionately reduced and it operates as at its full load, which represents highest efficiency. Thus I provide hand-operated stage-valves in combination with governor-controlled supply-valves, any number of which may be locked in a closed position to correspond with the stage-valves set closed.

My invention further relates to improvements in a governing mechanism for the normal and overload supply-valves and which controls fluid-pressure means to pulsate the supply-valves according to the principles set forth in my prior patents relating to pulsatory governor means.

The details of construction embodying my invention and which are hereinafter more fully described are illustrated in the accompanying drawings, forming a part hereof, and in which—

Figure 1 is a side elevation of my improved turbine and governor operating an electric dynamo. Fig. 2 is a partial transverse sectional view illustrating one of the supply-valves and its operating means disposed in the supply-head. Fig. 3 is a partial end view of the supply-head, illustrating a row of valves and the conduits leading thereto from the fluid-pressure-controller means. Fig. 4 is a sectional view along the line *x x*, Fig. 3, and illustrating the controller-nozzle. Figs. 5 and 6 are side and end views of the governor-cam. Fig. 7 is a sectional view through a group of working passages leading across the stages and shows the overload-valves closed and a row of normal-load valves across stages also closed. Fig. 8 is a sectional view along the line *y y*, Fig. 3. Fig. 9 is a broken-away view illustrating means for simultaneously opening all the supply-valves. Fig. 10 is an enlarged detail view of the indicator on the operating-stem for a stage-valve.

I have illustrated my invention as applied to a multiple-stage impact-turbine mounted upon a bed-plate 1 and acting to drive a dynamo 2 by means of a main shaft 3, suitably supported in bearings 4, which, with the dynamo, are also bolted to the bed-plate. The turbine comprises an outer shell 5, which surrounds the inner casing formed by the supply-head 6 and diaphragm-partitions 7, interposed between said supply-head and the exhaust or condenser casing 8. The exhaust-passage casing is securely bolted or otherwise connected to the shell 5, which is provided with a channel 9 around its end adjacent to the supply-head 6. The supply-head and succeeding diaphragms are provided with interlocking flanges 10 and 11, respectively, which constitute the side walls of the compartments within which the wheels 12 rotate. The wheels are keyed to shaft 3 and are disposed one in each compartment and provided with a peripheral row of concavo-convex buckets 13, secured to or formed integral with their rims 14. Segmental rings 15 are disposed around the inner walls of these several compartments and are provided with inwardly-disposed heat-radiating projections 16. A locking-ring 17 engages within the channel 9 in the shell and is provided with a flange 18, which engages the top surface of the supply-head 6 and serves as an abutment to hold the turbine-sections together against displacement by interior pressure. I provide a nozzle-strip 19, which is securely bolted to the inner face of the supply-head 6 and is provided with a plurality of nozzle-passages 20, leading at an incline therethrough and disposed to deliver motor fluid against the rotating buckets 13. This ring may be formed in segments and secured to the head by cap-screws 21, as seen in Fig. 2. Motor-fluid pressure is admitted to an annular chamber 22, formed between the shell 1 and the turbine-casing, through a port 23. (Shown in dotted lines, Fig. 1.) A gate-valve operated by wheel 24 controls this supply. Branch passages 25 lead from chamber 22 through the supply-head 6 and through ports 26 admit the motor-fluid pressure to each of the nozzle-passages 20. A beveled puppet-valve 27 engages a seat 28 at the inlet end of each port 26 and acts under the control of a piston 29 to admit or cut off motor fluid from a nozzle 20. I provide a plurality of chambers in the supply-head and seat therein blocks 30, formed with a chamber 31, serving as a cylinder for the piston 29, which operates the valve 27 by means of a hollow stem 32, leading through a suitably-packed opening in block 30 and through the passage 25. Screw-plugs 33, screwed into the open ends of chambers in the head, form the outer ends of the cylinders 31. The pistons 29 are preferably beveled at each end, and the ends of the cylinders are correspondingly beveled. Motor-fluid pressure after acting against the rotating buckets 13 in the first wheel-compartment will be discharged against the buckets in the second and succeeding wheel-compartments through stage-nozzle passages 34, leading transversely through the diaphragm-partitions 7 and provided with rotary valves 35. These valves, seated in chambers formed in said diaphragms, are disposed at the contracted or inlet portion of the nozzle proper. Enlarged openings 36 constitute the supply-openings in the diaphragms for the nozzles 34. Plugs 37 (shown in dotted lines, Fig. 8) close the outer ends of these valve-chambers, which are preferably bored into the diaphragms from their outer peripheries, and operating-stems 38 for the stage-valves lead through these plugs and across the supply-chamber 22 and through the shell 1. The outer ends of the stems 38 are disposed in the recessed end of a packing-gland 39, seated in shell 1 and acting to prevent the escape of motor-fluid pressure from chamber 22 around stems 38. I secure an indicator 40 to the squared end of each of these stems and provide suitable marks representing an open or closed position for the valve 35, so that by means of these indicators the position of the stage-valve can be immediately determined. It will thus be evident that it is my intention to control the stage-valves 35 manually and independently of the supply-valves, which, it will be noted in Fig. 7, are double in number to the stage-valves in each diaphragm.

My governor-controlled fluid-pressure means for actuating the supply-valves 27 constitutes an improvement upon controlling mechanism which is shown and the operation of which is fully described in my Letters Patent No. 753,773 and which, briefly described, comprises a controller-chamber 41, formed in a plug 42, inserted in the supply-head and disposed beneath the flange 18 of the ring 17. Fluid-pressure is admitted to chamber 41 through a passage 43, leading from the chamber 22 through the head and entering a cylinder 44, in which a governor-actuated controller-piston 45 moves pressure-tight. A curved nozzle-passage 46 leads through this piston and discharges the motor-fluid pressure from the cylinder 44 into a normally open exhaust-passage 47, leading through the head, and a suitable nozzle 48 in the ring 19. All of the controller fluid will be directed by the nozzle 46 when in its lower position into this passage 47; but when the nozzle is raised by means of stem 49 this nozzle portion will come opposite to one or both of the controller-passages 50 and 51, which are divided by a thin partition 52 from each other and disposed in vertical alinement with the passage 47. The passage 50 at its inlet end is separated from the passage 47 by a thin division-wall 53, formed integral in the plug 52, through which these several passages lead. As seen in Fig. 4, the passages 50 and 51 lead through the head to a channel 54, formed in the outer periphery of the supply-head and disposed in alinement with the upper ends of the cylinders 31. A curved strip 55 is inserted in this channel 54 and is cut away on either side of its inner end, so as to form two separate passages, Fig. 2, which constitute continuations of the controller-passages 50 and 51 and are so indicated. From the passage 50 branch passages 56 lead transversely through the head and plugs 33 and enter the upper ends of alternate cylinders 31 of the series. Corresponding passages 57 lead from the controller-passage 51 and enter the upper ends of the cylinders 31, which are not in communication with the passages 56. When the nozzle 46 is disposed opposite to the passage 50 the stream of controller fluid will be discharged therein, and since no outlet is provided for the fluid admitted thereto this stream will by impact raise the pressure throughout the passage and in the alternate cylinders 31, which are in communication therewith, until the pressure above pistons 29 is substantially that of the motor-fluid pressure. When this is the case, the pistons will move downwardly toward their "valve-closed" position, for it is my purpose to admit a relatively lower pressure from a stage to the lower ends of all the cylinders 31 by means of an annular passage 58, formed by a grooved strip 59, inserted in an annular channel in the head communicating with the several cylinders by branch passages 60 and with a stage-pressure by a passage 61, formed by a grooved strip 62, disposed in a channel leading across the supply-head and diaphragm to a point opposite the stage or wheel compartment. Here a branch passage 63 passes through the flange 11 and through the ring 15 and enters a stage-compartment. In this manner the stage-pressure, which is relatively lower than that of the supply-pressure, will be maintained below pistons 22 and will accordingly raise them whenever the high pressure is exhausted from the upper ends of cylinders 31. When the controller-nozzle 46 is opposite to the controller-passage 51, all of the supply-valves controlled thereby will be moved to their closed position in the manner just described in connection with the operation of the pressure in passage 50.

It will be seen that I have divided the supply-valves into two independent groups, the valves in each of which will be simultaneously opened or closed, according to the pressure existing in the passage which controls their action. The valves controlled by the passage 51, which I shall hereinafter refer to as the "normal-load" valves, will admit when held constantly open sufficient motor-fluid pressure to drive the turbine with the highest efficiency under its full load. As the load decreases I proportion the supply of motor fluid thereto by pulsating the valves, so that they vary the total volume of the motor fluid delivered without effecting its velocity. In previous patents I have shown and described various means for pulsating the motor fluid so that by interrupting its flow for periods of varying duration its volume will be directly proportioned to the load. My present governing mechanism comprises a governor 64, mounted on a counter-shaft 65, driven from shaft 3 through suitable speed-reducing gears disposed within the casing 66, forming a part of one of the shaft-bearings 4. A standard 67 is mounted on the top of casing 66 and forms at its lower end a bearing for shaft 65 and at its upper end a horizontal bearing for the stem 49, which actuates the controller-nozzle 46. This stem passes through an extension 68 of the plug 42, which is disposed in an elongated opening 69 in the flange 18 of the locking-ring 17. A screw-tap 70 engages this extension 68, which holds suitable packing around the stem to prevent leakage of pressure from chamber 41. The stem 41 is bifurcated at its outer end, and a roller 71 is rotatably mounted on an axis 72 therein. This roller is disposed to engage a controller-cam 73, feathered to shaft 65, from which it receives rotary motion, and suitably connected to the governor 64, by means of which it is vertically shifted. This cam, which is shown in detail in Fig. 5, is eccentrically shouldered at 74. This shoulder commences at a point near the cylindrical end 75 of the cam and leads in a spiral completely around the cam to form a helical shoulder 76. A similar shoulder 77 encircles the outer end of the cam, leaving a cylindrical path 78 between the straight edge 79 of the shoulder 77 and a corresponding shoulder 80 of the shoulder 74. A cylindrical path 81 encircles the other end of the cam 77. This cam will therefore have three circular paths 75, 78, and 81 at different radial distances from the center of the shaft 65. It follows, therefore, that the stem 49, which by means of this roller 71 engages this cam, can assume three stationary positions. When operating on path 75, the nozzle 46 will be opposite passages 50 and 51 and discharging its pressure directly thereinto will maintain all of the valves 27 closed. When operating on path 78, it will be in the position shown in Fig. 4, where all of the normal-load valves controlled by passages 51 will be held open and all of the overload-valves held closed by the controller-stream, which is directed partly into passages 50 and 47 and by its ejector action exhausts the pressure from passage 51, and when operating on path 81 nozzle 46 will be directly opposite to ejector-passage 47 and will exhaust the pressure from passages 50 and 51 to maintain all of the normal and overload valves open. When controlling the normal-load valves, the governor will shift the collar 73 so that the roller 71 moves between the cylindrical paths 75 and 78, when it will engage the straight edge 80 of the shoulder 74 and ride on said shoulder for periods of varying duration, according to its position relative to the spiral of shoulder 76. When riding on this shoulder, nozzle 46 will inject pressure into passage 51 to close the normal-supply valves, and when off the shoulder the nozzle will eject pressure from said passage and cause said valves to open. At full load the nozzle is stationary, since roller 71 will be riding on path 78. If now the load become excessive, the governor will lower cam 73 until the roller begins to engage the helical shoulder 77, when the nozzle 46 will commence to intermittently exhaust pressure from passage 50 and permit the overload-valves to pulsate. The load if it increases will cause the cam 73 to move downwardly until roller 71 ultimately rides on path 81, when all supply-valves are open. I thus provide means to compensate all intermediate variations of load, and they will operate successfully when the load is uncertain and varies largely.

It must be evident, though, that the highest efficiency in operation exists when the roller rides on path 78, since the flow of fluid is then directly proportioned to the load and uninterrupted; and it is my object to provide means to keep the turbine at its highest efficiency when running under a constant load less than its full power. This would be the case where a constant load required but half of the horsepower capacity of the turbine, and where without my present improvements the normal-load-supply valves would be opened and closed for equal intervals by the governor. If the capacity of the turbine be reduced by half, the governor would then act as at full load and the roller 71 would ride on path 78. I fractionalize the capacity of the turbine by providing a device to lock each supply-valve in a closed position independently of the governing means, which device comprises a screw-rod 82, leading through a central screw-threaded opening 83 through plug 33 and its extension 84, constituting a packing-gland similar to 68 and operated by a wheel 85 on its outer end. Its inner end is enlarged at 86 and forms a piston, which is disposed in a cylinder 87, formed in piston 28 and stem 32 and acts as a dash-pot to reduce the suddenness of the valve's movements. This rod can be screwed down until its end engages the inner end of cylinder 87, when the valve will be held firmly closed. This same construction applies to each supply-valve, and therefore when it is desired to reduce the capacity of the turbine I screw down any desirable number of supply-valves and by hand close the corresponding stage-valves in the line of the fluid's flow across stages, which reduces the total area of working passage and accordingly the capacity. At the same time it does not affect the governor's control of the other supply-valves, which are slightly pulsated or held constantly open, according to the accuracy with which the capacity of the turbine is proportioned to the load.

By having the stage-valves hand-controlled it is possible to adjust them to produce a great variety of effects, which will enable me to adapt the turbine to any use. I may also set the supply-valves to open any desired distance by moving the piston 86 inwardly to act as a stop.

In Fig. 9 I illustrate means for simultaneously opening all the valves 27 for starting the turbine and blowing out all water of condensation, which comprise a passage 88, leading from the upper end of chamber 22 to a chamber in head 1, which opens into a passage 89, leading through the grooved strip 59 and entering the annular passage 60 for admitting stage-pressure below valves 27. A valve 90, having a screw-threaded body portion which engages threads cut in the inner wall of its chamber, normally closes passage 89; but it may be opened by turning stem 91, connected to valve 90, and extending outwardly through casing 1 and a packing-gland 92. When this valve is unseated, the motor-fluid-supply pressure rushes through passages 89 60, opening the supply-valves by admitting a high pressure beneath them, and thus causing at once a full flow of pressure through the turbine. A part of this pressure from passage 89 will escape into the first stage through passages 61 and 63.

Though I have shown stage-pressure used to open the supply-valves, I may substitute therefor pressure from chamber 22, in which case I can readily secure the same differential in the pressure effects by increasing the size of stem 32 or otherwise reducing the area of pistons 29 exposed to the lower pressure to unbalance them.

By "normal-load-supply" valves I refer to any desired number of valves controlling the admission of motor fluid to supply-nozzle passages whose combined cross-sectional area is adapted to admit a volume of motor fluid sufficient to drive the turbine under its approximate full-load capacity, and they may accordingly be referred to as the "full-load-supply" valves and nozzles as contrasted with the overload-supply valves and nozzles which control the admission of motor fluid when the load has exceeded the approximate full-load capacity of the turbine. In this connection the construction of the several nozzle-passages and of the valves may be varied, and they may be formed as parts of a compound full-load and a compound overload nozzle, and in the same manner the construction of the valves may be varied and the manner of grouping changed without departing from my invention.

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

1. In a turbine, a plurality of fluid-actuated supply-valves which control the admission of motor fluid to nozzle-passages, a controller-nozzle for said valves, and a governor-shifted cam for oscillating said nozzle to pulsate said valves.

2. In a turbine, a plurality of full-load-supply valves, a passage for conducting an actuating fluid to the valves of said group, in combination with a group of overload-supply valves, a passage conducting actuating fluid to the valves of said group, and governor means to pulsate the pressure admitted to one of said passages while maintaining the other exposed to a high or exhaust pressure.

3. In a turbine, fluid-pressure means to simultaneously pulsate a group of supply-valves, fluid-pressure means to pulsate an independent group of supply-valves which admit pressure when the turbine is subjected to an overload, in combination with governor-controller means to pulsate one group of valves until the load exceeds the power developed by the volume of fluid-pressure which they admit, when they are held open and the other group of valves pulsated.

4. In a turbine having an approximate full-load capacity, nozzle-passages designed to admit a volume of motor fluid sufficient to drive the turbine at said full load, and a governor-controller means to vary the volume of fluid admitted by said nozzles, in combination with a group of nozzles designed to admit motor fluid only when the load exceeds the full-load capacity, and means to pulsate the valves of said latter group to vary the overload-supply of motor fluid in proportion to the overload, while the full-load valves are maintained open.

5. A governing means for elastic-fluid turbines comprising a plurality of valves, governor-controlled means to simultaneously pulsate said valves to vary the volume of fluid admitted in proportion to the load, and means to cut one or more of said valves out of service to increase the duration of the impulses of fluid-pressure delivered by the active governor-controlled valves during a substantially constant underload.

6. In a governing means for elastic-fluid turbines, governor-controlled means to admit a pulsatory supply of motor-fluid pressure to the turbine and to vary the duration of the impulses, in combination with means for reducing the cross-sectional area of the stream of governor-controlled motor fluid to maintain the impulses of fluid-pressure utilized to drive the turbine of maximum duration.

7. In a governing means for elastic-fluid turbines, governor-controlled means to admit a pulsatory supply of overload motor-fluid pressure, in combination with a constant supply of full-load fluid-pressure when the turbine is operating under an overload, and means for reducing the cross-sectional area of the stream of overload motor fluid to maintain the impulses of maximum duration.

8. In a governing means for turbines, a plurality of fluid-actuated supply-valves which are controlled in two groups, a fluid-controller passage for each group and a governor-controlled means which diverts a freely-flowing stream of fluid into one of said passages intermittently, and into the other constantly when the turbine is operating under a fraction of its full load.

9. In a governing means for turbines, a plurality of fluid-actuated supply-valves which are controlled in two groups, a fluid-controller passage for each group, a governor-controlled means which diverts a freely-flowing stream of fluid into one of said passages intermittently and by an ejector action exhausts the pressure from the other passage when the turbine is operating under a fractional overload.

10. In a turbine, a group of fluid-controlled full-load-supply valves, a group of fluid-controlled overload-supply valves, and a fluid-pressure-governing means comprising a controller device, a fluid-conduit leading to the several valves of each group, and a controller-cam which under a maximum load moves said device to a point where a freely-flowing stream under its control will operate by an ejector action to exhaust the pressure from said conduits and cause the valves of both groups to open.

11. In an elastic-fluid turbine, one or more nozzle-passages delivering motor fluid against a rotating element, one or more reciprocating supply-valves therefor, each of said valves having a chamber formed in a portion movable therewith, and means to dash-pot the action of said valves comprising an adjustable rod for each valve adapted to enter the chamber movable with said valve and act as the piston of a dash-pot to retard said valve's movements.

12. In a turbine, a rotating element, an induction-nozzle discharging fluid-pressure against said element, a reciprocating motor-fluid valve therefor, and a fluid dash-pot therefor comprising a cylinder movable with said valve, and an adjustable piston therein.

13. In a turbine, a plurality of full-load-

supply valves controlling the admission of motor fluid to nozzle-passages, governor-controlled means to pulsate said valves simultaneously to vary the total volume of motor fluid without affecting its velocity.

14. In a multiple-stage turbine wherein the motor fluid is fractionally converted into velocity, valves controlling the supply of motor fluid, governor-controlled means to intermittently actuate said valves under fractional loads to pulsate the supply of motor fluid, and rotary manually-operated valves for controlling the flow of fluid between stages.

15. In a multiple-stage turbine, supply and stage nozzle passages for discharging motor fluid against rotating elements, fluid-actuated valves pulsating the flow of fluid through the supply-passages, and manually-controlled valves between stages.

16. In a turbine, a plurality of nozzle-passages admitting a supply of motor fluid calculated to operate the turbine under full load, in combination with a plurality of overload-supply passages, valves therefor and a governor means to pulsate said valves.

17. In a turbine, a plurality of nozzle-supply passages admitting motor fluid, valves for said passages which are controlled in two separate groups, the valves and nozzles of one group being adapted to admit a sufficient volume of motor fluid to drive the turbine under loads not exceeding its full-load capacity, said other valves and nozzles being adapted to admit a supply of motor fluid to operate the turbine under overloads, and means to control the groups of valves separately.

18. In a turbine, a plurality of full-load-supply valves controlled simultaneously in a group, a plurality of overload-supply valves simultaneously controlled in an independent group, and governor-controlled means to pulsate the valves of one or the other of said groups when the load is above or below the turbine's full-load capacity.

19. In a turbine, a plurality of supply-valves which admit a volume of fluid-pressure sufficient to drive the turbine under full or fractional loads, in combination with one or more nozzle-passages for admitting fluid-pressure to drive the turbine under overloads, and means to pulsate the overload supply of fluid-pressure admitted by said nozzles.

20. In a turbine, one or more overload-supply passages, means to normally close said passages, and governor-controlled means to intermittently open said passages to admit a pulsating supply of overload fluid-pressure which varies in volume but not in velocity.

21. In a turbine, a group of full-load-supply passages and valves therefor, an independent group of overload-supply passages and valves therefor, in combination with a governing means which pulsates said group of full-load-supply valves under a fractional load, maintains them open under full and excessive loads, and pulsates said group of overload-valves only when the load is excessive.

22. In a governing means for an elastic-fluid turbine wherein the motor fluid is successively discharged against rotating elements, the combination of governor-controlled supply-valves all of which move simultaneously, with one or more independently-operated valves between rotating elements.

23. In a multiple-stage turbine, supply and stage valves, governor-controlled means to pulsate the motor fluid admitted by the supply valve or valves, and manual means to operate said stage-valves.

24. In a multiple-stage turbine, a supply-valve for the admission of motor fluid and means to pulsate it to vary the volume of the fluid without affecting its velocity, in combination with a stage-valve which is independently controlled.

25. In a multiple-stage turbine, a plurality of supply-valves for the admission of motor fluid capable of driving the turbine under an approximate full load, governor-controlled means to pulsate them simultaneously, in combination with a plurality of manually-operated valves between stages.

26. In a multiple-stage turbine, the combination of a plurality of full-load-supply valves for the admission of motor fluid to the first stage, governor-controlled means to open and close and to pulsate all said valves simultaneously, and independent manually-controlled valves between stages.

27. In a turbine wherein the velocity of the motor fluid is abstracted by succeeding rows of rotating buckets, the combination of passages for discharging a full-load supply of motor fluid against the first row of buckets, governor-controlled valves for said passages which are simultaneously pulsated until the turbine is under a full load when they are held open, passages for discharging motor fluid against succeeding rows of buckets and independent manually-controlled valves for said passages.

28. In a turbine, a plurality of passages for discharging motor fluid against a rotating element, valves for said passages, motors to actuate said valves, and governor-controlled means to intermittently energize all said motors to pulsate the motor-fluid supply without varying its velocity when the turbine is operating at less than full load, and which maintains said valves open under full load.

29. In a turbine, a plurality of full-load-supply valves, and a governor-actuated device to control fluid-pressure to simultaneously pulsate all said valves by definitely opening and closing them for periods of varying duration to vary the volume but not the velocity of the motor fluid.

30. In a turbine, a plurality of nozzle-passages, fluid-pressure-controlled valves there-

for, and a governor-nozzle utilizing fluid to actuate all said valves in a group simultaneously, when the turbine is operating under a fraction of its full-load capacity.

31. In a turbine, a plurality of nozzle-passages, a plurality of fluid-pressure-controlled full-load valves therefor, a conduit leading to all of said valves, and governor means to intermittently admit pressure to said conduit and pulsate said valves simultaneously until the turbine is under a full load when said valves are maintained constantly open.

32. In a multiple-stage turbine, a plurality of full-load-supply valves controlling the admission of motor fluid to the first compartment, a plurality of stage-valves controlling the discharge of motor fluid into a succeeding stage or wheel compartment and corresponding in number with said supply-valves, in combination with one or more overload-valves controlling the admission of an extra supply of motor fluid to said first stage.

33. In a multiple-stage turbine, nozzle-passages for admitting motor fluid to the several stages, the nozzle-passages for the first stage being greater in number than the passages which discharge the motor fluid therefrom into the succeeding stage, the excess number of supply-nozzle passages being adapted to admit an overload-supply of motor fluid.

34. In a multiple-stage turbine, a plurality of working passages for the motor fluid leading across the stages and comprising supply and stage nozzle passages and interposed rows of rotating buckets, in combination with one or more overload-supply nozzles for the first stage only.

35. In a turbine of the jet type wherein the motor fluid is discharged against rotating elements in successive compartments, conduits connecting said compartments, and passages for admitting motor fluid to the first compartment which equal or exceed in cross-sectional area the conduits leading therefrom to provide for the admission of an overload-supply of motor fluid to the first stage.

36. In a multiple-stage impact-turbine, means to drive the turbine under full or fractional loads comprising one or more supply-valves for each stage which increase in cross-sectional area, in combination with one or more auxiliary overload-supply valves which control the admission of an overload-supply of motor fluid to a high-pressure, as contradistinguished from a low-pressure stage.

37. In a multiple-stage turbine, a plurality of supply-valves for the first stage, a part of which constitute normally closed overload-valves, means to open said overload-valves to admit an overload-supply of motor fluid to the first stage whereby the effective working passage of the motor fluid is shortened and the velocity of the motor-fluid supply to the succeeding stages increased.

38. In a multiple-stage turbine, a plurality of valves between stages, a corresponding number of supply-valves for the first stage, and an independent group of overload-supply valves interposed among said supply-valves.

39. In a turbine operating by stage expansion, supply and stage valves, a governing means for the supply-valves, in combination with means to set both supply and stage valves so that the capacity of the turbine may be varied without interfering with the action of the governing means.

40. In an elastic-fluid turbine, a plurality of governor-controlled supply-valves, governor-controlled means to open and close said valves, in combination with manually-controlled means to lock any or all of said governor-controlled valves in their closed position.

41. In an elastic-fluid turbine, the combination of a plurality of supply-valves, governor-controlled means to operate said valves, a chamber carried by each of said valves, and a plurality of screw-rods adjustably mounted in a stationary element of the turbine and adapted to enter said chambers and engage said valves to hold them closed and to dashpot their action when they are opening and closing subject to the control of a governor means.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

JAMES WILKINSON.

Witnesses:
H. M. Horton,
R. D. Johnston.