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TURBINE CONTROL APPARATUS

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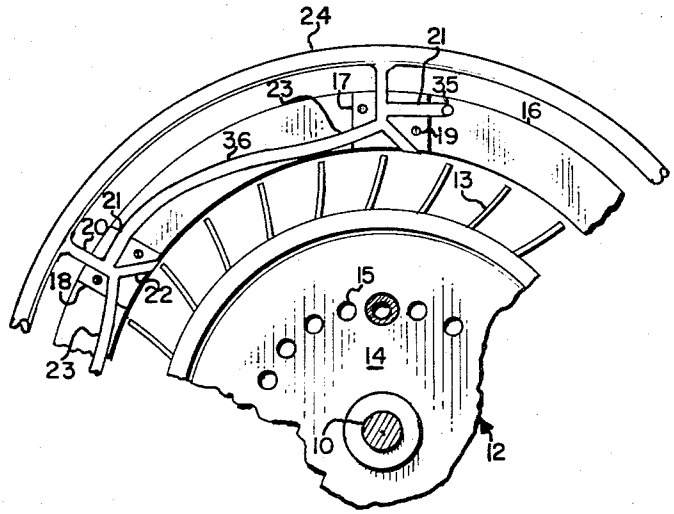


FIG. 2

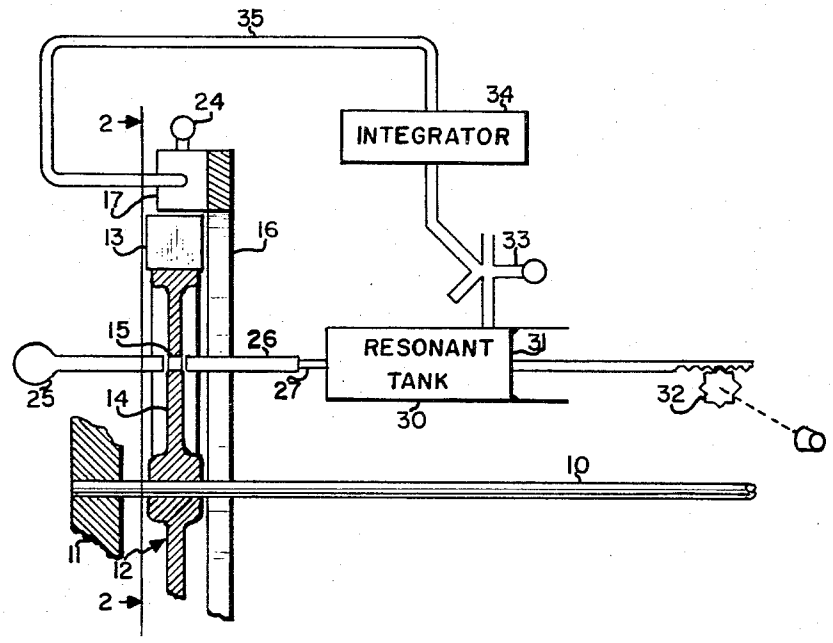


FIG. 1

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TURBINE CONTROL APPARATUS

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This invention relates to the field of control apparatus and more particularly to means for controlling the speed of operation of equipment powered by turbines and similar fluid actuated driving means.

The primary object of this invention is to provide speed control apparatus characterized by freedom from flyweights, springs, and moving parts generally, so that the speed control is simple, efficient, and economical to manufacture, and may be made integral to some extent with the power source being controlled.

FIGURE 1 in the annexed drawing, which forms a further part of this disclosure, is a schematic showing of a speed control system according to the invention, and FIGURE 2 is a view taken along the line 2—2 of FIGURE 1.

In the drawing **10** is a power shaft carried in suitable bearings such as **11**, for driving any suitable output load. A reaction wheel **12** is fixed to shaft **10** for rotation therewith, and is provided with a plurality of shaped blades or turbine buckets **13** at its periphery. The web **14** of wheel **12** is traversed axially by a plurality of equally spaced apertures **15**.

Concentric with wheel **12** is a mounting ring **16** which carries a plurality of fluid amplifiers **17**, **18**, and so forth spaced around the center of the ring and secured thereto by suitable means **19**. The amplifiers are shown as if transparent for clarity and illustration. Each comprises an inlet port **20**, a control port **21**, a first output port **22** through which fluid from inlet port **20** is initially discharged, and a second outlet port **23** through which the fluid is discharged when a signal is supplied to the control port. Outlet ports **22** act as nozzles for supplying reaction fluid to blades **13** of wheel **12**. Inlet ports **20** are connected through a manifold **24** to a source of fluid under pressure.

Mounted in any suitable manner on opposite sides of wheel **12** are a pair of tubes **25** and **26**. The common axis of these tubes is aligned with the axis of shaft **12**, and its radial displacement from the shaft is the same as the radius of the circle on which apertures **15** appear. Tube **25** is connected to the source of fluid under pressure. Tube **26** is connected through a restriction **27** to a resonant chamber **30** one dimension of which is variable by a piston **31** slideable within the chamber by a rack and pinion drive **32** to determine the resonant frequency of the chamber. The output of chamber **30** is transmitted through the fluid amplifier **33** of one or more stages, an integrator **34**, and a conduit **35** to the control port of fluid amplifier **17**. Outlet port **23** of this amplifier is connected by a conduit **36** to control port **21** of amplifier **18**, and so on around ring **15**.

The operation of my system is as follows. When it is desired to operate some load device driven by shaft **10**, fluid under pressure is supplied to manifold **24** and tube **25**. The fluid passes through outputs **22** of amplifiers **17**, **18**, and so on and impinges on turbine blades **13**, causing rotation thereof which moves apertures **15** past tubes **25** and **26**. This results in a train of fluid pulses in tube **26** at an initial low frequency. The frequency corresponding to the maximum speed of shaft **20** may be computed, and piston **31** is set to adjust the dimensions of chamber **30** so that the chamber is broadly resonant at frequencies beginning with this value and extending over a range of 20 percent for example. Unless the pulses have a frequency within this range, the chamber merely attenuates them and they do not emerge with sufficient amplitude to trigger amplifier **33**. When the frequency is within the predetermined range resonance results in reinforcement of the pulses and they become large enough to trigger the amplifier and thus supply a signal through integrator **34** and conduit **35** to the first amplifier **17**. The signal is a step function which causes the fluid stream to transfer from outlet port **22** to outlet port **23**, thus supplying a signal to transfer the fluid stream in amplifier **18**, and so on. The result is that fluid flow to drive the turbine wheel is quickly interrupted: there is no delay required to overcome the momentum of any rotating parts.

When the fluid flow is cut off the turbine speed naturally begins to decrease. In some applications a single increase of speed beyond the predetermined maximum calls for permanent stopping of the apparatus until some supervisory action, such as an inspection of the device driven by shaft **10** for example, may be accomplished. In this sort of an application amplifiers **17**, **18**, and so on may be bistable, so that once the stream has transferred to outlets **23** it continues there after the control signal in conduit **35** disappears, if such happens to be the case. Deliberate reset of the system is accomplished by temporarily interrupting the supply of power fluid to manifold **24**: when the supply of fluid is then established amplifier, **17**, **18**, and so on once more deliver fluid through output ports **22**. This is an overspeed cutoff system.

In other applications it is sufficient merely to reduce the speed until it is again less than the maximum value, continuous operation of the system being desired. In this case amplifiers **17**, **18**, and so on must be monostable, so that if the control signal disappears after the streams have transferred to outlet ports **23**, the streams automatically revert to outlet ports **22**. This is a speed control system.

It will be understood that the full stream from outlet port **23** of the first amplifier **17** may be more than sufficient to control subsequent amplifier **18** and that a tap in port **23** may be taken for the control function, the remainder of the stream in port **23** being dumped. One advantage of my invention is that outlet ports **23** may be continued to discharge against the back face of blades **23**, thus providing a braking action, where this is desired.

I claim as my invention:

1. Turbine control apparatus comprising:
   - a rotatable reaction wheel having a plurality of peripheral blades;
   - a first fluid amplifier for driving said wheel having an inlet port adapted to be connected to a source of fluid under pressure, a first outlet port oriented to act as a nozzle for normally directing fluid against said blades, a second outlet port for discharging fluid remote from said blades, and a control port which, when energized, provides a fluid control signal to interrupt the normal flow of fluid through said first outlet port and initiate flow of said fluid through said second outlet port;
   - means for producing a train of fluid pulses having a frequency which varies with the speed of rotation of said wheel;
   - a resonant chamber having an inlet connected to receive said train of fluid pulses and an outlet, said resonant chamber producing an output signal only when the frequency of said train of fluid pulses is substantially the same as the resonant frequency of said chamber;
   - a second fluid amplifier having an inlet port adapted to be connected to a source of fluid under pressure, said second fluid amplifier having a control port and an outlet port through which fluid is discharged when a signal is provided at said control port;

means connecting said outlet of said resonant chamber to said control port of said second fluid amplifier;

an integrator connected to receive fluid from said outlet port of said second fluid amplifier, said integrator being operable to supply a signal to said control port of said first fluid amplifier, thereby interrupting the flow of fluid normally discharged against said blades of said reaction wheel when the speed of said wheel substantially corresponds to the resonant frequency of said resonant chamber.

2. The apparatus of claim **1** wherein:

the size of said resonant chamber is adjustable, thereby providing an adjustable speed control for said wheel.

3. The apparatus of claim **1** wherein:

a plurality of fluid amplifiers are provided for driving said wheel, said plurality of amplifiers being arranged circumferentially around said wheel, each of said plurality of amplifiers having an inlet port adapted to be connected to a source of fluid under pressure, a first outlet port oriented to act as a nozzle for normally discharging fluid against said blades, a second outlet port for discharging fluid remote from said blades, and a control port which, when

energized, provides a fluid control signal to interrupt the normal flow of fluid through said first outlet port and initiate flow of said fluid through said second outlet port.

4. The apparatus of claim **1** wherein:

said means for producing a train of fluid pulses includes the web of said rotatable reaction wheel having a plurality of equally spaced axial apertures therein, a first tube adapted to be connected to a source of fluid under pressure and oriented to direct a stream of fluid through said apertures, and a second tube aligned with said first tube on the opposite side of said wheel from said first tube for receiving fluid therefrom whereby a train of pulses having a frequency indicative of the speed of said wheel is produced.

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