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ISOCHRONOUS GOVERNING MECHANISM

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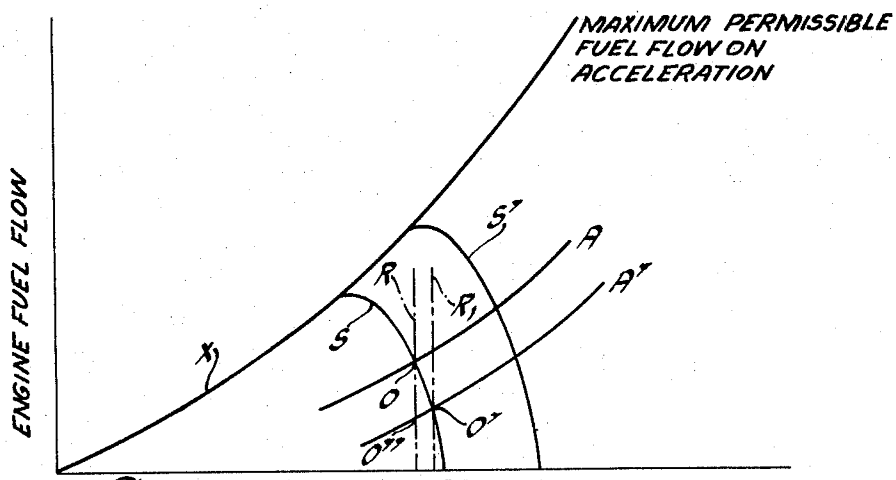

Fig. 1

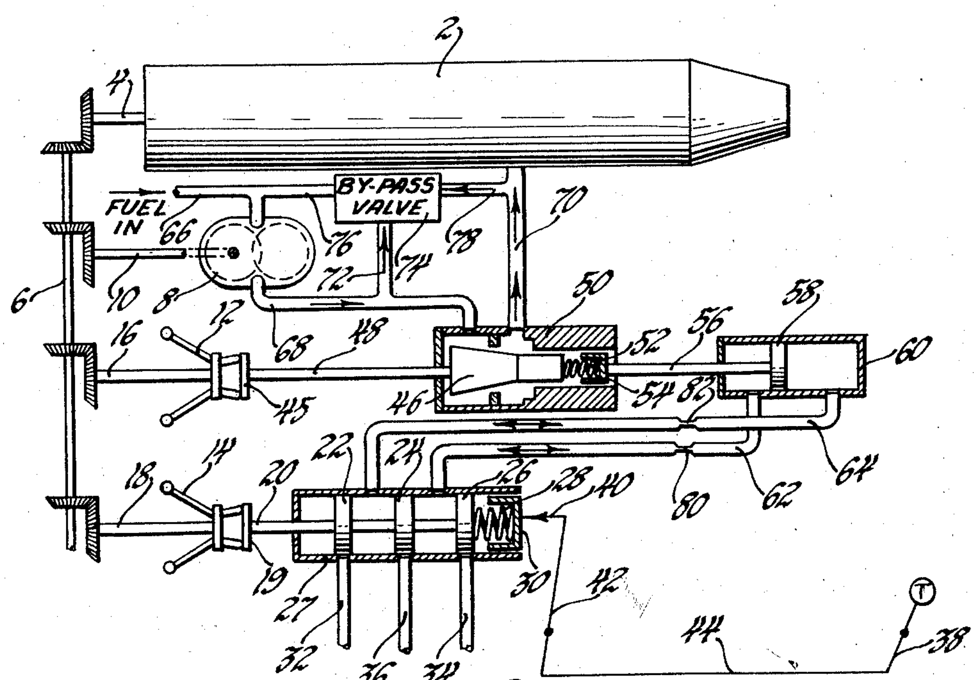

Fig. 2

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ISOCHRONOUS GOVERNING MECHANISM

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1 Claim. (Cl. 264—3)

This invention relates to a governing mechanism and more particularly to an isochronous governing mechanism maintaining the speed of an engine constant for each control lever setting regardless of load or any other condition of operation.

An object of this invention is to provide an isochronous governing mechanism for an engine including a control valve metering motive fluid to the engine and being biased in opposite directions by forces representing the actual speed of the engine and the desired speed of the engine, with the force representing the desired speed of the engine being variable whenever the actual speed does not equal the desired speed. A further object of this invention is to provide an isochronous governing mechanism for an engine including a control valve metering motive fluid to the engine and being biased in opposite directions by forces representing the actual speed of the engine and the desired speed of the engine, with the force representing the desired speed of the engine being variable and regulated by mechanism responsive to the difference between the desired speed of the engine and the actual speed of the engine.

These and other objects of this invention will be readily apparent from the following specification and drawings in which:

Figure 1 is a graph showing the operation of this governing mechanism;

Figure 2 is a schematic diagram of the isochronous governing mechanism.

In certain types of engines, particularly gas turbine engines, the purpose of a speed governor is to maintain the engine speed constant for each control lever position regardless of the load or other conditions of operation. This is necessary for engine stability.

In the conventional proportional governor, the governor flyweights are opposed by a compression spring, and the compression of this spring is set by the control lever position. The governor operates the control valve metering fuel or other motive fluid to the engine.

Referring now to Figure 1 of the drawings, the governor flyweight force does not equal the spring force as the engine accelerates along curve X. Various mechanisms are used to limit the maximum flow of motive fluid or fuel to the engine during acceleration as is well known in the art. As the engine comes up to speed, the governor flyweight force begins to oppose the spring force and the flow of motive fluid or fuel to the engine is reduced as the control valve closes. The flow of motive fluid or fuel then drops along a curve S as the flyweight force comes into balance with the spring force. There is a curve S for each control lever position or compression spring setting.

On each curve S, the flyweight force equals the spring force and the fuel or motive fluid flow rate to the engine is established by the operating conditions. Curves A and A′ are fuel or motive fluid requirement curves corresponding to various operating conditions. These curves intersect curve S at O and O′ representing the operating

points for a certain control lever position and for certain operating conditions.

Assuming now that a gas turbine engine is operating at point O and passes through warmer and less dense air, less fuel will then be required to maintain the engine speed or conversely more air is required. The engine therefore speeds up causing the flyweight force to be increased over the spring force. The fuel flow is reduced and moves along curve S to point O′ which represents a higher engine speed and a decreased fuel flow. This "droop" curve between points O and O′ describes the balance which always exists between flyweight force and spring force. The "droop" curve is undesirable, for the engine does not run at a constant speed.

A constant speed or isochronous line is shown as line R or R′ in the drawing. The undesirable "droop" curve can be straightened and made to approximate an isochronism line by adding a reset or compensating feature to the proportional governor. In my governor, however, the governor will exactly follow an isochronous line R, there being an exact speed line for each setting of the control **38**. Thus "droop" is eliminated and exact speed control is maintained regardless of changes in ambient conditions.

Referring now to Figure 2 of the drawings, the shaft **4** of a gas turbine engine **2** drives a shaft **6**. A conventional fuel pump **8** for supplying pressure fuel to the engine is driven by shaft **6** through shaft **10**. A pair of flyball governors **12** and **14** are also driven by shaft **6** through shafts **16** and **18**, respectively.

Flyball governor **14** operates against plate **19** secured to servo valve **20** having valve lands **22**, **24**, and **26** and mounted in cylinder **27**. The action of the flyball governor is opposed by a compression spring **28** exerting a force against both valve land **26** and cylindrical cup **30**. Constant pressure fluid is admitted to the servo valve through passages **32** and **34**, and a return passage **36** under a lower pressure is also provided. A control lever **38** operates a plunger **40** by means of links **42** and **44**. Plunger **40** bears against cup **30** and sets compression in spring **28** in accordance with control lever position.

Flyball governor **12** operates against plate **45** secured to rod **48** which is connected to a tapered valve plug **46**. Valve plug **46** is mounted in control valve **50** and controls the flow of fuel to the engine. The action of governor **12** is opposed by a compression spring **52** bearing against both the valve plug and a cylindrical cup **54**. A rod **56** connects cup **54** to a piston **58** mounted in cylinder **60**. Passages **62** and **64** connect the servo cylinder **27** to cylinder **60**.

Fuel is supplied to pump **8** by passage **66** and is delivered under pressure to the control valve **50** through passage **68**. The control valve supplies metered fuel to the engine through passage **70**. The excess of fuel delivered by the pump over what is required by the engine is returned from the outlet to the inlet of the pump through passage **72**, by-pass valve **74**, and passage **76**. The by-pass valve **74** receives a pressure input from the engine fuel supply passage **70** through passage **78**. The by-pass valve is provided to maintain a substantially constant pressure drop across the control valve **50** for more accurate metering of the fuel in accordance with the position of the valve plug **46**. Thus, the fuel flow to the engine will be a known function of the valve plug displacement.

The operation of this isochronous governing mechanism will now be described. Assuming that it is desired to increase the speed of the engine, the control lever **38** is moved counterclockwise, which compresses spring **28** and moves the servo valve **20** to the left from its equilibrium position as shown in Figure 2. Pressure fluid is then admitted from passage **32** to passage **64** leading to the right side of piston **58**. Passage **62** from the left side of piston **58** is connected to drain through passage **36**.

Pressure fluid admitted to the right side of piston **58** compresses spring **52** and moves valve plug **46** to the left to admit more fuel to the engine to increase its speed.

Consider first the control valve unit. As the engine accelerates, governor **12** tends to close the valve plug **46** against the action of spring **52**. If piston **58** has a fixed position, then proportional governing occurs. An increase in speed due to operating conditions will cause the governor to further close valve plug **46** and a decrease in speed will cause spring **52** to open the valve plug against the action of governor **12**. Thus, the fuel flow will increase or decrease along a curve S and the proportional governor will have undesirable speed droop.

However, in this isochronous governing mechanism, piston **58** does not have a fixed position. As the engine accelerates, governor **14** will tend to return the servo valve to its equilibrium position wherein the force of spring **28** equals the governor force and valve lands **22**, **24**, and **26** close passages **32**, **36**, and **34**, respectively. Governor **12** will also tend to close the fuel valve plug **46** against the action of spring **52**, and piston **58** will continue to move until the servo valve has reached equilibrium position.

Since a constant pressure is applied to the servo valve, the rate of flow through the valve is a function of servo valve displacement which can be called the speed error. The rate of flow from the servo valve to the piston in cubic inches per second is proportional to the flow area (orifice opening). The volumes of fluid flowing into and out of cylinder **60** through passages **62** and **64** will be equal to each other and to the velocity of the piston multiplied by its area. Assuming only moderate leakage past the piston, the velocity of the piston is directly proportional to the rate of flow past the servo valve and piston velocity is thus a function of speed error. Piston displacement, which is the time integral of velocity, is thus proportional to the time integral of a function of speed error.

The initial compression is set into spring **52** by means of piston **58** whose velocity is a function of speed error. The position of this piston and the compression of spring **52** is then determined by the time integral of the speed error. Since the piston velocity is a function of speed error, the piston will not have zero velocity until the speed error is zero or until the servo valve has returned to equilibrium.

If the engine speed increases beyond the compression set into spring **28** by the control lever, either during acceleration of the engine or due to a change in operating conditions, then servo valve **20** is unbalanced to the right by governor **14**. Pressure fluid then flows from passage **34** through passage **62** to the left side of piston **58** to reduce the compression of spring **52** and reduce the fuel flow. This aids governor **12** in reducing the fuel flow and establishes a new position of piston **58** and, hence, a new compression set into spring **52**. Piston **58** will continue to move until the speed error is again zero.

Damping orifices **80** and **82** are provided in passages **62** and **64**, respectively, in order to obtain stability. If desired, the damping orifices may be placed within the servo valve cylinder **27** between the inlet pressure passages and passages **62** and **64**.

While a specific embodiment of this invention has been shown and described, various changes and modifications may be made within the scope and spirit of the following claim.

I claim:

An isochronous governing mechanism for an engine comprising a control lever for setting the desired speed of said engine, a control valve metering motive fluid to said engine, a source of fluid under pressure, first speed responsive means biasing said valve in one direction, resilient means exerting a force opposing said first speed responsive means, hydraulically actuated means regulating the force exerted by said resilient means, a hydraulic servo valve controlling the rate of flow of fluid to and from said hydraulically actuated means to vary the rate of change of said force, second speed responsive means exerting a force on said servo valve tending to control the rate of flow to said hydraulically actuated means to decrease said force exerted by said resilient means, and resilient means exerting a force on said servo valve tending to control the rate of flow to said hydraulically actuated means to increase said force exerted by said first-mentioned resilient means, said last-mentioned resilient means being set by said control lever whereby the rate of travel of said servo valve and rate of change of force exerted by said first mentioned resilient means on said control valve is responsive to the difference between the actual speed of the engine and the desired speed of the engine.

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