July 23, 1963 R. F. SUMMERS 3,098,935

LOAD-SENSING BOOSTER FOR MECHANICAL GOVERNORS

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Fig. 1.

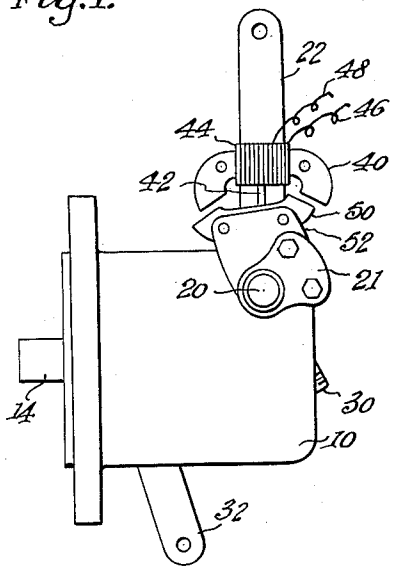


Fig. 2.

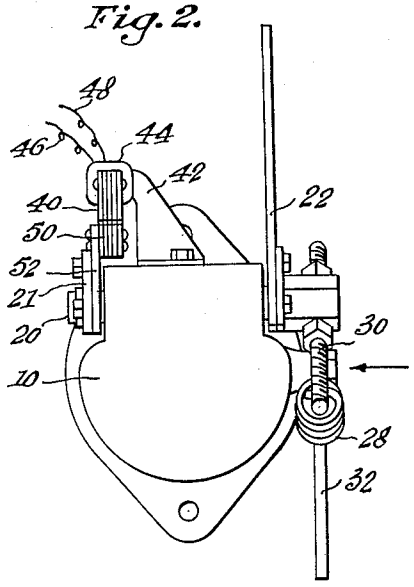


Fig. 4.

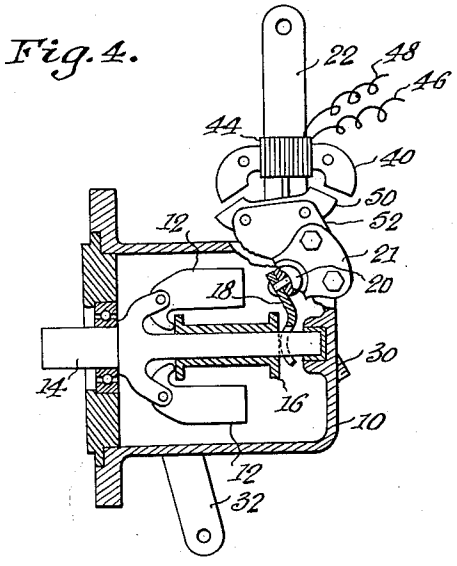
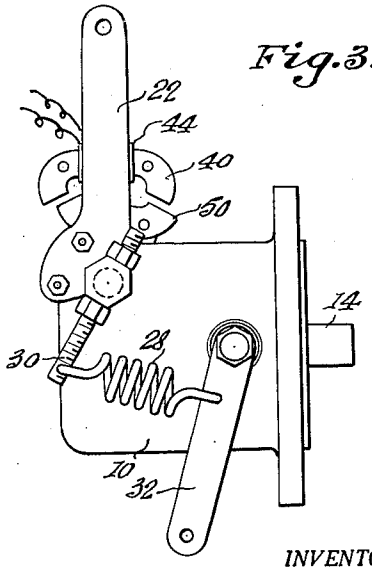


Fig. 3.



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LOAD-SENSING BOOSTER FOR MECHANICAL GOVERNORS

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Fig. 5.

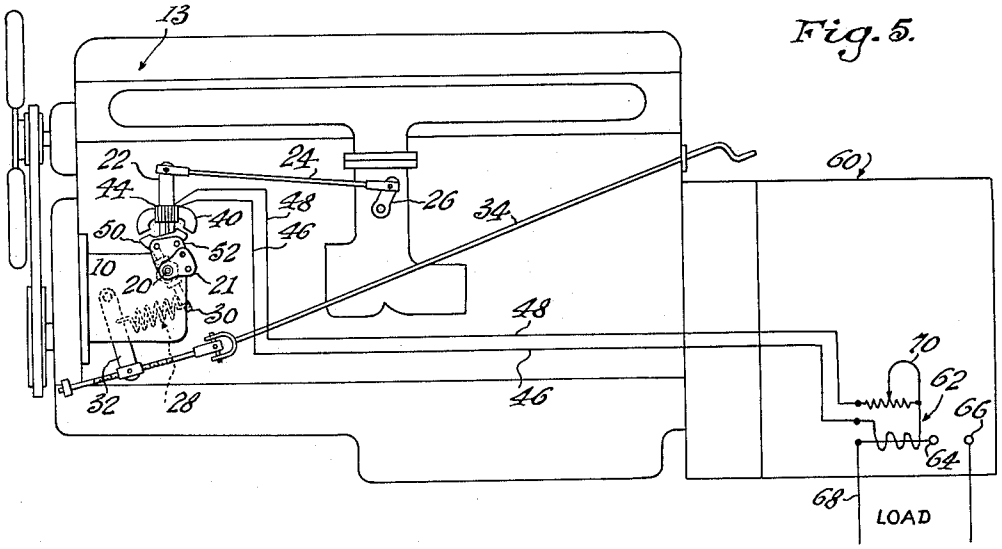


Fig. 6.

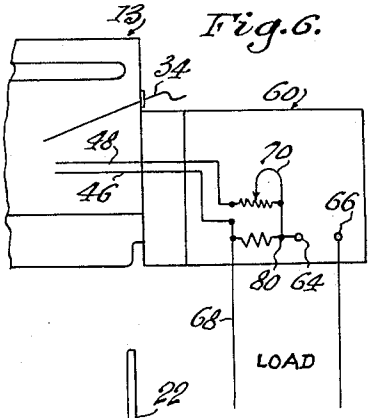


Fig. 7.

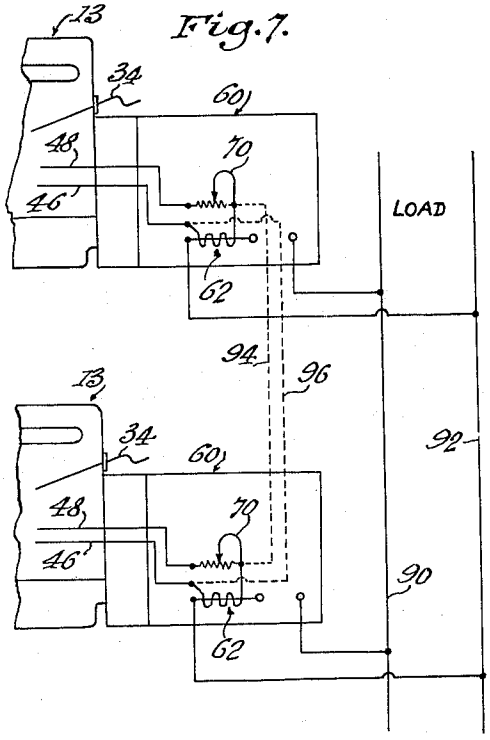
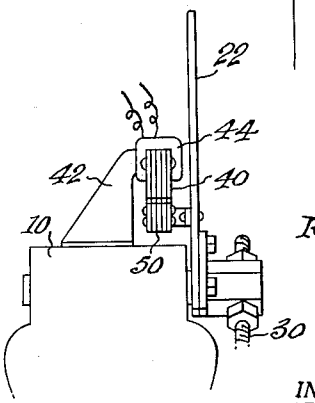


Fig. 8.



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LOAD-SENSING BOOSTER FOR MECHANICAL GOVERNORS

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7 Claims. (Cl. 290—40)
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The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment of any royalty thereon.

This invention relates to speed governors for internal combustion engines and the like and in particular to a load-sensing booster to be used in conjunction with a mechanical governor to improve the speed control of engine-generator sets.

It is well known that wherever an internal combustion engine or the like drives an electric generator connected to a power line, excessive overspeeding may occur when heavy loads are thrown off the generator. This overspeeding is caused by the time lag between the load change and the closing of the engine throttle by a conventional governor. The action of governors is defective in that they cannot act until the engine speed has changed. For each load carried there is a certain speed to which the engine must settle in order that the governor can permit the supply of sufficient power to carry that load. To reduce time lag and to obtain stability of regulation, various types of load-sensing boosters have been devised. Perfect stability of engine regulation would involve the elimination of inertia of all moving parts in the load-sensing booster and engine throttle assembly, friction in bearings of such moving parts, and lost motion therein.

Inertia of moving parts is detrimental to governor performance, because it results in delay in initial movement of the governor linkage when corrective forces are generated, and because it usually causes overtravel of linkage after corrective forces have ceased. The result is speed surge which is the undesirable rise and fall of engine speed. When the driven equipment is an alternating-current generator, the corresponding change in frequency may exceed the tolerable limits. This has been a serious problem with military electrical generator sets.

Friction and lost motion in bearings of moving parts are detrimental to governor performance because they result in a delay in initial movement of the governor linkage when corrective forces are generated, and because they introduce a hysteresis loop (dead band) in the motion of the governor linkage. The result of the time lag is an undesirable speed surge, while the result of the hysteresis loop is an inability of the equipment to return to an original speed following a load change and return to the original load. Friction in governor linkage pivot bearings has been found to be the direct cause for the inability of a considerable number of engine-generator sets to meet military specifications on speed surge and recovery time after load change, and dead band.

One object of the invention is to provide an improved construction and arrangement for regulating mechanisms of engines whereby the time lag of the governor, that is, the period of time passing between a change in load and the positioning of the throttle in accordance with the load change, is considerably reduced.

Another object of this invention is to overcome the difficulties resulting from inertia, friction, and lost motion and provide a governor for prime movers which is not primarily dependent for its action upon a change of speed in the engine governed by it.

A further object of the present invention is to provide a load-sensing booster in conjunction with a mechanical

governor on an internal combustion engine, which booster forms a variable, indirect connection between a load supplied by said engine and the throttle of said engine.

The load-sensing booster constituting the present invention hereinafter described has been developed to fulfill, among others, the above-mentioned objectives and requirements. Other special objectives and/or novel features claimed herein will be made apparent from the following description of the herewith illustrated embodiments of the invention.

In the accompanying drawings forming part of this description:

FIG. 1 is a side elevation of a mechanical governor and the load-sensing booster;

FIG. 2 is an end elevation of the mechanical governor and load-sensing device;

FIG. 3 is a side elevation of the mechanical governor and load-sensing booster looking in the direction of the arrow of FIG. 2;

FIG. 4 is a vertical section of the mechanical governor, parts thereof and the load-sensing booster shown in elevation;

FIG. 5 is an elevation of an engine-generator set including a mechanical governor and the load-sensing device in relation thereto and showing the wiring diagram of the electric load signal producing means;

FIG. 6 shows the wiring diagram for an alternate method of producing an electric load signal;

FIG. 7 is a diagrammatic view of two engine-generator sets showing the wiring diagram for connecting two electric load signal means in parallel; and

FIG. 8 is a fragmentary view of a modified mechanical arrangement of the load-sensing booster.

The same numbers of reference refer to like parts in all the drawings.

In order to understand more fully the present invention, the operation of the conventional mechanical governor without the load-sensing booster is described. Referring to FIG. 2, the governor housing 10 contains a set of flyweights 12, which generate a centrifugal force when rotated by the engine 13 (FIG. 5) through the governor mainshaft 14. This force is transmitted through a sliding spool 16 and a rocker arm 18 to a rocker shaft 20 having a hub 21 rigidly attached to one end. On one end of the rocker shaft 20 a governor output lever 22 is rigidly mounted. Referring to FIG. 5, motion of the governor output lever 22 is transmitted through a throttle rod 24 and throttle lever 26 to an engine throttle not shown. A governor's spring 28, FIGS. 2 and 3, interconnects an adjustable arm 30 secured to the rocker shaft 20 and a speed control lever 32. This lever controls the governed speed of the engine 13, and its position can be manually adjusted by turning a speed control rod 34, FIG. 5.

The load-sensing booster, constituting the present invention, consists of a tractive type electromagnet having a laminated core 40, FIG. 4, supported in a mounting bracket 42, FIG. 2, rigidly mounted on the governor housing 10 and having a centrally positioned coil 44 wound about it. The coil 44 has electrical leads coupled to a main generator 60 as hereinafter described. A laminated armature 50, corresponding to the electromagnet 40, is fastened to a plate 52 rigidly attached to the governor rocker shaft hub 21. The armature 50 moves with the rocker shaft 20 and maintains a small clearance with the electromagnet 40 throughout its arc of movement. The type of electromagnet and armature shown is one of several types which could be used. The solenoid type of electromagnet having a movable core for an armature is also considered to be quite suitable. The type of mounting of the electromagnet can also be varied. For example, if the design were changed (FIG. 8) so that the armature

50 were mounted directly to the output lever 22 rather than the rocker shaft hub 21, the same results would be obtained.

The electromagnet coil 44 is energized by a small electrical load signal current approximately proportional to the output from the main generator 60. Several methods are known for obtaining the necessary electrical load signal for energizing the load-sensing booster.

A current transformer 62, FIG. 5, may be utilized to obtain the electrical load signal. The generator 60, FIG. 5, has two power outlet connections, 64 and 66, having a constant voltage maintained by the voltage regulators commonly included with generators. A power or load line 68 runs from connection 64, to which the primary of the current transformer 62 is connected. The secondary side of the current transformer 62 is connected in series with a rheostat 70 and to coil 44 of the booster electromagnet through electrical lead 46 and return through lead 48. The rheostat 70 is to adjust the load signal strength to the booster when the installation is first made and periodically thereafter when engine conditions change. In the case of direct current generators and alternating current generators operating at 100% power factor, the secondary current is proportional to the electrical load on the generator, since the voltage is regulated at a constant value. An accurate signal current for operation of the load-sensing booster can thus be obtained. Standard items of electrical equipment are also available to make corrections in signal current when there are appreciable differences in phase loads. The sensing equipment for each phase will be similar to that described for a single phase.

An alternate method of obtaining an electrical load signal, applicable to small direct current generator sets may be obtained by using a shunt 80, FIG. 6, instead of the current transformer 62, FIG. 5. The shunt 80, FIG. 6, is placed in series with the power line 68 originating at the generator outlet connection 64. A voltage drop is developed across the shunt in proportion to the current in the power line 68. This in turn produces a signal current through the load-sensing booster in proportion to the electrical load on the generator.

Engine-generator sets equipped with load-sensing boosters may be connected in parallel, even though each unit is adjusted for approximately constant speed governing. Two engine-generator sets, FIG. 7, are connected in parallel to common load lines 90 and 92. The governors, not shown, for the engines 13 are equipped with the load-sensing boosters (not shown) previously described, and the generators 60 are coupled to the electrical load signal producing means described above in reference to FIGS. 5 and 6 for the load-sensing boosters. To assure that each generator 60 in parallel carries the same relative load a tie line consisting of conductors 94 and 96 is used to connect the respective load signal systems in parallel as shown in FIG. 7 wherein conductor 94 connects the rheostats 70 and conductor 96 connects the electrical leads 46 of the electromagnetic coils 44 of the load-sensing boosters. This equalizes the load signal voltages at similar connections along the tie line. The rheostats 70 are still effective in their individual circuits. As a result, the throttle openings for all engine-generator sets so connected will be the same. This is the requirement for maximum possible output from engine-generator sets connected in parallel. Engine-generator sets equipped with boosters can be adjusted for paralleling with similar generator sets not so equipped by breaking the electrical circuits to the load-sensing boosters. Paralleling can then be carried out in the manner established for engine-generator sets equipped with conventional mechanical governors.

In utilizing the present invention the engine of the engine-generator set is set to operate at a fixed governed speed without a load on the generator by turning the speed control rod 34 which action is through the speed control lever 32 which resists such action, the adjustable arm 30, governor spring 28 and through the governor

rocker shaft 20 and throttle connections to obtain the setting of the engine throttle. A load is thrown on the generator and current flows through the power line. An electrical signal is picked off by the current transformer 62 and supplied the electromagnet 40 of the load-sensing booster. A force is generated by the electromagnet 40 which acts on the armature 50, which, being rigidly attached to the governor rocker shaft 20, rotates the shaft against the action of the governor spring to open the throttle. The objective is to keep the engine speed constant and to this end the rheostat 70 can be adjusted to vary the strength of the electric load signal to the electromagnet. The electric load signal having once been adjusted to enable the load-sensing booster to maintain the fixed rate of speed of the engine at one load, all other loads will be obtained with no change in speed due to proper variations in the electric load signal which is directly proportioned to the load on the generator, and all throttle positioning required by changes in load is done by the booster action taken, in the case of decreasing loads, in conjunction with the governor spring.

I claim:

1. In combination with a governor housing, governor rocker shaft, rocker arm, sleeve, flyweights, engine for rotating the flyweights, throttle for regulating the engine, governor output lever rigidly secured to the governor rocker shaft, connection means interconnecting the governor output lever and throttle, speed control lever connected to the governor housing, adjustable arm connected to the governor rocker shaft, governor spring interconnecting the speed control lever and adjustable arm, and means for operating the speed control lever of an engine-generator set, a load-sensing booster comprising an armature in rigid mechanical connection with the governor rocker shaft, an electromagnet rigidly mounted upon the governor housing in spaced relation to the armature, a generator connected to said engine, means for producing an electric signal responsive to the load on the generator, and circuit connections for connecting the generator to the electric signal producing means and the electric signal producing means to the electromagnet for furnishing power to the electric signal producing means and the electric signal to the electromagnet producing a force acting on the armature for making substantially immediate adjustment of the throttle through the governor rocker shaft, governor output lever and throttle connection means.

2. In combination with a governor rocker shaft, rocker arm, sleeve, flyweights, governor housing, engine for rotating the flyweights, throttle for regulating the engine, governor output lever rigidly secured to the governor rocker shaft, connection means interconnecting the governor output lever and throttle, speed control lever connected to the governor housing, adjustable arm connected to the governor rocker shaft, governor spring interconnecting the speed control lever and adjustable arm, and means for operating the speed control lever of an engine-generator set, an armature, an armature support means rigidly connected to the governor rocker shaft and the armature, an electromagnet, a support means rigidly connected to the governor housing and electromagnet for supporting the electromagnet in a spaced relation to the armature, a generator connected to said engine, means for producing an electric signal responsive to the load on the generator, and circuit connections for connecting the generator to the electric signal producing means and the electric signal producing means to the electromagnet for transmitting power to the electric signal producing means and the electric signal to the electromagnet producing a force acting on the armature for making substantially immediate adjustment of the throttle through the governor rocker shaft, governor output lever and throttle connection means.

3. In combination with a governor rocker shaft, rocker

arm, sleeve, flyweights, governor housing, engine for rotating the flyweights, throttle for regulating the engine, governor output lever rigidly secured to the governor rocker shaft, connection means interconnecting the governor output lever and throttle, speed control lever connected to the governor housing, adjustable arm connected to the governor rocker shaft, a governor spring interconnecting the speed control lever and adjustable arm, and means for operating the speed control lever, an armature, an armature support means rigidly connected to the governor output lever and armature, an electromagnet, a support means rigidly connected to the governor housing and electromagnet for supporting the electromagnet in a spaced relation to the armature, a generator, means for producing an electric signal responsive and proportionate to the current output of the generator, and circuit connections for connecting the generator to the electric signal producing means and the electric signal producing means to the electromagnet for transmitting power to the electric signal producing means and the electric signal to the electromagnet producing a force acting on the armature for making substantially immediate adjustment of the throttle.

4. The combination of an engine having a throttle, a governor adapted to operate said throttle, including a governor output shaft and housing, a generator connected to the engine, and a compensating mechanism responsive to voltage change of the said generator, said compensating mechanism consisting of an armature rigidly secured to the governor rocker shaft and an electromagnet rigidly mounted on the governor housing in spaced relation to the armature, electrical signal producing means for producing an electric signal responsive and proportionate to the current output of the generator, means electrically connecting the electrical signal producing means to the generator, and means for supplying the electrical signal to the electromagnet for substantially instantaneous adjustment of the engine throttle through the governor output lever.

5. In combination with a governor housing, governor

rocker shaft, rocker arm, sleeve, flyweights, engine for rotating the flyweights, throttle for regulating the engine, governor output lever rigidly secured to the governor rocker shaft, connection means interconnecting the governor output lever and throttle, speed control lever connected to the governor housing, adjustable arm connected to the governor rocker shaft, governor spring interconnecting the speed control lever and adjustable arm and means for operating the speed control lever, an armature rigidly secured to the governor output lever, an electromagnet rigidly mounted upon the governor housing in spaced relation to the armature, a generator connected to the engine, means for producing an electric signal responsive to the load on the generator, and circuit connections for connecting the generator to the electric signal producing means and the electric signal producing means to the electromagnet for furnishing power to the electric signal producing means and the resulting signal to the electromagnet producing a force acting on the armature for making substantially immediate adjustment of the throttle through the governor output lever and throttle connecting means.

6. The engine-generator set of claim 1 in which the electric signal producing means comprises a transformer having a primary and secondary coil, the primary coil connected to a load line of the generator, and a rheostat connected in series between the secondary coil of the transformer and the electromagnet.

7. A plurality of engine generator sets of claim 6 in which the electric signal producing means associated with each one of said plurality of engine generator sets are connected in parallel by conductor means connecting the rheostats and conductor means connecting the return electrical leads of the electromagnets.

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