

Aug. 27, 1957

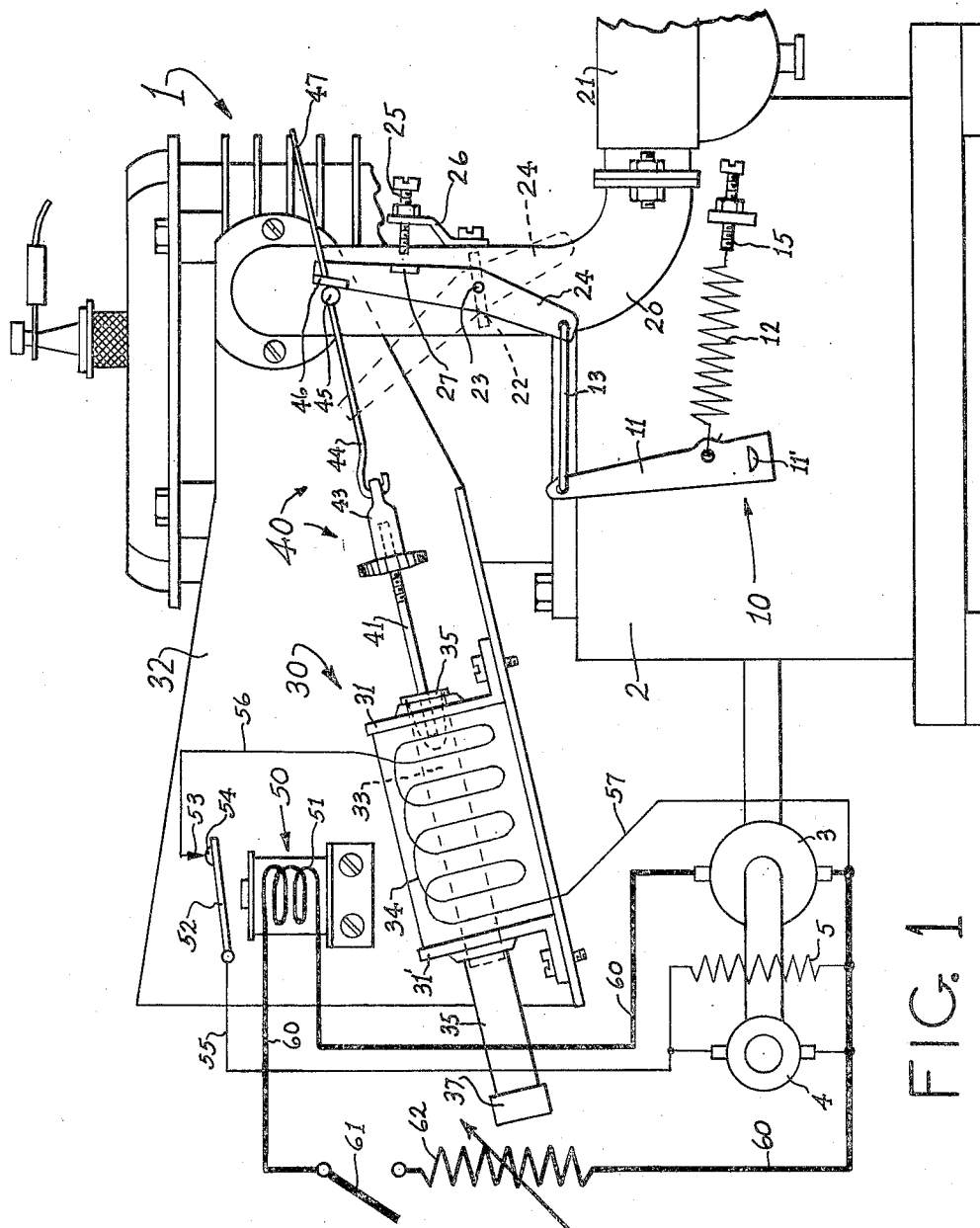
W. E. McFARLAND

2,804,552

SPEED-GOVERNING IDLING DEVICE

Filed Sept. 26, 1955

3 Sheets-Sheet 1



WILLIAM E. McFARLAND
INVENTOR.

BY *Peter J. Baylor*
Attorney

Aug. 27, 1957

W. E. McFARLAND

2,804,552

SPEED-GOVERNING IDLING DEVICE

Filed Sept. 26, 1955

3 Sheets-Sheet 2

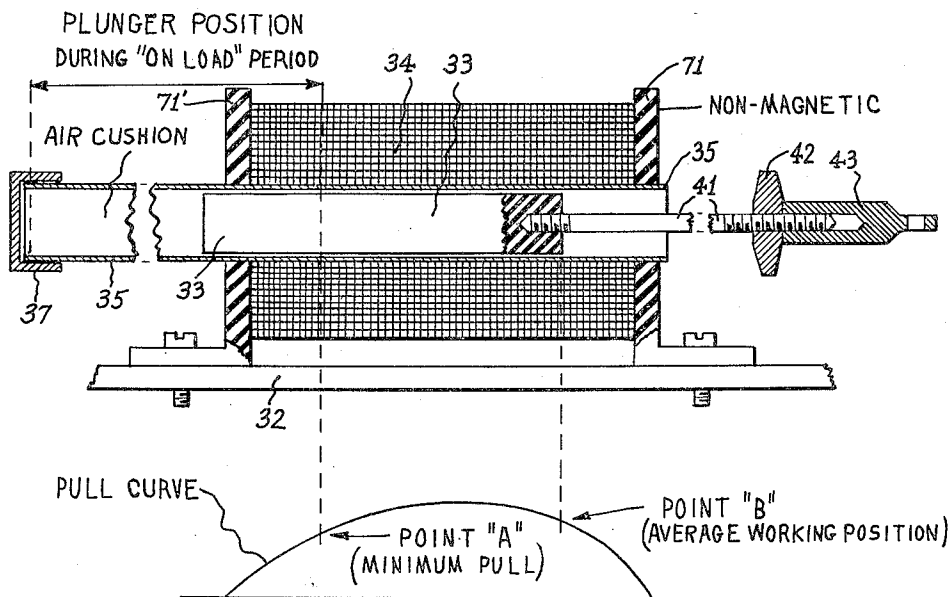
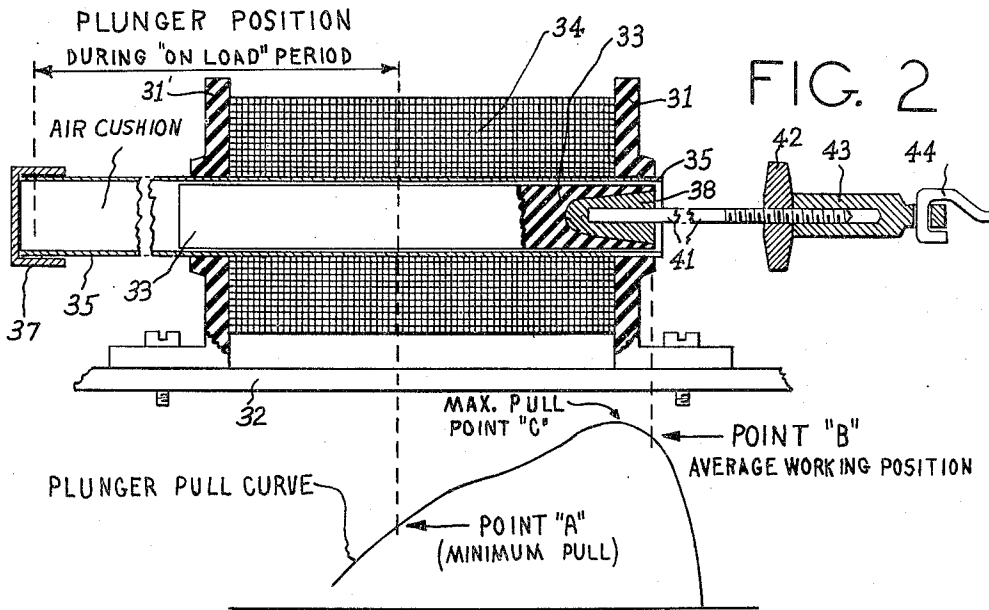


FIG. 3

WILLIAM E. McFARLAND
INVENTOR.

BY *C. J. Boyer*
attorney

Aug. 27, 1957

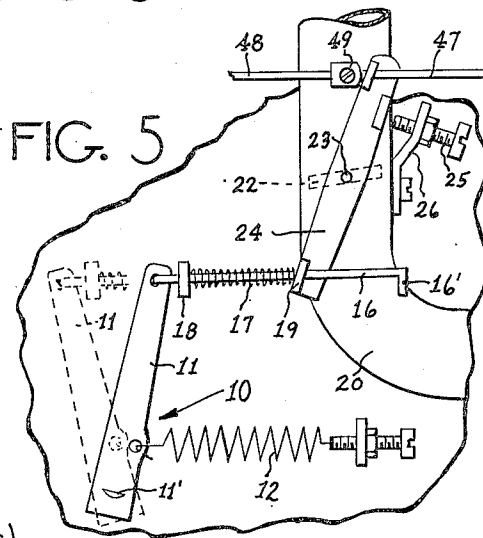
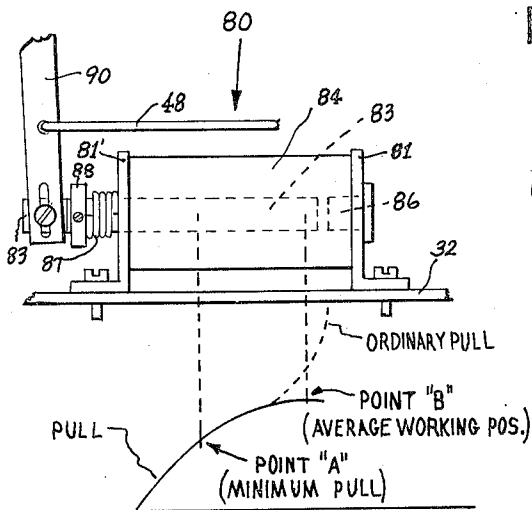
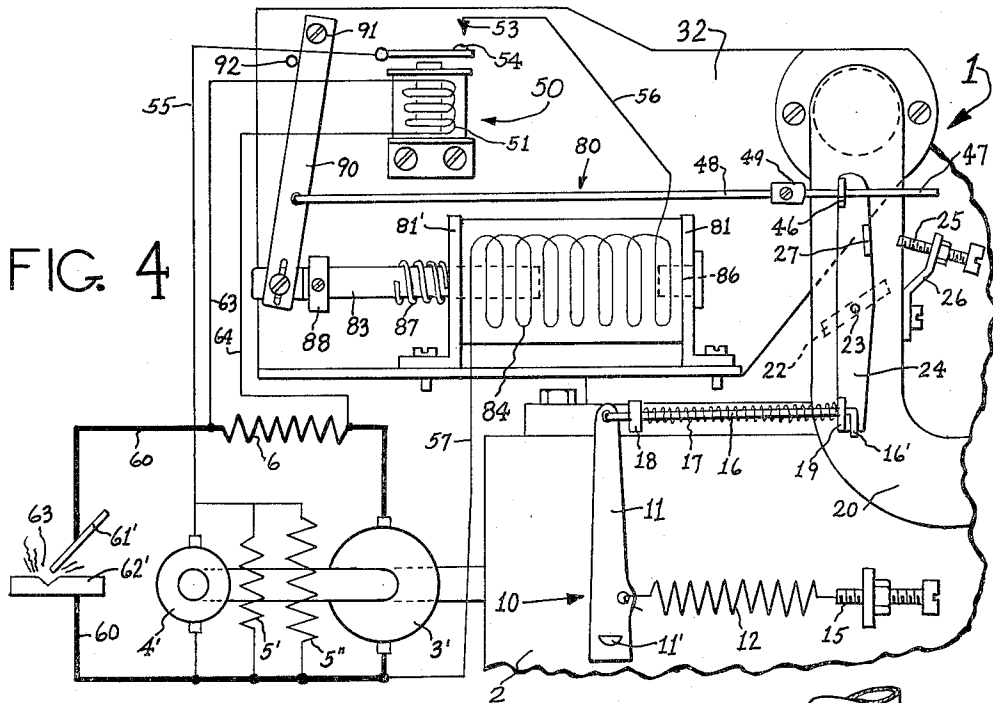
W. E. McFARLAND

2,804,552

SPEED-GOVERNING IDLING DEVICE

Filed Sept. 26, 1955

3 Sheets-Sheet 3



WILLIAM E. McFARLAND
INVENTOR.

BY *Peter J. Bayler*
Attorney

1

2,804,552

SPEED-GOVERNING IDLING DEVICE

William E. McFarland, Nutley, N. J.

Application September 26, 1955, Serial No. 536,519

8 Claims. (Cl. 290—40)

This invention relates to an idling device for engine-generator sets, which device also serves as a low speed engine governor. More specifically, it deals with an idling device wherein idling condition is enforced by a generated current-energized electromagnetic actuator during the off-load period effected through means of a load-responsive relay, said actuator being thus variably energized during the forced idling period to provide a governing action at the low speed condition. As energized, the actuator opposes the loading spring of the engine's centrifugal (mechanical) governor, but with electromagnetic force of such variable characteristic as to exert a sensitive governing influence during the forced idling period, so that engine speed and generated voltage tend to remain constant. Also, they are independent of engine temperature changes or other conditions which would affect the engine speed if the engine were merely operated on the basis of a fixed throttle position during the forced idling period.

The invention is particularly applicable to small engine-generator sets of the portable type as commonly used for operating power tools, and for providing light and power in isolated locations, and is also applicable to sets designed for electric arc welding use. Power demand, in the case of such small plants, usually is highly intermittent, and it is especially desirable to equip such plants with an idling device which is responsive at termination of load circuit current flow to effect the forced idling condition. There is an advantage in the engine being under governor control, even when operating at slow idling speed, and it has been proposed heretofore to obtain such an effect by adjusting the action of the centrifugal engine governor by means of said idling device. In such case, upon termination of load circuit current flow, the idling device effectively reduces the effect of the loading spring acting against the governor's centrifugal mechanism, so that the engine operates at slower (but governed) speed and, upon initiation of load circuit current flow, the idling device acts to restore the full normal spring loading of the centrifugal governor so that normal load speed is re-established. The principal defect of such a system is that the centrifugal governor, when its spring loading is lessened for slower speed operation, becomes weak and irregular in its action, so that it is impractical to establish the idling speed as slow as is really desired. In many cases, therefore, idling devices are very commonly arranged only to hold the engine throttle to a fixed position, which has obvious disadvantages, and especially so, in the case of light weight modern engines which may not idle slowly and reliably, on the basis of a fixed adjustment of the throttle, so that it may be necessary to provide a much faster idle than is really desired.

In copending application Serial No. 490,470, filed on February 25, 1955, by William E. McFarland, there are shown several arrangements of electrical idling speed governors coacting with idling-enforcing actuators, the effect of the actuator, at the termination of load circuit current flow, being to connect mechanically the idling speed gov-

2

ernor with the fuel intake system in such a manner that the engine throttle is controlled by the electrical governor until the next initiation of load. Such a system provides the desired accurate control of slow idling speed and insures that a necessary minimum of voltage is continuously generated, but the system requires a separate element in addition to the basic idling device structure, for obtaining the governing effect. Hence, it is desirable that there be provided a simplified form of electrical idling speed-governing action. In broad aspect, the present invention embodies the following elements:

1. An engine-generator set having a governed throttle system, including a centrifugal governor connected in controlling relation to the throttle, the governor having a loading spring which yieldingly resists closure of the throttle for a forced idling condition;

2. A load responsive switching relay, actuating its contacts in response to initiation and termination of load circuit current flow in a manner to control the energization of the actuator; and

3. An electromagnetic actuator connected with the throttle system in a manner to apply its electromagnetic force in opposition to the governor loading spring, forcing idling condition of the engine, the actuator being energized by generated current upon termination of load circuit current flow through action of the load-responsive relay, the actuator also being arranged so that, when deceleration to idling speed has taken place, the force applied by the actuator is variable in accordance with variation in generated voltage, thereby maintaining the engine under electromagnetically governed speed control in a predetermined slow (idling) speed range until the actuator is de-energized by action of the load-responsive relay at the next initiation of load circuit current flow.

The invention will be more readily understood by reference to the accompanying drawings in which Figure 1 illustrates diagrammatically an engine-generator set with the load circuit open and the engine operating at governed slow (idling) speed. Figure 2 illustrates, cross-sectionally, details of the actuator of Figure 1, and shows a graph indicating the pull characteristics of the plunger of the actuator. Figure 3 illustrates cross-sectionally, details of an actuator of less preferred construction, and also depicts a graph of the pull characteristics of its plunger. Figure 4 presents a modification of the invention, with the engine-generator set under load and the idling device in inactive position. Figure 5 shows positions of certain elements of the Figure 4 structure after termination of load circuit current flow, while Figure 6 illustrates the actuator of the Figure 4 structure, with positions of its elements in effect during the period of deceleration from load speed operation to idling speed operation, and also a graph showing the pull characteristics of its plunger. The same numerals refer to similar parts in the various figures. In these drawings, the circuits may, in some cases, be optionally A. C. or D. C. according to requirement or preference. No distinction is made between "resistance" and "impedance," the term "resistance" being used throughout.

Referring again to the drawings, and particularly to Figure 1, numeral 1 represents, generally, an internal combustion engine such as a small gasoline engine, having crankcase 2, carburetor 21 and fuel intake pipe 20. Engine 1 drives a load generator schematically represented by numeral 3, which may be A. C. or D. C., and which is shown having a field 5 energized by an exciter generator 4. Only the one field 5 is indicated, since in many small engine-generator sets, particularly A. C., there is an exciter armature, a load armature and a common field all combined in one structure. For convenience, however, the term "generator" will be used to designate either the

exciter generator structure or the load generator structure as though they were separate in all cases.

Numeral 10 indicates the engine's mechanical governor having the usual centrifugal mechanism (not shown) which may be inside crankcase 2, as is conventional in many small engines. This governor hereinafter will be referred to as the "centrifugal governor" and it has the usual arm or lever 11 which is connected with the centrifugal mechanism by rocker shaft 11', the motion of lever 11 being adapted to regulate fuel throttle valve 22 for close speed control. The centrifugal mechanism is of such effect as to move arm 11 to the left when the predetermined load speed is exceeded, while, if engine speed falls below the predetermined speed, the force exerted by the centrifugal mechanism is sufficiently weakened so that the governor loading spring 12 can and will move arm 11 to the right. Adjustment screw 15 enables adjustment of loading spring 12 for selecting exact adjustment of governed speed. Throttle valve 22 (hereinafter also referred to as the throttle) is mounted within intake 20 on pivot shaft 23 to which is fastened, externally, throttle arm or lever 24. The engine, throttle, etc., are conventional units or parts and are not novel elements of the present invention, since the invention is generally adaptable to governed fuel intake systems of any common type that includes a centrifugal governor of the kind requiring a loading spring and, in addition, is of a kind where an actuator can be readily connected in a manner to oppose the effect of the loading spring. Since the governor of such a system is necessarily connected with the throttle, an actuator for imposing the forced idling condition can be connected to the system at any convenient point, such as either to the throttle directly, or to the governor directly, without any difference in effect, so that the governed throttle system may be considered as a whole for the purpose of the present invention. An adjustable stop 25 is mounted on bracket 26 which, in turn, is mounted on intake 20. This stop limits the motion of throttle arm 24 in fuel-reducing direction, through inclusion of flange 27 on arm 24. Thus stop 25 can be adjusted to prevent cutting off of engine fuel completely by any temporary action of the actuator to be described.

An electromagnetic actuator is indicated generally by the numeral 30, and is mounted on an iron or steel angle-shaped panel or bracket 32 which, in turn, is shown as rigidly supported on the engine by being clamped between intake 20 and the engine proper. Electromagnet 30 includes iron end frames or brackets 31 and 31' which, together with panel 32, form the return magnetic circuit of the actuator. The actuator has a slidable plunger 33, an operating winding 34, and the usual non-magnetic plunger tube 35 which has a leftward extension, which terminates in a cap or seal 37. Plunger 33 is arranged to have a close but sliding fit in tube 35 so that the sealed leftward end of tube 35 acts as a cushion or dashpot to retard unduly rapid motion of the plunger in either direction. Actuator 30 is shown as disposed at an angle to the horizontal, thus tending to hold plunger 33 by gravity to its leftward limit.

Plunger 33 is connected with the governed throttle system by means of an adjustable linkage indicated generally as 40, and comprising a threaded rod 41 rigidly attached at one end to plunger 33, a thumb screw 42 on or near the other end of rod 41, an adjuster element 43 having one end interiorly threaded for adjustable attachment to rod 41, a wire or similar rigid link 44 having one end swivelly attached to the adjuster 43 and its other end slidably supported by throttle arm 24 by means of flange 46 having an opening to accommodate the link 44, with the free end 47 of link 44 extending rightwardly past the flange 46. A ball 45 serves as a stop or thrust member and is affixed to rod 44, enabling the force of plunger 33 to be applied as thrust on arm 24 at such time as winding 34 is energized. Unless winding 34 is energized, electromagnet 30 is ineffective, and governor 10 will be

in unopposed control of the throttle to effectively maintain the predetermined load speed operation.

Load generator 3 has a load circuit 60, shown in a bold line, which includes a load switch 61 and load 62. In practice, the load often will consist of a variety of individual power tools or appliances, each having an individual switch.

A load-responsive relay is indicated by numeral 50 and, for the purpose of describing the invention, is shown merely as a simple electromagnetic switching relay with its operating winding 51 directly in series with load circuit 60. This relay has an armature 52, and normally-closed switching contacts 53 and 54. The function of relay 50 is to control the energization of actuator 30 in such manner that actuator winding 34 is energized from the termination to the next initiation of load circuit current flow. The relay apparatus for accomplishing the necessary control will ordinarily be somewhat more complex than is indicated by the simple relay 50, but the particular relay apparatus details for affording control of energization of winding 34 are not a subject of the present invention.

The energization requirement of actuator winding 34 is that the energization be variable in accordance with variations of engine speed or, more particularly, variable in accordance with variations in voltage generated during periods when there is no flow of current in the load circuit. Either load generator 3 or exciter generator 4 could be selected for energization of winding 34, since the voltage output of either generator, under the idling condition, will rise and fall in suitably close approximation with variations in the engine speed. In Figure 1, actuator winding 34 is shown as energized by simple shunt connection with exciter generator 3, through a circuit including wires 55, 56, and 57, and the switching contacts 53 and 54, when closed.

Figure 1 shows the load switch 61 open, hence there is no flow in load circuit 60. Normally-closed contacts 53 and 54 are closed, and winding 34 is energized. The plunger pull thus developed holds plunger 33 toward its rightmost position, as more clearly illustrated in Figure 2, thus providing a forced idling condition of the engine, since the plunger force exerted is in a direction opposite to that of the governor loading spring 12, thereby rendering the centrifugal governor incapable of regulating the throttle on the basis of load speed operation. Plunger 33, however, is arranged so that it does not become magnetically locked in a final position at the limit of its motion. While the actuator of Figure 1 is illustrated as an iron frame type of plunger electromagnet, and there is consequently a strong air gap pull, representing the pull between the iron plunger and the iron frame 31, which pull is of significant force only in the late stage of possible plunger motion, there are means incorporated in the electromagnet to prevent increasingly strong plunger pull as the plunger traverses the last portion of its rightward motion. Figure 2 shows that iron plunger 33 has a tapered hole bored out at its right hand end, the open space, thus formed, being filled with solder or other non-magnetic material 38 which also serves to hold non-magnetic rod 41 in the end of the plunger. This tapered-bored plunger represents one easy means for obtaining a properly graduated final plunger pull for the present purpose. Under the condition depicted by Figures 1 and 2, plunger 33 is rather nearly centered with respect to winding 34, so that there is relatively little remaining effect of the long range pull of the electromagnet, that is, the pull existing between winding 34 and plunger 33. The air gap pull (that between the plunger and the iron end frame 31), however, is of strong effect. While the rightmost portion of plunger 33 is in such position as to be encircled by the end frame 31 so that, in a sense, the magnetic circuit is closed, it will be noted that the thus-encircled portion of the plunger is of reduced cross-sectional area and therefore cannot carry all the magnetic

5

flux of the plunger. The approximate plunger pull curve is graphically illustrated in the lower portion of Figure 2, as the pull curve would appear on the basis of a constant uniform D. C. energization of the winding 34.

In both Figures 1 and 2, plunger 33 is shown to have assumed that position which coincides with point "B" on the plunger-pull curve depicted at the bottom of Figure 2. At this point, plunger pull is desirably strong, which eliminates the necessity of an excessively large and powerful actuator. The force of the plunger pull, as exerted through the described linkage 40, tends to move the throttle to the closed position. Likewise, the centrifugal mechanism (not shown) of governor 10 is exerting some force tending to close the throttle, but, at the slow engine speed of a forced idling condition, the effect of the centrifugal mechanism is slight. The governor loading spring 12 is resisting the combined electromagnetic and centrifugal governing forces. Considering the several forces involved, the throttle (and thus the engine speed) is held in a state of governed balance. Should engine speed fall off a little, the energization of winding 34 consequently is weakened, and spring 12 is able to drive plunger 33 leftwardly, simultaneously advancing throttle 22. In being moved slightly leftwardly of point "B" on the graph, the plunger becomes positioned nearer point "C" which is the point of maximum pull. Therefore, unless the loss of engine speed is very sudden, the plunger will resist appreciable immediate displacement toward the left. With the throttle being advanced, engine speed should pick up before the plunger has moved leftwardly beyond point "C." It will be clear, also, that the air-cushion effect in the left end of tube 35 is an aid in preventing the plunger from passing point "C" of the curve prior to the response of the engine to the widened throttle opening. When engine speed picks up a little, winding 34 becomes more strongly energized, so that the plunger can move rightwardly against the force of spring 12, and thus will return to point "B" or thereabouts, and again the plunger will not tend to overshoot, because the effective plunger pull is increasingly lighter as the plunger moves rightwardly.

It may be apparent that, in order to smoothly govern slow engine speed, the governing effect must be quite responsive. This is because, at a slow (idling) speed, any appreciable change in throttle position quickly produces a considerable percentage change in engine speed and, if the governing effect is not sufficiently rapid and responsive, there will be a severe speed-hunting tendency. At point "B" on the graph, the plunger pull is effectively high, but has descended from the point of maximum pull and is of a nature to provide a responsive governing influence for obtaining steady, slow (idling) speed. If the connecting linkage 40 is shortened, as by loosening thumbscrew 42 and turning adjusting element 43 further onto rod 41, the average working position of the plunger will be to the right of point "B" on the graph, and the idling speed governing effect will be very stable, but engine speed will be somewhat faster because the working position of the plunger will be one in which the electromagnet does not exert the strongest plunger pull. Thus, by simple adjustment of the length of the linkage, the particularly desired idling speed may be selected.

At the adjustment illustrated in Figures 1 and 2, the engine will be operated at a slow but governed idling speed so long as a load is not connected. Flange 27 of lever 24 ordinarily will not be in contact with stop screw 25, although, to stabilize the slow speed operation to the maximum extent, stop screw 25 preferably is adjusted to prevent unnecessary throttle closure. If it were specifically desired, stop screw 25 could be adjusted so as to increase the idling speed above that which the actuator tends to permit, in which case the actuator would assume no governing function except to act as a safeguard against

6

engine stalling, such as during the warming up period after cranking.

At such time as switch 61 is closed to connect load, the current flow in circuit 60 will energize relay winding 51 to cause opening of contacts 53 and 54 to de-energize winding 34. The unopposed force of spring 12 then is effective to open the throttle 22 with throttle lever 24 momentarily held at the broken line position (Figure 1). By this action, plunger 33 necessarily is positioned leftwardly, but the air cushion effect of the sealed end of tube 35 prevents the opening of the throttle from being so rapid as to possibly stall the engine.

With throttle 22 open, the engine will come up to governed load speed, at which point the centrifugal mechanism of governor 10 will be effective, in the usual manner, to maintain proper governed speed for any varying load condition. Plunger 33 merely will remain by gravity at its leftward position, with the right hand end of the plunger coinciding with point "A" on the graph of the plunger-pull curves. This is a point on the pull curves where pull is relatively weak, which is not disadvantageous. It is desirable to utilize as much of the available plunger motion as is possible so as to be able to connect the plunger to the governed throttle system with maximum leverage effect.

If switch 61 now is opened, contacts 53 and 54 immediately will close to energize again winding 34, with full engine speed in effect at the initial moment of energization. This insures a strong initial energization which will rather powerfully move the plunger rightwardly against the force of spring 12, with the air cushion in tube 35 providing some degree of retarding effect. The energization, however, is sufficiently powerful to move the plunger rightwardly to the maximum extent, temporarily closing the throttle to the adjusted limit, as determined by stop screw 25 and, during the interval of deceleration, plunger 33 will remain somewhat rightward of point "B" on the graph of the plunger-pull curve. As deceleration to the proper idling speed is reached, the plunger pull is weakened sufficiently so that the plunger will settle back and stabilize around point "B" on the curve, as heretofore explained, and the governed idling speed again is in effect.

As shown in Figures 1 and 2, plunger 33, when it is in working position for effecting governing of the throttle, is at a point on the plunger-pull curve where the plunger pull has not only been flattened out but is descending. It is not strictly necessary that the working position be one in which the plunger pull is actually descending, but it is necessary at least to modify the final or gap pull sufficiently to avoid a sharply ascending characteristic in the pull, which is not a suitable governing influence and which, as used heretofore, has resulted merely in holding the throttle at a fixed position. The Figure 2 structure, utilizing the pull between plunger 33 and end frame 31, with a tapered bore in the end of the plunger, is a very simple and efficient arrangement for obtaining the desired pull characteristics.

Figure 3 illustrates the use of a simple solenoid and plunger (sometimes referred to as a "sucking" coil) as the actuator 30; that is, a plunger electromagnet having an incomplete iron circuit, as the end frames or brackets 71 and 71' in Figure 3 are non-magnetic. The only pull existing in this type of electromagnet is that between plunger 33 and winding 34 and, since the pull therefore is of weaker and shorter range than in an iron frame electromagnet, the Figure 3 electromagnet would necessarily be larger for a given force requirement. Point "B" is shown as a suitably average working position for the plunger, with respect to the graph of the plunger-pull curve. The actuator of Figure 3 may be substituted in the structure of Figure 1 and will operate in the same general manner.

Figure 4 is illustrative of minor modifications, and par-

ticularly shows that the governed throttle system may be modified in a manner whereby the actuator can enforce the slow governed speed of the engine without having to overcome the entire force of the centrifugal governor's loading spring 12. The figure also shows, as compared with Figures 1 and 2, an alternate method of levelling out the air gap pull of the plunger electromagnet serving as the actuator. In Figure 4, a welding application is illustrated, the welding electrode being designated schematically as 61' and the work piece as 62', with the welding arc 63 having been struck and in effect as a load. The welding generator is indicated by 3', the exciter generator as 4', having a field 5' while the main generator shunt field is shown as 5". The generator 3' is shown also as having a series field 6, and the load-responsive relay 50 has its operating winding 51 connected across series field 6 by means of wires 63 and 64 so that a portion of the welding circuit current will flow through operating winding 51.

The actuator in Figure 4 is designated generally as 80, and includes iron end frames or brackets 81 and 81', plunger 83, operating winding 84 and a fixed iron core or stop 86 extending a distance within winding 84. A long lever 90 is pivotally mounted on panel 32 at 91 and is connected with plunger 83 in swinging relation therewith. A suitably rigid link 48 is swivelly connected at its left end with lever 90, while its right end 47 is slidably mounted in flange 46 of throttle lever 24. An adjustable collar 49 is fixed onto link 48, enabling thrust against flange 46 when plunger 83 is pulled rightwardly by energization of operating winding 84.

Centrifugal governor 10 of Figure 4 is connected to throttle lever 24 by means of a one-way yielding auxiliary spring arrangement, permitting governor 10 normally to control the throttle to maintain a predetermined load speed operation of the engine. But governor loading spring 12 can resist throttle closure for a forced idling condition only to the extent of the yielding point of the auxiliary spring. This one-way yielding connection arrangement includes a rigid link 16 swivelly connected at one end to governor arm 11, and slidably supported in a flange 19 on throttle arm 24. A bent-over end 16' of link 16 serves as a stop and permits positive thrust of governor arm 11 for pulling throttle 22 toward closed position when governor arm 11 moves leftwardly. An adjustably fixed collar 18 is provided on link 16 and a helical spring 17 is disposed about link 16, pressing against both collar 18 and the flange 19. Aside from any opposing force on the throttle system, spring 17 transmits any rightward motion of arm 11 to move lever 24 in a direction to open throttle 22. However, a forced idling condition may be imposed by overcoming, at most, the force of spring 17. Ordinarily, it is desirable to omit the yielding auxiliary spring arrangement as described for Figure 4, as the actuator needs to oppose a fairly strong spring such as the governor loading spring 12, in order to provide a strong and sensitive governing effect. In the case of some engines, however, the governor loading spring is too powerful and the described expedient is beneficial. Also, in the case of Figure 4, the electromagnet incorporates a strong spring 87, to be described, which makes it unnecessary for the actuator to have to oppose the entire strength of governor loading spring 12.

The positions of the elements shown in Figure 4 represent the period with the welding arc 63 in effect, and thus generator 3' is under load. Relay winding 51 is energized, contacts 53 and 54 are open, and the actuator 80 is in ineffective condition. Plunger 83 may remain at its leftward limit as determined by a stop pin 92. Governor 10 controls throttle 22 for load speed operation, as flange 46 of lever 24 can slide freely over the free end 47 of link 48.

A collar 88 is rigidly positioned on plunger 83, and a relatively stiff short spring 87 surrounds the plunger. These latter elements are of no effect during the period when the welding arc is in use. When the electrode 61'

is moved sufficiently away from work 62' to break the welding arc, contacts 53 and 54 must close and, through these closed contacts and wires 55, 56 and 57, operating winding 84 is strongly energized by current from exciter generator 4. This immediately pulls plunger 83 rightwardly to the maximum extent as indicated in Figure 6, and collar 49 will bear against flange 46 to force throttle 22 closed to the maximum extent as permitted by adjustable stop screw 25. At this point, spring 17 would not be appreciably compressed so that the motion of arm 24 is transmitted (via extended spring 17) to move governor arm 11 leftwardly as indicated by the broken lines in Figure 5, since very little force is necessary therefor, there being a state of balance present between the centrifugal force of the governor and that of loading spring 12. After significant deceleration has taken place, governor loading spring 12 will be effective to move governor arm 11 to the position shown in Figure 5 in an attempt to open throttle 22, but compression spring 17 will yield as link 16 slides rightwardly through flange 19. Governor arm 11 thereafter will remain in the Figure 5 position, and spring 12, in a general sense, is opposing the forced idling condition, but actuator 80 is required only to exert sufficient force to overcome the yielding point of spring 17.

Referring again to Figure 6, the positions of the elements depicted therein are those during deceleration, with winding 84 still highly energized. This degree of energization holds plunger 83 to its rightward limit of motion, which limit may be determined by adjustment of stop screw 25 but, in any event, will not be more rightward than indicated by Figure 6, as collar 88 and fully compressed spring 87 will permit no further motion of the plunger. With plunger 83 at the limit of motion, it is beyond that position coinciding with point "B" on the graph of the plunger-pull curve. As deceleration becomes completed, and, due especially to the characteristics of short range spring 87, the plunger will settle back approximately to point "B," at which point throttle 22 will be open the small necessary degree to provide engine fuel for idling speed and, thereafter, plunger 83 will move back and forth slightly, as necessary, to provide the suitably responsive governing influence. The "ordinary pull" of the plunger, as indicated by the broken line in the graph, would be unsuitable for governing effect, but the short range spring 87 offsets the excess force of the air gap pull between plunger 83 and core or stop 86, so that the net effective plunger pull, as applied against the governed throttle system, is sufficiently flat to enable sensitive governing. It will be observed that, with respect to the Figure 1 structure, the magnetic circuit of the actuator was unconventionally designed to obtain a level final pull, while in Figure 6, the magnetic circuit is conventional. In both cases, however, the plunger is exerting a desirably strong force when it is located near point "B" on the graphs and, in both cases, it is possible to employ a desirably long plunger stroke with respect to the length of the actuator.

When electrode 61' is placed again in contact with work piece 62' to establish a new welding arc, relay winding 51 is energized and contacts 53 and 54 are opened. Spring 17 immediately expands, and centrifugal governor 10 again is in control of engine speed, as was described with respect to Figure 4.

I claim:

1. In an idling device for an internal combustion engine-generator set supplying generated current and voltage to a load circuit, the engine thereof having a governed throttle system, including a centrifugal governor connected to the throttle for maintaining predetermined load speed operation of the engine under varying load condition, said governor including a governor loading spring yieldingly resisting throttle closure effecting a forced idling condition of the engine, the improvement comprising a switching relay responsive to initiation and termination of load circuit current flow and having contacts arranged to effect the control of the energization

and de-energization of the hereinafter mentioned actuator, and an electromagnetic actuator connected with said governed throttle system in a manner to apply the electromagnetic force of the actuator in opposition to that of said loading spring and tending to close the throttle when the actuator is energized, said relay being constructed and arranged to effect energization of said actuator by generated current upon termination of load circuit current flow, said actuator being arranged whereby, after deceleration to idling speed, it applies its force variably in accordance with variations in generated voltage, thereby resulting in motion which maintains the engine under electromagnetic governed speed control in a predetermined idling speed range until de-energization of said actuator through action of said relay at initiation of load circuit current flow.

2. An idling device according to claim 1 in which the actuator is a plunger electromagnet having its plunger connected with the governed throttle system in a manner to apply its motive force in opposition to that of said loading spring for forced idling condition of the engine when the actuator is energized, the force of the plunger, upon deceleration to idling speed, being variable in accordance with variation in generated voltage, resulting in motion which maintains the engine under governed speed control.

3. An idling device according to claim 2 in which the plunger electromagnet is an iron frame electromagnet designed to have a long range plunger pull representing the pull between the electromagnet operating winding and the plunger, and to have also a short range air gap pull occurring toward the completion of the plunger motion when the winding is energized, the position of the plunger, when the engine is maintained in a predetermined governed idling speed range, being that in which the effective pull is primarily the short-range air gap pull, and magnetic-force reducing means included to prevent application of increasingly stronger plunger force as the air gap nears closure in the final plunger motion, whereby the plunger pull is made effective for application of a sensitive governing effect.

4. An idling device according to claim 3 in which the air gap pull is between the plunger and one end frame of the electromagnet, and the plunger has a tapered bore in its end adjacent said one end frame, whereby the plunger pull is progressively decreased.

5. An idling device according to claim 2 in which the plunger electromagnet is an iron frame electromagnet having an iron stop and is designed to have a long range plunger pull representing the pull between the electromagnet operating winding and the plunger, and to have also a short range air gap pull effected between the plunger and the iron stop, the position of the plunger, when the engine is maintained in a predetermined governed idling speed range, being that in which the effective pull is primarily the short range air gap pull, and a short range spring arranged and disposed to oppose plunger motion only in the range of the air gap pull, whereby the short range effective air gap plunger pull is progressively decreased.

6. An idling device according to claim 2 in which the electromagnetic actuator includes a tube within which slides the plunger, said plunger having, at one end a mechanical connector attached thereto for enabling application of the plunger force in opposition to that of said loading spring, said tube being sealed at its other end to form an air cushion for retarding the speed of motion of said plunger.

7. An idling device according to claim 1 in which the engine-generator set includes a load generator and an exciter generator, and in which the actuator is energized by shunt connection with the exciter generator.

8. An idling device according to claim 1, in which said centrifugal governor is connected to the throttle, for advancing the throttle, by a one-way yielding auxiliary spring connection constructed and arranged to enable the governor normally to control the throttle and maintain predetermined load speed operation under varying load condition, whereby said loading spring can yieldingly resist throttle closure for a forced idling condition only to the extent of the yielding point of the auxiliary spring connection.

References Cited in the file of this patent

UNITED STATES PATENTS

1,178,596	Okey	Apr. 11, 1916
2,242,072	Holslag	May 13, 1941
2,396,176	Hobart	Mar. 5, 1946