W. C. MAYO & J. HOULEHAN.

GOVERNOR FOR EXPLOSIVE ENGINES.

APPLICATION FILED JUNE 4, 1907.

920,074. Patented Apr. 27, 1909.

2 SHEETS—SHEET 1.

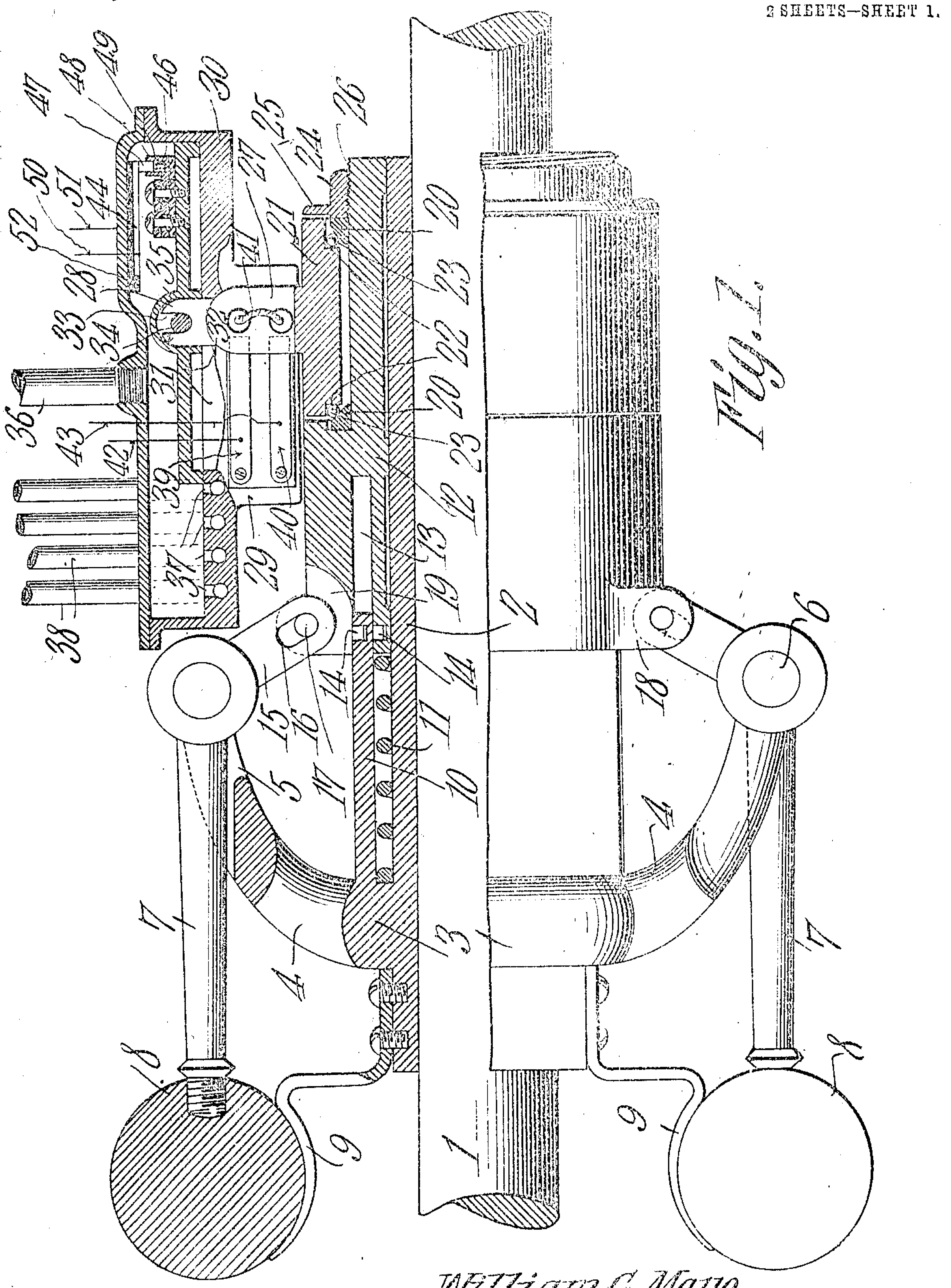

Fig. 1.

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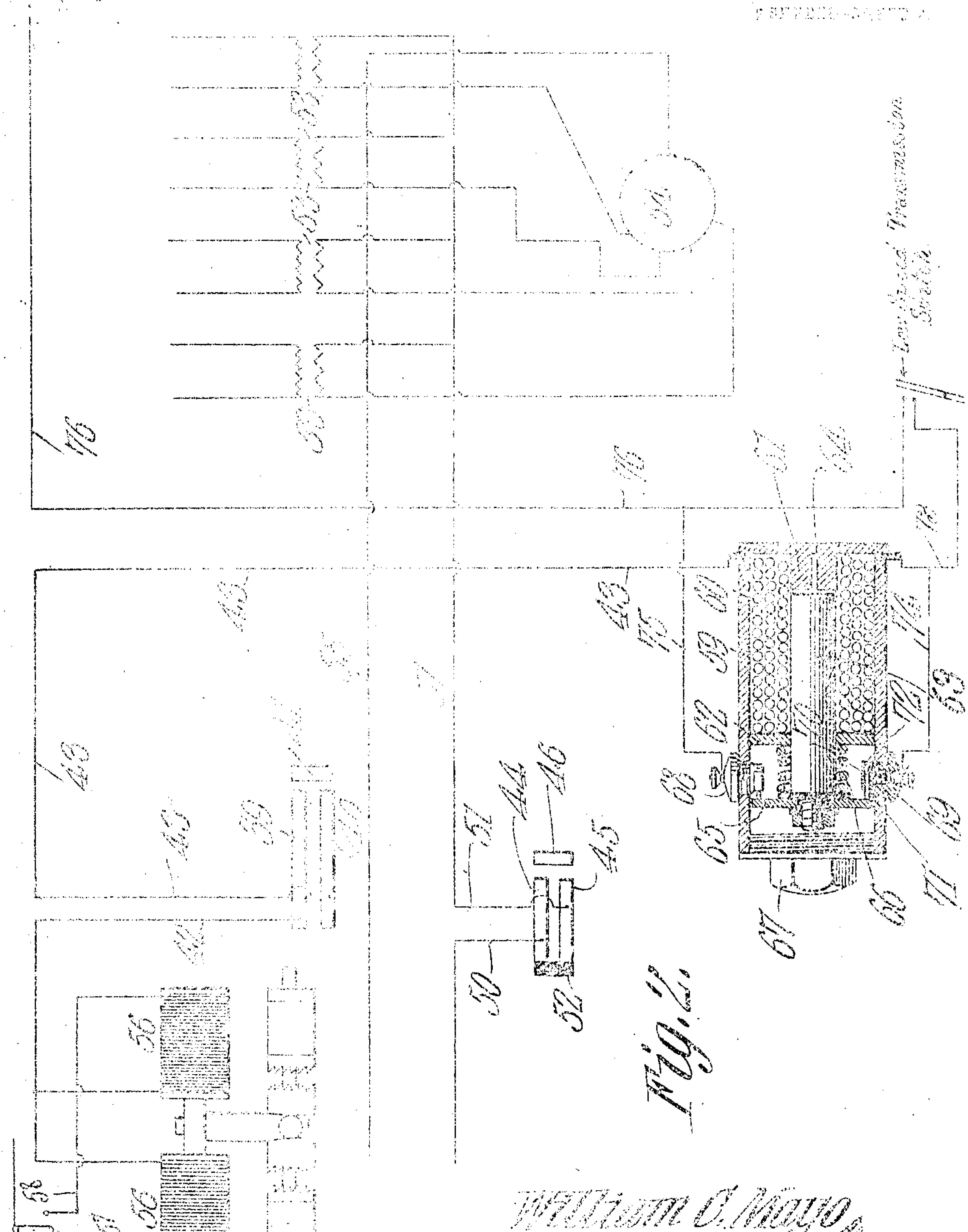

Fig. 2.

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GOVERNOR FOR EXPLOSIVE-ENGINES.

No. 920,074. Specification of Letters Patent. Patented April 27, 1909.

Application filed June 4, 1907. Serial No. 377,169.

To all whom it may concern:

Be it known that we, WILLIAM C. MAYO and JOHN HOULEHAN, citizens of the United States, residing at El Paso, in the county of El Paso, State of Texas, have invented a new and useful Governor for Explosive-Engines, of which the following is a specification.

This invention has reference to improvements in governors for explosive engines, being designed more particularly for use with multi-cylinder engines, whereby such engines may be maintained at practically constant speed under great variations of load.

In order that the invention may be best understood a brief consideration of the conditions giving rise to the invention will be found of value.

In our complete system of motor car propulsion for urban, suburban or interstate traffic, of which the present invention is an integral part, each car, whether used alone or coupled into a train, is a unit in itself including a prime source of power and all the several parts necessary for the automatic performance of the operations of propelling and controlling the car. For a prime source of power in such a system the advantages of an explosive or internal combustion engine of the multi-cylinder type are deemed predominant and our present invention is based upon the use of such type of engine, although not limited to any particular type, size or power of engine or kind of fluid fuel used. We may state, however, that a twelve-cylinder engine of either the two-cycle or four-cycle type, and preferably the latter, has certain advantages in connection with our system, and we prefer to use such an engine with all the twelve pistons connected to one crank shaft in such manner as though there were three four-cylinder, four-cycle engines connected to the crank shaft one hundred and twenty degrees apart, with six cylinders on each side of the shaft in a more or less horizontal plane to said crank shaft, but in this connection we may simply follow the best practice.

The present invention is designed to replace the prevailing methods of throttle control and spark control for gasolene engines, which methods of control are wasteful and inefficient, and the object of the invention is to obtain the greatest possible efficiency and at the same time maintain the engine under substantially constant speed whatever be the load so long as the latter does not exceed the limit of power of the engine. Of course, it is not designed that the engine shall run at an actually constant speed, but by means of other structures comprised with the general scope of our system, but not entering into this particular invention, allowance is made for these variations.

The present invention consists of a governor responsive to variations in speed and designed by such variations in speed to cut into and out of active service certain of the engine cylinders, but to always maintain certain other of the engine cylinders in active service except under certain occasional conditions where these constantly active cylinders may tend to speed up to too great an extent.

In accordance with the present invention the power developed by a certain predetermined number of engine cylinders, say four in a twelve-cylinder engine, is unaffected by the governor, which is designed to cut into or out of action additional cylinders as required, so that the constantly active engine cylinders may work at or about full load, which in explosive engine practice is found to be the most efficient point of operation. When, then, other cylinders are added in response to an increased demand for power, these added cylinders will also work at or near full load, and, therefore, most efficiently. Furthermore, provision is made by the present invention for disconnecting the engine from the load should an overload be applied as, for instance, when it is attempted to start a car under high gear or to take a grade under high speed where the conditions would impose an overload upon the engine, so that the motorman controlling the car must needs establish the proper speed relation between the engine and car wheels in order to obtain the requisite power to start or drive the car under the conditions named or any other similar conditions.

With all these considerations in view, the invention and its purposes will be best understood by reference to the following description taken in connection with the accompanying drawings forming part of this specification, in which,—

Figure 1 is a longitudinal section, with parts in elevation, of the improved engine governor; and Fig. 2 is a diagrammatic representation of the electric circuits entering into the operation of the governor.

Referring to the drawings, and for the time being, more particularly to Fig. 1, there is shown a shaft 1 representing one end of the crank shaft of the engine. Fixed upon the shaft so as to turn therewith is a sleeve 2 formed near one end with an integral collar 3 from which project arms 4, shown in the drawing as two in number and diametrically oppositely disposed. These arms are curved so as to project toward the other end of the sleeve and at their ends they are bifurcated, as shown at 5, and receive between these bifurcated ends the pivot pins 6 of arms 7, to the outer ends of which latter are secured the governor balls 8. When in the inactive position the balls 8 are supported by brackets 9 fast on the sleeve 2 beyond the collar 3. Extending from the collar 3 toward the other end of the sleeve 2 is a cylindrical overhang 10 parallel with the outer surface of the sleeve 2 and together with the said sleeve constituting an annular chamber housing a helical spring 11.

Mounted to slide upon the sleeve 2 and to rotate therewith is a cylindrical member 12 in one end of which is formed a longitudinal, annular recess 13 of such size as to receive the overhang 10, which latter acts as an annular piston entering said recess 13, while that portion of the cylinder 12 between the recess and the sleeve 2 enters the annular chamber between the overhang 10 and the outer face of the sleeve 2 and constitutes an annular piston for said chamber. In suitable grooves in the free end of the overhang 10 and the end of the cylinder 12 entering the chamber occupied by the spring 11 there are packing rings 14 arranged to make joints that are nearly but not quite air-tight.

Each arm 7 carrying a governor ball 8 is provided with a short angle arm 15 on the side of the pivot 6 opposite the ball 8, and this arm has at its end a slot 16 through which passes a pin 17 secured in ears 18 formed on the corresponding end of the cylinder 12, while between these ears 18 the cylinder is recessed, as shown at 19, to receive the end of the short arm 15.

Now, considering the structure thus far described, let it be supposed that the shaft 1 begins to rotate. The sleeve 2 and cylinder 12, together with the arms 7 and balls 8, also rotate and the balls 8 tend to move away from the brackets 9. This tendency is communicated to the cylinder 12 through the angle arms 15 but the movement is resisted by the spring 11. As the speed of the shaft 1 increases the centrifugal force acting upon the balls 8 ultimately overbalances the resistance of the spring 11 and the balls move away from the brackets 9 and the cylinder 12 is moved toward the arms 4, compressing the spring 11 to a corresponding extent. Assuming a still greater increase of speed of the shaft 1, it will be seen that ultimately the cylinder 12 will be moved along the shaft by the outward movement of the balls 8 until the resistance of the spring 11 becomes sufficiently great to prevent any further movement of the cylinder 12. As the shaft 1 decreases in speed the reverse of the movement of the cylinder 12 and balls 8 takes place, the cylinder 12 moving away from the arms 4 and the balls 8 approaching the brackets 9.

During the movement of the cylinder 12 to or from the arms 4 the air confined in the chamber housing the spring 11 and also in the recess 13 cushions this movement because of its inability to move rapidly past the packing rings 14. There is, therefore, introduced a dash-pot resistance to the movement of the cylinder 12 which prevents it from responding too quickly to changes in speed of rotation of the shaft 1. It is not designed that the damping action due to the dash-pot should be very great; consequently, the recess 13 and that containing the spring 11 may be made small since, with good packing, the air can escape but slowly. It will also be seen that the length of these recesses is so great as compared with their area that a considerable movement of the balls 8 will occur before there is very much damping effect. The purpose of this dash-pot action is just contrary to that of the dash-pots used on steam engine governors. In the latter case the dash-pot is designed to delay the action of the governor until the heavier parts of the engine can respond. In the present instance the governor will move through a considerable range before materially impeded by the dash-pot, and, as will hereinafter appear, this will result in the almost immediate introduction of additional engine cylinders into active service. The purpose of the dash-pot action of the governor we have devised is to retard the governor only when there is a relatively large increase or decrease in the speed of the engine.

Now, while with this governor there are variations in speed which would be intolerable in steam engine practice, since these variations would at times be quite large, we have devised means as a part of our general system, but which, forming no part of the present invention, need not be here considered, for neutralizing the deleterious effect of such comparatively wide variations upon other parts of our system. These wide variations are more or less unavoidable by reason of the fact that our system comprises a positive instead of a friction clutch, as being the more advantageous for the transmission of large power. For this reason, no very close regulation of the engine speed from moment to moment can be maintained without subjecting the motive apparatus to excessive and possibly destructive strains.

Referring now again to the cylinder 12, it will be seen that the end remote from the connection with the arms 15 is considerably reduced in diameter and receives two beveled rings 20—20 which may be of properly ground and tempered steel, and over which is applied an annulus 21, also of ground and tempered steel and having angular end recesses 22 for the reception of the balls 23, these angular recesses 22 and the rings 20 forming ball-races of well-known type. Finally, a screw collar 24, having an annular flange 25, is screwed upon the threaded end 26 of the cylinder 12 and confines the annulus or sleeve 21 in position upon the cylinder 12 in anti-friction relation thereto. This collar 24 may be locked in place by a suitable set-screw (not shown). The annulus or sleeve 21 is held stationary while the cylinder 12 rotates.

Projecting radially from the annulus or sleeve 21 is a lug or arm 27 having a radial extension 28. The lug 27 enters between wings 29 formed on the lower side of a slide-valve chest 30, while its upper end extends into a slot 31 formed in the lower side of said valve chest 30, which slot 31 permits the movement of the extension 28 as well as the arm 27 with relation to said valve chest. This is necessary since the valve chest 30 is fixed against movement by being supported on an appropriately fixed portion of the engine frame, while the sleeve 21 and the arm 27 with its extension 28 move longitudinally with reference to the shaft 1 because of the mounting of the sleeve 21 on the cylinder 12, which latter has longitudinal movement with reference to the shaft 1.

Within the chest 30 there is a slide-valve 32 engaged about midway of its length by the extension 28, which latter is provided with a recess 33 straddling a pin 34 passing laterally through said valve in a hooded portion 35 thereof. The interior of the valve chest 30 is in communication with a source of compressed air by means of a pipe 36. This source, as will be seen, may be the same source of air which supplies the air-brake system of the car.

The valve chest and valve may be quite narrow, and in line therewith are a number of ports 37, four being shown in the drawings. Leading from these ports are pipes 38 extending to suitable air cylinders (not shown) arranged to control certain of the explosive engine cylinders. Since all through this description it is taken for granted that the prime mover is a twelve-cylinder engine and that four cylinders are always in active service to be governed by an ordinary explosive engine governor, preferably of the hit-and-miss type, it will be seen that but four pipes 38 are needed, since for purposes of balance it will be advisable to introduce or cut out cylinders in pairs, and, consequently, the eight governed cylinders need but four controlling means.

Now, assuming that the valve chest has air under pressure therein, it will be seen that in the position shown in Fig. 1, which would be the condition for greatest load, compressed air will flow through the pipes 38 and so set all the cylinders of the engine in operation. It is not material to the present invention how the compressed air flowing through the pipes 38 renders the engine cylinders active, and it is only necessary to state in this connection that this compressed air will operate suitable mechanisms which will cause the engine cylinders to be charged with explosive mixtures and then exploded in the usual manner. If the load be decreased, immediately the engine speeds up and the balls 8 fly outward. This causes the cylinder 12 to be moved toward the arms 4 and the slide-valve 32 is correspondingly moved until one after the other of the ports 37 are closed to the compressed air supply and are opened to the slot 31 which communicates with the external atmosphere. The pipes 38 are therefore progressively exhausted and the engine cylinders are one after the other put out of commission until the continuously active cylinders, four in number in the case under consideration, are left; provided, of course, that the load is decreased until it would be taken care of by these four cylinders.

Now, suppose that a heavier load is put upon the engine, tending to and actually reducing the speed of the engine. Under these conditions the balls 8 move to a corresponding extent toward the brackets 9 and the cylinder 12 is moved away from the arms 4, carrying the slide-valve 32 with it to uncover one or more of the ports 37, depending upon the reduction in speed of the shaft 1. As soon as the first port 37 has been uncovered the compressed air enters the first pipe 38 and through suitable mechanism, which has been referred to but neither shown nor described, renders the corresponding pair of engine cylinders active; and, if the speed has been sufficiently reduced, two or three or even all four of the ports 37 will be uncovered and a corresponding number of engine cylinders thereby rendered active. The increasing power thus generated by the engine, due to the number of cylinders put into commission, will act on the shaft 1 to increase its speed, and if the increased power demanded has been greater than that necessary for the continual running of the car, the speed of the shaft will rise and certain of the engine cylinders will be cut out until an equilibrium is established. Any variation from the last established speed will be responded to by the governor and a new equilibrium will be established. If the demand for power is great, the governor will not immediately respond through the full possible extent of its travel but will, after responding to a certain extent, become more sluggish in its action, due to the dash-pot effect, and so the sudden application of greatly increased power will be prevented and the machinery will be saved the strain and possible damage due to the effects of sudden application of power.

It will, of course, be understood that the shaft speed due to the impulse of the constantly active cylinders of the engine will be sufficient to maintain the governor balls in a position which will cut out all the other cylinders of the engine provided the load does not exceed the power of these constantly active cylinders. It is only after such limit is reached that the governor becomes active, and it may be so adjusted as to respond through a comparatively small range of speeds in order that the engine speed may not vary to too great an extent from the constancy of action desirable for other devices forming parts of our general traction system. If closer regulation is desired, there may be more ports 37 and pipes 38 so that each pipe 38 controls a single cylinder instead of a pair of cylinders. In either case a port 37 and pipe 38 controls a power unit whether such unit be a single cylinder or include a plurality of cylinders.

Located on one of the wings 29 are two spaced conducting strips 39 and 40, and carried by the lug or arm 27 is a bridging conductor 41 with its terminal so located as to couple the two strips 39 and 40. From the strip 39 there leads a conductor 42, and from the strip 40 there leads a conductor 43, both of which conductors will be hereinafter referred to.

Within the valve chest 30 but suitably insulated therefrom are two conducting strips 44—45, only one of which is shown in Fig. 1 but both of which are shown in Fig. 2. Carried by the slide-valve 32, but insulated therefrom as shown, is a bridging conductor 46 having contact brushes 47, one only of which is shown. These brushes 47 are held in sockets 48 and urged toward the strips 44—45 by springs 49 within said sockets. The strip 44 is connected to a conductor 50 and the strip 45 is connected to a conductor 51. At the end of the strips 44—45 in the path of the brushes 47 is an insulating section 52 upon which the brushes 47 pass when the slide-valve 32 has reached the limit of its travel, covering all the ports 37. The purpose of this insulating strip 52 will appear farther on.

Now, consider that the car is standing still with but a small load consisting principally of a light, intermittent load from the air pump and, in daytime, practically nothing from the dynamo used for lighting and other purposes. Under these conditions the four cylinders of the engine may tend to speed up too fast. In such case the governor balls, under the speed generated by the four cylinders covering the four ports 37, will tend to and will actually move still farther outward until the brushes 47 on the bridging conductor 46 will pass from the strips 44—45 on to the insulating section 52, thus breaking the circuit between the strips 44 and 45.

The various circuit connections are shown in Fig. 1. From this figure it will be seen that the conductor 51 leading from the strip 45 has the primaries of a number of induction coils 53 connected on one side in multiple thereto, while the other sides of the primaries of these induction coils are connected to a suitable spark timer 54, simply indicated diagrammatically in the figure.

The conductor 50 leading from the strip 44 is carried to a suitable source of current (not shown) which source may be the dynamo carried by the car or a special sparking dynamo or a suitable battery. From this source of current another conductor 55 leads to the spark timer 54 to constitute the common return for the primaries of all the coils 53. It will be understood, of course, that the secondaries of the coils 53 lead to the sparking plugs of the four cylinders of the engine designed to be in constant operation.

Now, when for any reason the speed of the engine under the impulse of the four cylinders shall increase sufficiently to carry the bridging contact 46 on to the insulation 52, the sparking circuit for these four cylinders will be broken on the low tension side and the cylinders, being deprived of power because of the failure of the spark to explode the mixture therein, will drop in speed until the governor responds and the bridging contact 46 again closes the circuit between the strips 44 and 45.

Instead of opening the circuit to all four induction coils at the same time, it is obvious that single cylinders may have their individual spark circuits opened consecutively.

The arrangement just described for opening and closing the spark circuits operates on the hit-and-miss type of regulation such as is used on stationary explosive engines, and we consider this type of regulation the best for the purpose since it is less wasteful than other throttle regulation, or that type of regulation where the spark time is divided or retarded, since at all times the hit-and-miss principle of regulation provides for the maximum efficiency of compression.

It may be here added that while all the pistons in all the cylinders of the engine are reciprocating when the engine is running, explosions occur only in the active cylinders, but the valves are made of liberal size and provision is made for keeping the valves open when the cylinders are not active, and thus the only losses are the friction losses, which may be made very small. This also tends to keep the cylinders cool. Of course relief valves may be used to prevent compression in the cylinders, but it is advantageous to simply hold open the regular inlet valves for this purpose.

From the foregoing it will be seen that by means of the governor we have devised the engine may be made to economically furnish power through a wide range from a minimum output to a maximum output several times greater than the minimum, and this without the low efficiency due to running explosive engines on light load, for in our system the engine is practically at all times on full load throughout the entire range of power output, and, therefore, its efficiency is always manitained at the highest point.

Now, let it be supposed that the motorman attempts to overload the engine, as, for instance, by stopping on a steep up-grade and then attempting to start on such grade instead of keeping in motion all the way upgrade. Suppose such overload causes the slowing down of the entire engine until the balls 8 come to rest upon the brackets 9, or nearly so. In this position the bridging contact 41 will pass off the end of the strips 39 and 40 and break the circuit at this point. Again referring to Fig. 2, it will be seen that the conductor 42 coming from the strip 39 leads to two solenoids 56—56 in multiple. The other ends of these coils are connected to conductors 57 and 58 coming from the controller under the charge of the motorman. The controller referred to is the regular controller under the charge of the motorman, but for the sake of simplicity of illustration such controller is conventionally illustrated in the drawings as a simple switch indicated at 80. The solenoids 56 and the structure shown, diagrammatically therewith are representative of a clutch mechanism forming a part of our general system but which need not be here described in detail and need not be further considered than to state that by this clutch mechanism the engine may be thrown into and out of gear with the car axles.

The clutch may be held in the inactive position by a spring and moved into active position in one direction or the other by one or the other of the solenoids against the action of such spring so that when the circuit of the solenoids is broken the clutch will return to the inactive position under the influence of the spring or springs. This clutch and the parts controlled thereby form no part of the present invention but is fully shown and described in our application No. 385,645, for speed changing gear, filed July 26, 1907.

When the engine is unclutched from the car axles and thus put on practically no load it will immediately speed up and put the clutch into action because the circuit would be again closed by the bridge 41 and, the load still remaining, would again slow down and the engine be again unclutched, and so on. This would, of course, be detrimental to the system, and so we have devised a means which we may term an overload relay which we will now proceed to describe.

Referring, now, to Fig. 2, there is shown a cylindrical casing 59 containing a solenoid 60 which may be made to have a comparatively feeble pull by being formed of a few turns of large wire. One end of the casing is formed with an axial stud 61 constituting one of the pole pieces of the solenoid, and the other end of the solenoid may be covered by a suitable cap plate 62. The armature 63 of the solenoid is provided with a guide pin 64 adapted to a central hole or recess in the stud 61, and at the other end the core 63 carries a metallic plate 65 which may be made of brass or bronze or some other suitable material. This plate is of sufficient size to slide easily within the cylinder but is insulated at its edges therefrom, as indicated, and is also insulated from the armature 63. Between the plate 65 and the plate 62 the armature 63 is surrounded by a spring 66 which for the purposes of this structure need not be of much strength. The end of the cylinder 59 is closed by a screw-plug 67 so that on the removal of the latter access may be had to the interior of the cylinder. Screwed through the sides of the cylinder 59 at diametrically opposite points and between the head 62 and plate 65 are two plugs 68—69, the latter being insulated from the cylinder. Within the cylinder each of these plugs is provided with a socket 70 in which plays a pin 71 acted upon by a spring 72 within the socket so that the pin 71 is projected for a distance beyond said socket but may be pushed into the same against the action of the spring 72. These pins 71 are made of metal or some other conducting material and are arranged to engage the plate 65, as will hereinafter appear.

The conductor 43 coming from the plate 40 is connected to one terminal of the solenoid 60, and the other terminal of the solenoid is connected to a conductor 73 to be hereinafter referred to. The plug 69 is connected to the conductor 73 by a branch conductor 74 and the plug 68 is connected by a branch conductor 75 to another conductor 76 coming from the main line conductor of the power dynamo carried by the car. It will thus be seen that when the solenoid 60 is included in a charged circuit its armature 63 is pulled against the tension of the spring 66 and the plate 65 is brought into contact with the pins 71. Under these conditions, current will flow through conductor 76 coming from the main power circuit through the branch conductor 75, plug 68, pin71, plate 65, the other pin 71, plug 69, branch conductor 74, conductor 73, thence through the solenoid by conductor 43 to the plate 40, thence across the bridge 41 to the plate 39, thence by conductor 42 to one or the other of the solenoids 56 and by conductor 57 or 58 to the controller on the car and back to the other side of the main power circuit by a conductor (not shown). In tracing this circuit it is assumed that the conductors 73 and 76 beyond the overload relay, which includes the solenoid 60, are normally on open circuit, and in the operation of the system this is true, since it is designed that this circuit shall be closed but momentarily for a purpose which will presently appear.

Now, let it be assumed that the engine has so slowed down that the bridge 41 has passed off the strips 39 and 40 and so broken the circuit at this point. This causes the deënergization of the solenoid 60 and the expansion of the spring 66 will force the plate 65 away from the pins 71 sufficiently to break contact therewith, it being understood that these pins are so mounted in the sockets 70 as to have only a limited movement outward from the same. The circuit including one or the other of the clutching solenoids 56 being broken, not only at the strips 39 and 40 but at the plate 65 and also between the continuation of the conductors 73 and 76, the clutch will at once uncouple the engine from the car axles; and even though the engine speed up and the bridge 41 again complete the circuit between the strips 39 and 40, the circuit will remain deënergized, being broken at the plate 65, and the overload relay will remain inactive. However, provision is made in our system for momentarily closing the circuit between the conductors 73 and 76 at a point beyond the overload relay so as to again energize the solenoid 60, but these means form a part of another portion of our complete system and need not be referred to here further than to say that the structure is such that this circuit can be completed only when the controller is set to run a certain transmission gear, forming still another part of our complete system, at its lowest speed, and, therefore, in position to develop the greatest power factor. Thus if the motorman should stop the car on a grade upon which he should not have stopped, the engine will automatically refuse to propel the car until the motorman has moved the controller to the lowest speed. Under these conditions the circuit across the conductors 73 and 76 is completed and the solenoid is energized. This draws the plate 65 toward the pins 71 until in contact therewith and the circuit between the strips 39 and 40 being already completed through the bridge 41 by the speeding of the engine, one or the other of the clutch solenoids 56 will be energized and the engine will be coupled to the car axles, but only at the lowest speed, whereat the greatest power is developed. The temporary circuit between the conductors 73 and 76 may now be broken, since the solenoid 60 is included in complete shunt circuit across these conductors 73 and 76.

From all the foregoing, it will be seen that there is provided an engine governor whereby an engine of the explosive or internal combustion type may have a very wide range of power output without sacrifice of efficiency, and whereby any attempt to drive the engine under onerous conditions will be defeated by the automatic uncoupling of the engine from the load, the running conditions to be again established only when the engine is placed in proper speed relation to the load.

We claim:—

1. A governor for multi-cylinder explosive engines, in which engines the cylinders constitute a plurality of power units, said governor being responsive to various speeds of the engine and having means for cutting into and out of action a plurality of additional cylinders in regular order and each at full charge, said governor being inactive to a predetermined group of cylinders and remaining inactive to the additional engine cylinders until the predetermined group of cylinders is over-loaded, and then cutting the additional cylinders into full action, one power unit at a time, in regular order, as the load increases, and in accordance with such increase of load.

2. A governor for multi-cylinder explosive engines, in which engines the cylinders constitute a plurality of power units, said governor comprising a centrifugal member responsive to various speeds of the engine, and controlling means connected to and actuated by the centrifugal member for cutting into and out of action a plurality of additional engine cylinders in regular order and at full charge, by and in accordance with variations of load, said controlling means being inactive to a predetermined group of cylinders and remaining inactive to the additional engine cylinders until the predetermined group of cylinders is over-loaded and remaining inactive to each additional power unit until the preceding active cylinders are over-loaded.

3. A governor for multi-cylinder explosive engines, having a member responsive to the speed of the engine, a compressed air chamber, a series of leads therefrom, and a valve directly controlling said leads for cutting them into and out of communication with the compressed air chamber in regular order, said valve being positively connected to and under the control of the governor.

4. A governor for multi-cylinder explosive engines having means for cutting engine cylinders into action in proportion to the slowing down and out of action in proportion to the acceleration of the speed of the engine, and retarding means inactive at all times to

slow variations of speed, and active only to speed variations which are both large and rapid.

5. A governor for multi-cylinder explosive engines having means for cutting engine cylinders into action in proportion to the slowing down and out of action in proportion to the acceleration of the speed of the engine, and retarding means active only to large rapid variations in speed but inactive to slow variations of any extent in the speed at any point in the entire range of speed controlled by the governor.

6. A governor for multi-cylinder explosive engines comprising a centrifugal member, means for cutting engine cylinders into action in proportion to the slowing down and out of action in proportion to the acceleration of the speed, and a dash-pot retarder for the centrifugal member active only to rapid variations in the speed of the engine when the variations are both large and rapid.

7. A governor for multi-cylinder explosive engines comprising a centrifugal member, an air chamber, means for conveying compressed air to said chamber, compressed air leads therefrom, and a valve positively connected to said centrifugal member and directly opening or closing the compressed air leads in succession.

8. A governor for multi-cylinder explosive engines comprising a centrifugal member, an air chamber, means for conveying compressed air to said chamber, compressed air leads therefrom, a valve positively connected to said centrifugal member and directly opening or closing the compressed air leads in succession, and a dash-pot retarder for the centrifugal member.

9. A governor for multi-cylinder explosive engines comprising a governing member responsive to speed variations, means under the control of said governing member for cutting engine cylinders into action in proportion to the slowing down and out of action in proportion to the acceleration of the speed, and a dash-pot retarder for said governing member active to variations in the speed of the engine in both directions only when such variations are both large and rapid.

10. A governor for multi-cylinder explosive engines having means for cutting engine cylinders into action in proportion to the slowing down and out of action in proportion to the acceleration of the speed of the engine, and retarding means active to both a rise and fall of the speed throughout the entire range of speed controlled by the governor when the variations are large and rapid but inactive to slow variations of speed or rapid variations of speed of small extent.

11. A governor for multi-cylinder explosive engines responsive to changes in the speed of the engine and having means for cutting engine cylinders into action in proportion to the slowing down and out of action in proportion to the acceleration of the speed of the engine, an electrically operated clutch for connecting the engine to the car axles, electric circuit terminals under the control of the governor with means coacting therewith for breaking the circuit at said terminals under abnormally low speed of the engine, and another circuit breaker in the same circuit out of the control of the governor and acting to break the circuit at another point when broken by the governor.

12. A governor for multi-cylinder explosive engines comprising a centrifugal member responsive to speed variations of the engine; a retarding means for the centrifugal member responsive only to large, rapid variations in the speed of the engine; means under the control of the governor for cutting engine cylinders into action in proportion to the slowing down and out of action in proportion to the acceleration of the speed of the engine; a sparking circuit for certain of the engine cylinders; means under the control of the centrifugal member for breaking said sparking circuit when the engine exceeds a predetermined speed; electro-responsive means for coupling the engine to the load; an electric circuit including said electro-responsive means; electric circuit terminals under the control of the centrifugal member for breaking the circuit through the electro-responsive means when the speed of the engine is below a certain predetermined point, and other circuit controlling means out of the control of the governor for breaking the circuit including the electro-responsive means at another point when broken by the operation of the centrifugal member.

13. A governor for multi-cylinder explosive engines having means for cutting engine cylinders into action in proportion to the slowing down and out of action in proportion to the acceleration of the speed of the engine, and a dash-pot for controlling the governor said dash-pot having a long range of movement but being of small cross-sectional area to provide a correspondingly long movement of the dash-pot before it becomes active to retard the governor.

14. A governor for multi-cylinder explosive engines, comprising a centrifugal member and a dash-pot for controlling the governor comprising an annular chamber, an annular piston fitting therein, and connections between the piston and the governor.

15. A governor for explosive engines comprising centrifugal members, an annular chamber, a spring housed therein, and an annular piston connected to the centrifugal members and movable in the said chamber against the action of the spring.

16. A governor for explosive engines com-

prising centrifugal members, an annular chamber closed at one end, a spring housed in said chamber, and an annular piston connected to the centrifugal members and entering the open end of the chamber and engaging the spring.

17. A governor for explosive engines comprising a sleeve fixed upon a rotatable member receiving motion from the engine, an annular chamber formed therein and having one end closed, a spring housed in said chamber, an annular piston movable longitudinally on the sleeve and having one end entering the open end of the chamber and engaging the spring, and centrifugal members mounted upon the sleeve and connected to the piston to impart longitudinal movement thereto when the centrifugal members become active as the speed increases.

18. In a governor for explosive engines, a sleeve mounted upon and fixed to the rotatable shaft receiving motion from the engine and having a chamber formed therein with one end permanently closed, centrifugal members mounted upon the sleeve, a spring housed in the chamber, and a piston entering the open end of the chamber and connected to the centrifugal members.

19. In a governor for explosive engines, a sleeve mounted upon and fixed to the rotatable shaft receiving motion from the engine and having a chamber formed therein with one end permanently closed, centrifugal members mounted upon the sleeve, a spring housed in the chamber, a piston entering the open end of the chamber and connected to the centrifugal members, a chamber receiving air under pressure, a series of leads therefrom, and a valve positively connected to the centrifugal members and movable thereby to close or open the leads from the pressure chamber as the speed increases or decreases.

20. A governor for multi-cylinder explosive engines responsive to the speed of the engine, means controlled by the governor for cutting engine cylinders into action in proportion to the slowing down and out of action in proportion to the acceleration of the speed of the engine, a bridging contact movable by the governor through a predetermined range of movement, a spark circuit for the engine, and circuit terminals in the path of the bridging contact and of such length that the bridging contact will move off of said circuit terminals only when the engine cylinders controlled by the governor have all been cut out and the speed is further increased.

21. A governor, for engines, responsive to speed variations, and means controlled by said governor for uncoupling the engine from the load when the engine is slowed down abnormally.

22. An engine governor responsive to speed variations, means controlled by said governor for uncoupling the engine from the load when the engine is slowed down abnormally, and means for preventing recoupling of the engine to the load when the speed again becomes normal.

23. An engine governor responsive to speed variations, electrically operated means for coupling the engine to the load, means under the control of the governor for breaking the circuit controlling the coupling means, and another circuit breaker under the control of the coupling circuit and moved to open circuit position on the breaking of the coupling circuit by the governor.

24. An engine governor responsive to speed variations, electrically operated means for coupling the engine to the load, means under the control of the governor for breaking the circuit controlling the coupling means and another circuit controlling means held in closed position by the current flowing through the circuit controlling the coupling means and provided with means for moving it to open circuit position when the coupling circuit is broken by the governor.

25. An engine governor responsive to speed variations, electrically operated means for coupling the engine to the load, and means under the control of the governor for breaking the circuit controlling the coupling means.

26. An engine governor responsive to speed variations, electrically operated means for coupling the engine to the load, circuit terminals included in the circuit controlling the coupling means, and a bridging means for said circuit terminals movable over both said circuit terminals by the governor and having a greater range of travel in the direction of movement of the governor when the engine slows down than the length of said circuit terminals so that when the engine slows down abnormally the bridging member will move off the circuit terminals and so break the circuit.

27. An engine governor responsive to speed variations, electrically operated means for coupling the engine to the load, a circuit breaker in the circuit controlling the coupling means, means under the control of the governor for opening the circuit at the circuit breaker when the engine is slowed down abnormally, and another circuit controlling means under the control of the coupling circuit and included in said circuit, said last named circuit controlling means having a normal tendency to rupture the circuit and held in the closed position by the flow of current through the circuit controlling the said coupling means.

28. An engine governor responsive to speed variations, electrically operated means

for coupling the engine to the load, means under the control of the governor for breaking the circuit controlling the coupling means, an electro magnetic circuit-controlling means included in the circuit controlling the coupling means, and a shunt controlled by the said electro magnetic means.

In testimony that we claim the foregoing as our own, we have hereto affixed our signatures in the presence of two witnesses.

WILLIAM C. MAYO.
JOHN HOULEHAN.

Witnesses:
W. A. WARNOCK,
JOHN L. SPADER.