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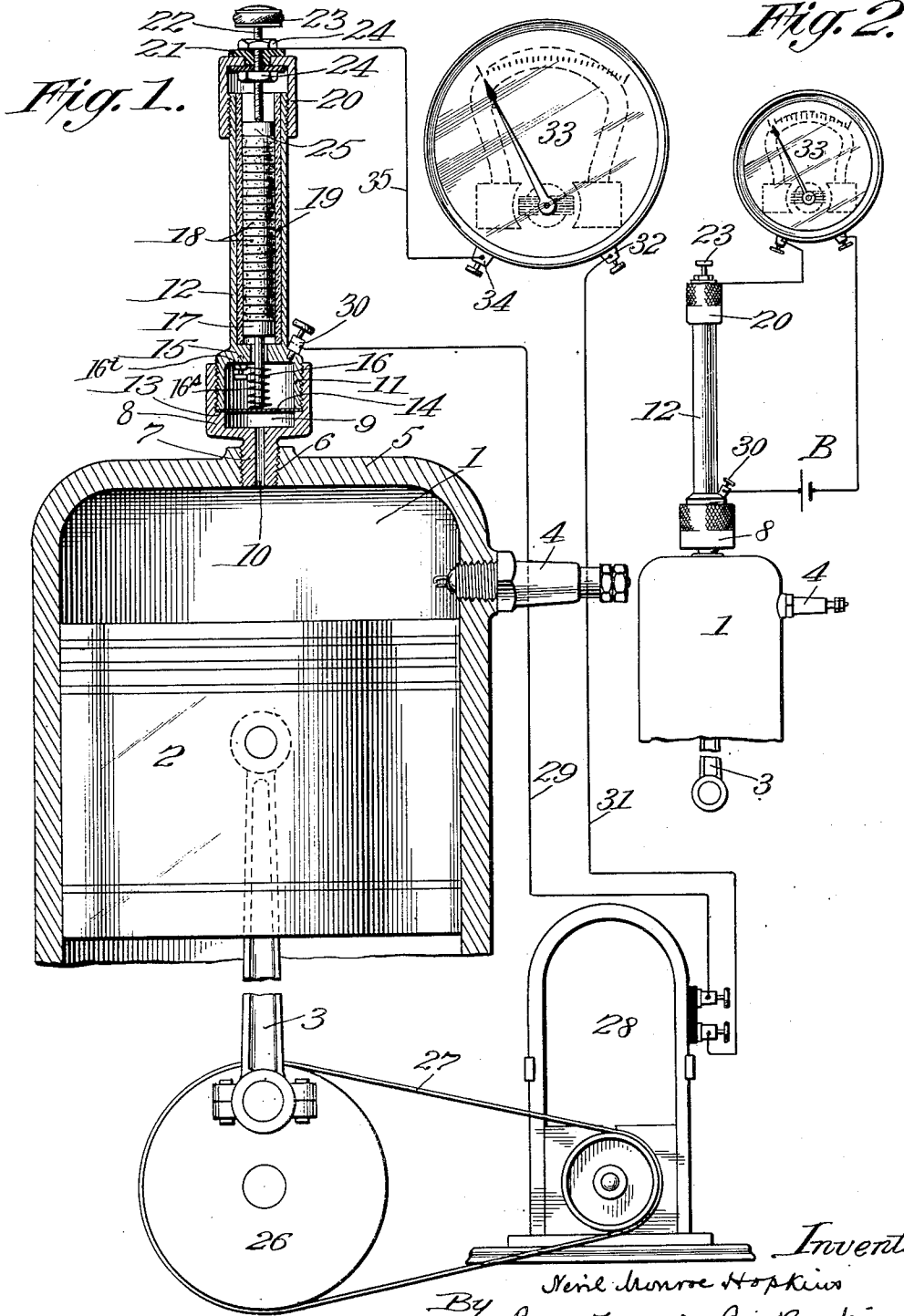
INDICATOR.

APPLICATION FILED APR. 29, 1915.

Patented Mar. 30, 1920.

2 SHEETS—SHEET 1.

1,335,238.



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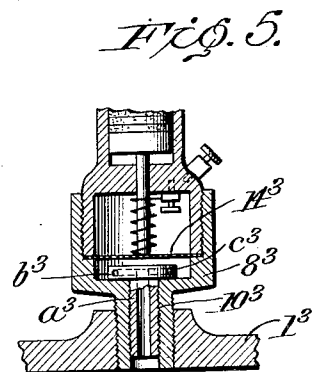
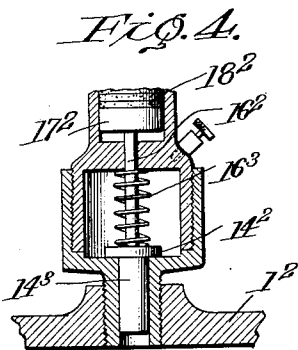
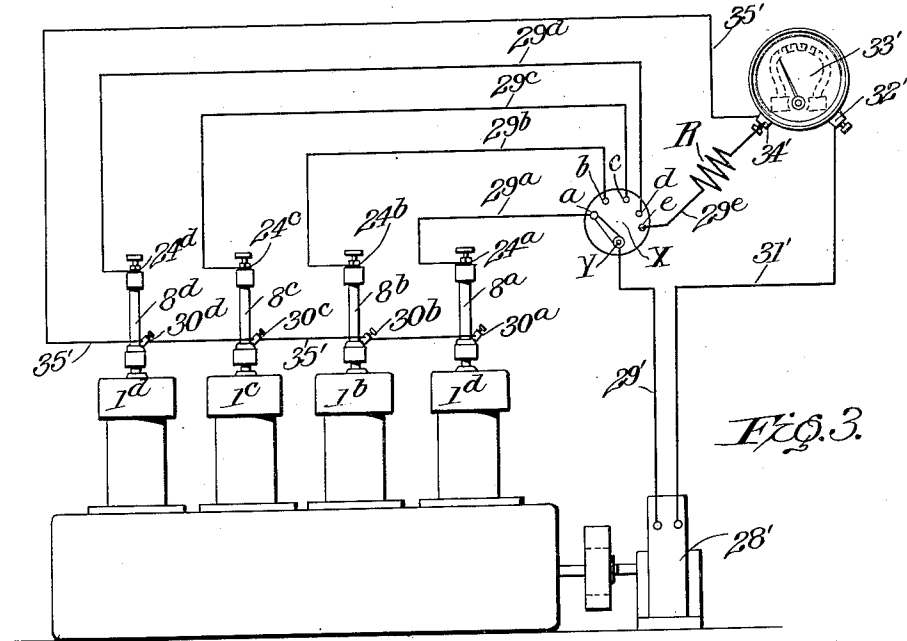
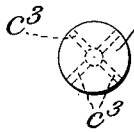


FIG. 5a



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UNITED STATES PATENT OFFICE.

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INDICATOR.

1,335,238.

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To all whom it may concern:

Be it known that I, NEVIL MONROE HOPKINS, a citizen of the United States, residing at Washington, in the District of Columbia, have invented certain new and useful Improvements in Indicators, of which the following is a specification.

This invention relates to a system for continuously indicating the performance of an internal combustion engine or a steam-engine or a turbine or any prime-mover in which pressure and speed are factors.

The object of this invention is to provide an inexpensive and ready means attachable, for example, to the cylinders of an internal combustion engine, and especially to the several cylinders of a multi-cylinder internal combustion engine, and one which will enable the operator to see the continuous performance of the engine not only in respect to carbureter adjustment, mechanical output, etc., but also to compare the relative amounts of work performed in each cylinder.

Heretofore, indications of the action of internal combustion engines, steam-engines, and the like have been made upon diagrams drawn upon revolving drums, complex curves being thus obtained from which the rate of work may be learned by calculating the areas of the cards, etc. This method, being rather delicate, is only possible in the hands of the skilled engineer, and is practically inapplicable as a device for general use.

According to the present invention, by means of several compression members, each making a gas-tight joint with the respective cylinder of a multi-cylinder internal combustion engine, and a suitable multi-contact electrical switch, the relative compressions of each cylinder may be compared, the relative seating of the various valves, the snugness of the various piston rings, etc., may be tested. The device will not only indicate defects in compression, but will also exhibit at once defects in ignition, and the cylinder of a series failing to ignite its charge properly may be located at once with the aid of the multi-contact switch.

The present invention depends upon the simultaneous integration of cylinder-pressure and piston-speed, and comprises briefly a pressure-member connected with the interior of the engine-cylinder, and provided with a diaphragm subjected to the action of the gas in the cylinder. Beyond the diaphragm, with its stem resting against the latter, there is a small piston, the head or outer end of which is movable within the lower end of an insulated tube, and in this tube there is a column of carbon disks or buttons of low ohmic resistance, forming a variable resistance element. At the outer end of the tube, an insulated adjustment-screw is so mounted that by turning the same in and out the crowding effect between the buttons may be varied at pleasure. Suitable means are provided for causing an electric current to pass through the resistance element, and a suitable meter indicates the amount thereof.

It is a well-known fact that buttons, disks, balls or fragments of carbon, when included in series in an electrical circuit, vary in conductivity according to any variation in pressure brought to bear thereupon, due to the elastic qualities of the carbon. By stacking up a column of carbon disks in an insulated tube, equipping one end with an insulated adjusting screw abutting against the disks, and the other end with a piston resting upon a flexible metallic diaphragm, and providing an opening under said diaphragm in communication with the interior of an engine-cylinder, the value of an electrical current flowing through said column of carbon will be modified by either a rarefaction or compression of the gases in the cylinder of the engine to which the carbon compression device is attached.

The invention will be better understood by reference to the accompanying drawing, wherein is shown one embodiment of the same applied to an internal combustion engine, and in which—

Figure 1 is a vertical section, certain of the parts being shown in elevation;

Fig. 2 is a somewhat diagrammatical illustration of a slightly modified form;

Fig. 3 is a diagrammatical illustration of the invention as used in connection with a multiple-cylinder engine;

Fig. 4 is a vertical section of a portion of the device, showing a modified form of pressure-transmitting device;

Fig. 5 is a vertical section of a portion of the device provided with gas-deflecting means; and

Fig. 5^a is a plan view of the gas-deflecting device.

In the drawing, numeral 1 indicates the cylinder of an internal combustion engine, 2 its piston having the usual rod 3, and 4 represents a spark-plug or other ignition device. In some convenient portion of the outer end of the cylinder 1, preferably in its head 5, as shown, a threaded aperture 6 is formed in which is screwed, gas-tight, the nipple 7 of a shell 8 forming a pressure-chamber 9 in continuous communication with the interior of the cylinder 1 through a restricted passage 10. The interior upper portion of shell 8 is cut away and threaded to receive the threaded collar 11 of a metallic tube 12. When turned into the shell 8, the collar 11 secures in place against the shoulder 13 a metallic diaphragm 14 which becomes subjected to the action of the gas in the cylinder 1 during operation of the motor.

The tube 12, which is preferably of brass, is provided with an apertured partition 15, through the aperture of which plays the stem or rod 16 of a small piston, the lower or inner end of which rests upon the diaphragm 14, while its upper or outer end 17 supports a column of carbon disks or buttons 18, of low ohmic resistance. To insure electrical connection between the tube 12 and the rod 16, a coil 16^a is preferably wound rather snugly about the latter, its upper end being suitably secured to the tube 12, as by a screw 16^b. The carbon elements 18 are insulated from the outer metallic tube 12 by means of a non-conducting sleeve or tube 19, preferably of glass. The outer end of the tube 12 is closed by means of a threaded apertured cap 20. Through the aperture of this cap but insulated therefrom by a suitable bushing, washers, or the like 21, is a set-screw 22, having a suitable thumb-piece 23 and binding-nuts 24. The inner end of the screw extends within the glass tube 19 and strikes against the outermost of the carbon disks 18, or, as illustrated, against a suitable follower 25.

Connected to any rotating member 26 of the engine, as by a chain-drive 27, or by any other convenient mechanism, is a low-voltage direct-current magneto-generator 28, electrically connected through wire 29 with a terminal 30 near the base of the tube 12, and through a wire 31 with a terminal 32 of

a suitable meter 33, preferably a milli-ampere meter of low ohmic resistance, which meter may be of course calibrated in any desired units. Through the other terminal 34 of the meter, and wire 35, electrical connection is made with the binding-nut 24 of the set-screw 22.

In operation, as will be readily understood, an E. M. F. will be generated as the piston 2 moves to and fro in the cylinder 1, and a current will be produced which is in direct proportion to the speed of the piston 2. The current will flow through wire 29, terminal 30, rod 16, carbon disks 18, set-screw 22, and wire 35 to the meter 33, whence it will return through wire 31 to the generator 28. As the piston 2 makes its out-stroke and gas is compressed in the end of the cylinder, the pressure is transmitted through the passage 10 and the chamber 9 to the inner side of the diaphragm 14. According to the degree of pressure, the diaphragm is forced outward, lifting with it the rod 16 and thereby causing the disks 18 to be packed tightly together, this effect being regulated by adjustment of the set-screw 22. The conductivity of the resistance element 18 is materially increased by this compression of its component parts, and this increase, which is to an extent proportional to the degree of compression, is indicated by the consequent deflection of the pointer of the meter 33.

If, during a test, the speed of the piston 2 is slow for some reason, the horse-power will be low, and this will be directly reflected in the subnormal performance of the generator 28, and in turn will be indicated by the meter 33. A leaky valve, a misfitting piston ring, a defect in ignition, etc., will cause a decrease in the pressure transmitted to the diaphragm 14. The resistance of the element 18 will be increased, and such a variation will be at once obvious from the reading of the meter 33.

From the foregoing description, it will be apparent that by the use of the present indicator, not only may faulty compression be detected, but also that a ready and continuous measure of the rate of work or horse-power of the engine is exhibited.

Although the system above described is based upon the use of a direct current, as fundamentally described, it could obviously be operated with alternating current instruments, without departing from the scope of the invention. For structural reasons, the direct-current equipment is preferred.

If it is desired to study compression only, the seating of valves, the tightness of piston-rings, or to compare in this respect one cylinder with another, a cell or battery B (see Fig. 2) may be used instead of the synchronously driven magneto-generator. Piston-

speed, horse-power, etc., would not of course then be factors in the meter-readings.

Also, by providing several of the compression members, one for each cylinder, the relative conditions of working of the several cylinders of multi-cylinder engines may be ascertained. Such a system is illustrated somewhat diagrammatically in Fig. 3. Each of the several cylinders 1^a , 1^b , 1^c , and 1^d is provided with a pressure-device 8^a , 8^b , 8^c , and 8^d , respectively, the lower terminals 30^a , 30^b , 30^c , and 30^d , of which are all electrically connected by wire $35'$ with the binding-post $34'$ of the galvanometer. In the circuit, between the source of current $28'$ and the first pressure device 8^a , there is interposed a suitable switch X having a series of contacts a , b , c , and d , electrically connected through wires 29^a , 29^b , 29^c , and 29^d , respectively, with the binding-nuts 24^a , 24^b , 24^c , and 24^d of the several pressure-devices. The primary contact Y of the switch is electrically connected through the wire $29'$ to the source of power, and the latter is connected to the meter by the conductor $31'$, as before. It will be obvious that by moving the switch-arm over the various contacts a , b , c , and d , when the engine is running, any one of the cylinders may be tested in the manner heretofore described.

By supplying the switch X with an additional contact e and a meter-connection 29^e , it will be apparent that the device may be used as a tachometer, all of the pressure-devices being cut out of the circuit when the arm of the switch is moved over the contact e . In such case, however, it will be necessary to insert in the connection 29^e a calibrated wire resistance R , or its equivalent, to make the meter $33'$ indicate the true R. P. M., as will be readily understood.

The metallic diaphragm 14 may be dispensed with in certain cases, and such a device as that shown in Fig. 4 substituted. As illustrated, the stem 16^2 of the plunger 17^2 is somewhat lengthened and rests upon the head 14^2 of a piston or plunger 14^3 . The lower end of the plunger 14^3 is in direct communication with the interior of the cylinder or other pressure-chamber 1^2 , and any movement thereof due to variations of pressure will be imparted to the rod 16^2 , and therefore, as before, to the carbon elements 18^2 of the resistance. A suitable spring 16^3 may be provided to maintain the plunger 14^2 in its normal inward position.

Also, it may be desirable to provide some means for preventing direct contact of hot gases or products of combustion with the diaphragm, and such an arrangement is shown in Figs. 5 and 5^a . In the aperture 10^3 of the cylinder 1^3 , which aperture may for this purpose be somewhat enlarged, there is threaded or otherwise secured a hollow

plug a^3 having a radially bored head b^3 , shown in plan in Fig. 5^a . The gases from the cylinder 1^3 forced through the passage of the plug a^3 will travel radially outward through the openings c^3 , and a substantial amount of heat thereof will be absorbed by the metal shell 8^3 before impingement of the gases upon the metallic diaphragm 14^3 . The temper and life of the latter will therefore be preserved.

I claim:

1. The combination of a fluid pressure chamber, of a secondary pressure chamber in open communication with the first, a variable resistance comprising a column of carbon elements, means for transmitting pressure from said secondary pressure chamber to said column of elements, an electrical circuit including said variable resistance, a galvanometer and a source of current.

2. The combination with a fluid-pressure chamber, of a secondary pressure-chamber in open communication with the first, a diaphragm in the secondary chamber, a variable resistance comprising a column of carbon elements, means for transmitting pressures upon said diaphragm to said column of elements, and an electrical circuit including said variable resistance, a galvanometer, and a source of current.

3. The combination with an engine cylinder, of a fluid-pressure chamber in open communication with said cylinder, a diaphragm in said chamber, a variable resistance comprising a column of carbon elements, means for transmitting pressures upon said diaphragm to said column of elements, and an electrical circuit including said variable resistance, a galvanometer, and a dynamo driven by said engine.

4. The combination with a fluid-pressure chamber, of a detachable secondary pressure-chamber in open communication with the first, a diaphragm in the secondary chamber, a variable resistance comprising a column of carbon elements, means for transmitting pressures upon said diaphragm to said column of elements, and an electric circuit including said variable resistance, a galvanometer, and a source of current.

5. The combination with a fluid-pressure chamber, of a detachable secondary pressure-chamber in open communication with the first, a diaphragm secured transversely of said secondary chamber, a variable resistance comprising a column of carbon elements, a plunger between said diaphragm and the inner end of the column of elements for transmitting pressures to said column, and an electric circuit including said variable resistance, a galvanometer, and a source of current.

6. The combination with a fluid-pressure chamber, of a detachable secondary pressure-

chamber in open communication with the first, a diaphragm in the secondary chamber, a variable resistance comprising a column of carbon elements, means for transmitting pressures upon said diaphragm to the inner end of said column of elements, means for adjusting the tightness of said carbon elements from the outer end of the column, and an electric circuit including said variable resistance, a galvanometer, and a source of current.

7. The combination with a fluid-pressure chamber, of a detachable shell having its interior in open communication with said chamber to form a secondary pressure-chamber, a diaphragm in the secondary chamber, a metallic tube connected to said shell, a variable resistance in said tube comprising a column of carbon elements, insulating means between said tube and said carbon ele-

ments, means for transmitting pressures upon said diaphragm to said column of elements, and an electric circuit including said variable resistance, a galvanometer, and a source of current.

8. The combination of an engine cylinder, a variable resistance, means for causing variations of pressure in said cylinder to vary said resistance, an electrical circuit including said resistance, a dynamo driven by the engine and an indicator and a switch for cutting out said resistance to provide a tachometer.

In testimony whereof I affix my signature in presence of two witnesses.

NEVIL MONROE HOPKINS.

Witnesses:

EDITH C. TATE,
CHARLES H. POTTER.