Dec. 13, 1932. C. E. COX 1,890,601

INTERNAL COMBUSTION INDICATOR

Filed July 29, 1929 5 Sheets-Sheet 1

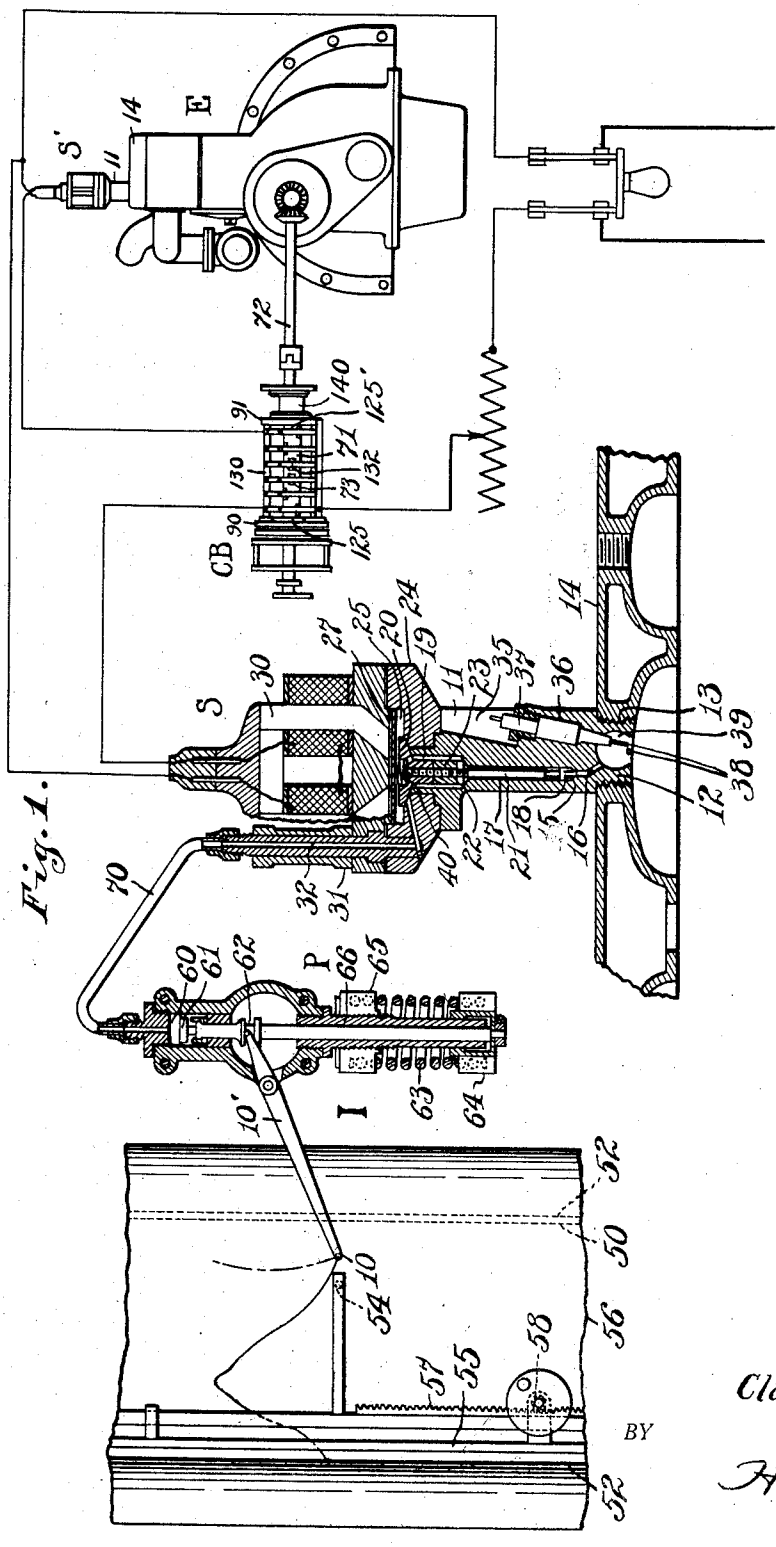


Fig. 1.

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Fig. 3.

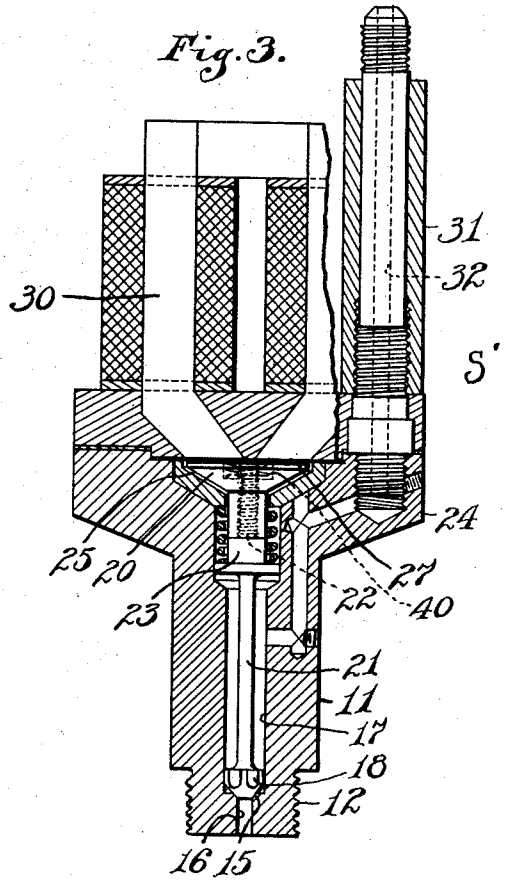
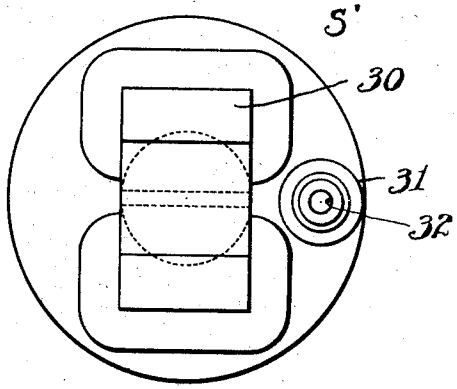


Fig. 2.



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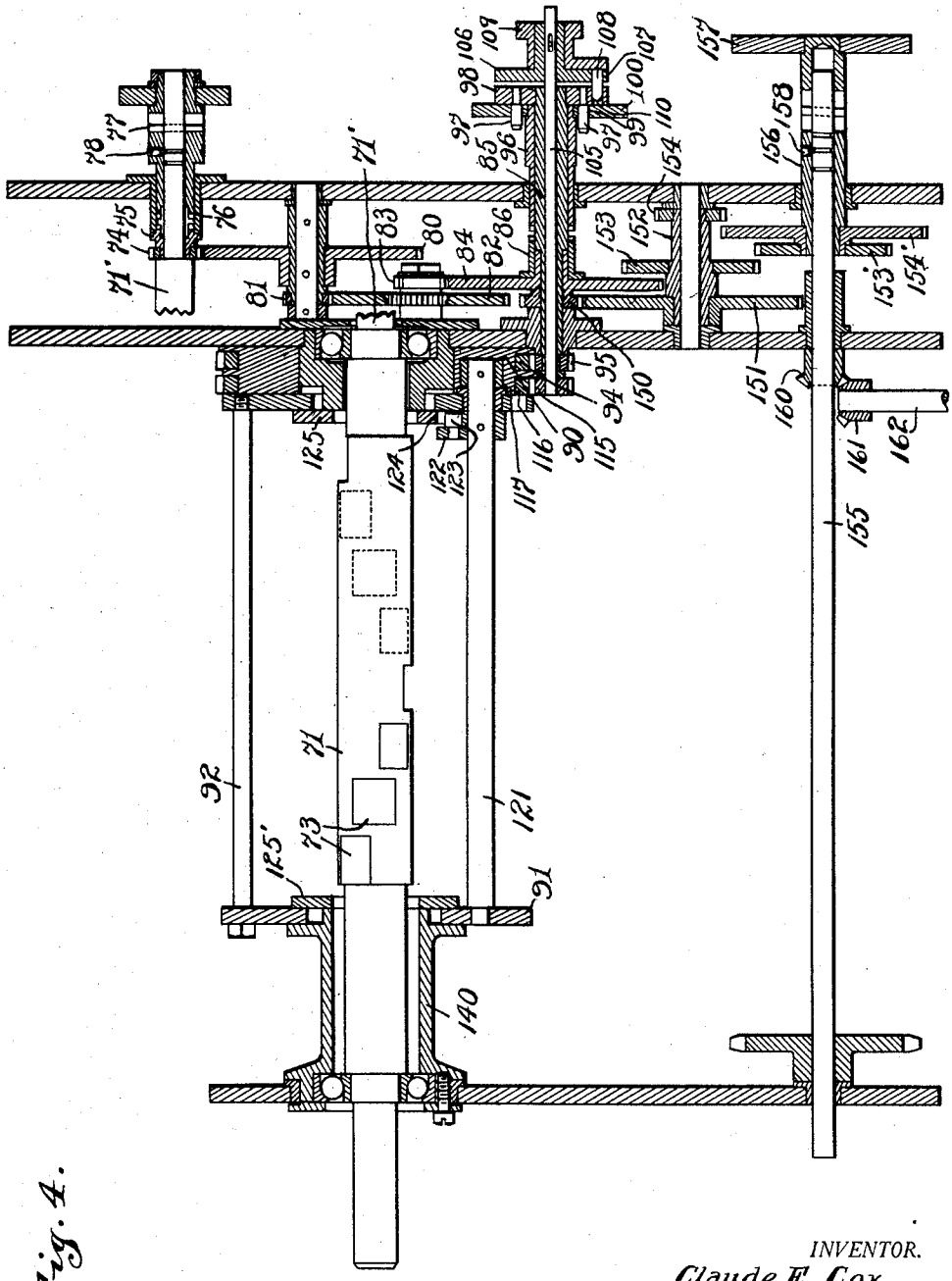


Fig. 4.

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INTERNAL COMBUSTION INDICATOR

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Fig. 7.

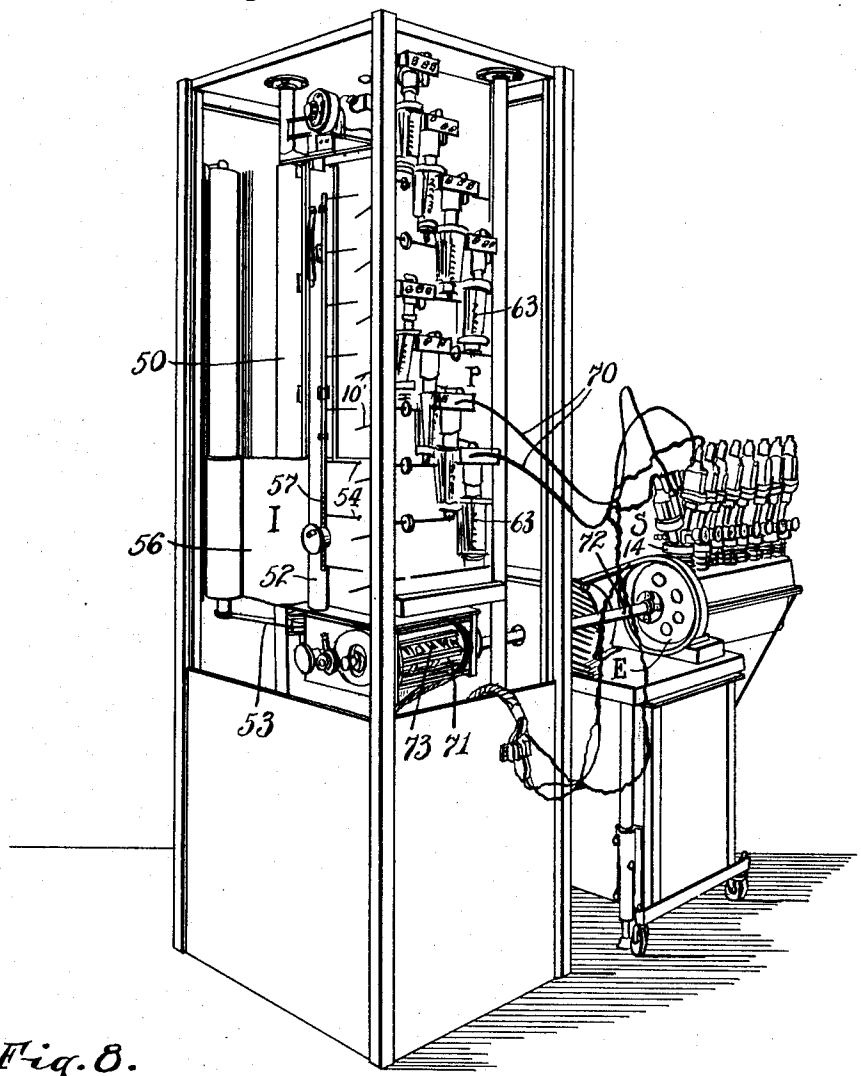
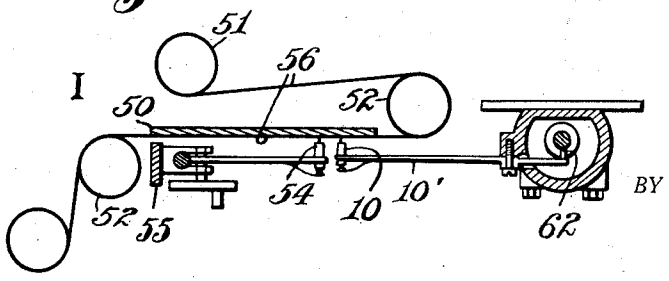


Fig. 8.



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Fig. 5.

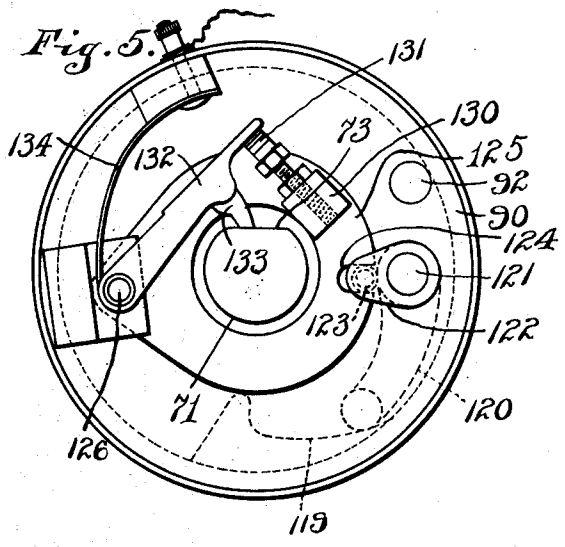
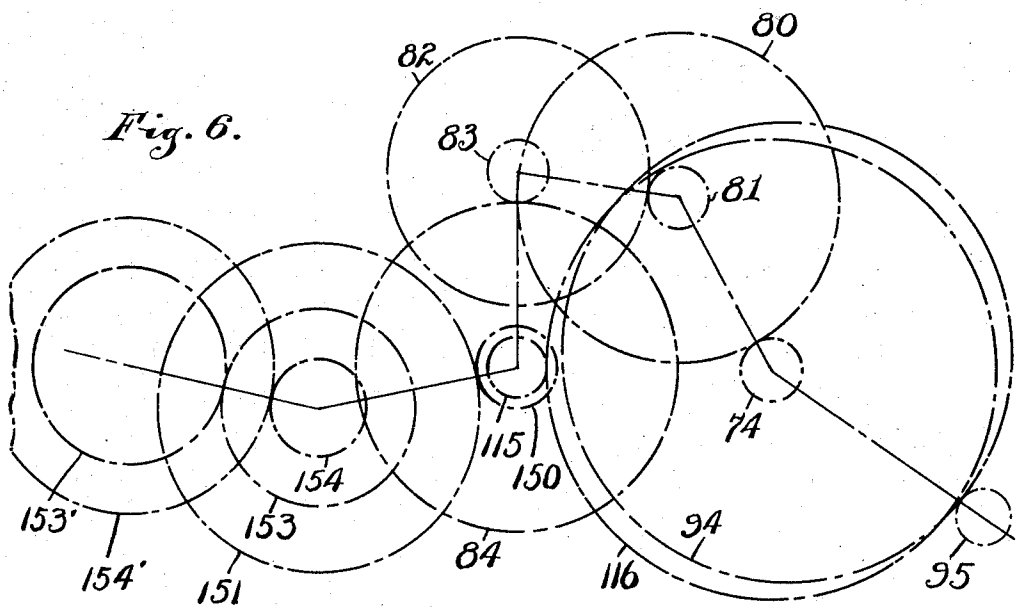


Fig. 6.



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Patented Dec. 13, 1932 1,890,601

UNITED STATES PATENT OFFICE

CLAUDE E. COX, OF DETROIT, MICHIGAN

INTERNAL COMBUSTION INDICATOR

Application filed July 29, 1929. Serial No. 381,993.

The general object of my invention is to produce improved mechanism by means of which diagrams of average pressure conditions within a cylinder of a high speed engine may be produced with a high degree of accuracy at comparatively low speed of diagram production.

A feature of novelty, and probably the most important, is the provision of mechanism by means of which, all of the cylinders of a multi-cylinder engine being equipped with sampling valves, a corresponding number of pressure diagrams may be simultaneously produced in exact working phase relationship, thus enabling a more accurate comparison of pressure conditions in the entire engine than has heretofore been possible.

Another feature of novelty in my device resides in an improved sampling valve by means of which sample pressures, effective upon the diagram drawing mechanism, may be obtained and segregated from the working cylinder at a point at a minimum distance from the cylinder, thereby reducing to a minimum the possibility of pressure fluctuations upon the diagram drawing means, which do not occur within the working cylinder, and which may otherwise be imposed upon the diagram drawing means because of the character of the necessary conduit between the working cylinder and the sampling valve.

Another feature of novelty in my device resides in a combined sampling valve, of the character specified above, and sparking means whereby the need of a special opening for reception of the sampling valve is avoided.

Another feature of novelty in my device resides in the electro-magnetic character of my sampling valve, the simplicity of which makes possible the ready application of diagram drawing means to each cylinder of any engine of common construction without the need of elaborate special equipment.

The accompanying drawings illustrate my invention.

Fig. 1 is a developed view of the apparatus, some of the parts (including one of the sampling valves of the spark-plug form) being shown in axial section;

Fig. 2 is a plan of the sampling valve shown in Fig. 1;

Fig. 3 is an axial section of one form of my improved sampling valve without an immediately associated spark means;

Fig. 4 a schematic diagram of driving and phase changing gearing for the circuit breaker and indicator;

Fig. 5 is a fragmentary section of one element of the circuit breaker;

Fig. 6 is an end elevation of the gearing indicated in Fig. 4;

Fig. 7 a perspective of the recording element, and

Fig. 8 is a diagrammatic plan of the diagram drawing means.

In the drawings E indicates the engine to be tested; I indicates any suitable indicator-card drawing mechanism comprising a drawing tool 10; P a pressure-affected positioning device for the tool 10; S my improved sampling valve embodying sparking terminals; S′ an alterative form of sampling valve; and CB a desirable form of circuit breaker by means of which actuation of the sampling valves may be obtained at any desired phase of a cylinder cycle.

The two illustrated forms of sampling valves S and S′ are, in the main, identical. Each comprises a main body 11 provided at one end with a threaded plug 12 preferably sized for reception in a threaded opening 13 in an engine cylinder 14 capable of receiving a standard spark plug. In the body 11, as close as possible to the end of plug 12, is a small, outwardly-presented valve seat 15 at the outer end of a short, small diameter passage 16 which leads to the end of plug 12. Leading outwardly to the outer end of seat 15 is a valve passage 17 in which is mounted a valve 18.

The upper end of passage 16 is enlarged and provided with circumferentially-spaced inwardly projecting ribs 19 which form a guide for an armature head 20 which is adjustably secured to the outer end of the valve stem 21 by threads 22 and check nut 23. At the outer end of body 11 is a flange 24 which forms a wall of the chamber 25 within which head 20 lies. Head 20 forms an armature

for an electromagnet. Chamber 25 is closed by a non-magnetic plate 27.

Secured to flange 24 is a relatively strong electromagnet 30, the poles of which lie against the outer face of plate 27. Leading from passage 17, through a nipple structure 31 mounted on the base of the electromagnet, is a passage 32.

In the structure S the body 11 is longitudinally grooved, as indicated at 35 (Fig. 1), and chambered at 36 to receive the terminal-carrying porcelain element 37 of a standard spark-plug, the sparking terminals 38 of which are projected into a small chamber 39 at the end of plug 12 and with which the inner end of passage 16 communicates.

Formed in the outer end of head 20 is a pocket in which is a compression spring 40 abutting against plate 27 and serving to normally seat valve 18 on its seat 15.

The indicator mechanism I (Figs. 1, 7, 8) may be of any desired construction and I have indicated one of the open card type comprising a platen 50, paper supply roll 51, guide rolls 52, 52, one of which may be driven from the circuit breaker CB by suitable driving connections 53 (Fig. 7), and a plurality of drawing tools 10. A plurality of drawing tools 54 for drawing "atmosphere" lines or reference lines indicating any desired instant of working cycle for each diagram may be carried by a carrier 55 adjustable laterally of the paper 56 by means of a rack 57 and manually adjustable pinion 58.

The device P may, of course, be of any suitable form having a pressure-affected element adapted to position the tool 10. A convenient structure comprises a cylinder 60 containing a piston 61 connected at 62 with the arm 10′ which carries tool 10. Piston 61 is normally urged to the receiving end of cylinder 60 by a tension spring 63 anchored at one end to a collar 64 rotatively associated with the piston rod and anchored at the other end to a collar 65 axially adjustable on the cylinder body by the threaded mounting 66. Cylinder 60 is connected to nipple 31 of the sampling valve by a pipe 70, preferably of as small volume capacity as practical.

Any suitable timing and phase changing means may be provided for momentarily energizing each electro-magnet 30 and thereby momentarily opening communication between the engine cylinder and cylinder 60 at accurately determinable times throughout the cycles of engine operation. The time interval during which the electro-magnet 30 is energized must, of course, be a very small fraction of the time interval of the stroke of the piston of the engine from one end of its cylinder to the other.

Referring now to Figs. 4 to 6. A cam shaft 71 is connected by a suitable driving connection 72 (Figs. 1 and 7) to the engine to be tested so as to move in synchronism with the engine crank shaft. In a four cycle engine this will be at one-half the speed of the crank shaft. Shaft 71 is provided with a plurality of cam surfaces 73, one for each cylinder to be tested and circumferentially-spaced in accordance with the number of cam surfaces in phase relation with the engine to be tested. This shaft is made readily removable from the instrument now to be described so that any desired shaft with a proper number and circumferential spacing of cam spaces may be substituted, depending upon the number of cylinders in the engine to be tested.

The gearing in Fig. 4 is illustrated schematically, the parts being stretched out into a single plane from the positions indicated by the center line in Fig. 6. In interpreting this figure, therefore, it is to be understood that one end 71′ of shaft 71 is shown as broken off and distorted from its actual position. Journaled on the end 71′ is a pinion 74 having a clutch element 75 adapted to be engaged by a clutch element 76 splined at 77 on the shaft end 71′ and movable into and out of clutching engagement with the clutch element 75, being retained in either one of its two positions by a common form of retainer 78. Pinion 74 meshes with the gear 80 which carries a pinion 81 meshing with a gear 82 which carries a pinion 83 which meshes with gear 84 journaled on a sleeve shaft 85 and provided with a clutch element 86. The train of gears 74—84 forms a speed reduction gear the purpose of which will appear.

Journaled concentric with shaft 71 is a head 90 and a spool 91 which are connected together by suitable connectors 92 so as to be rotatable as a unit.

Head 90 carries a gear 94 which meshes with a pinion 95 on one end of sleeve 85 and slidably mounted on said sleeve 85 is a clutch element 96 which is adapted to be moved into or out of clutching engagement with the clutch element 86, element 86 being splined to sleeve 85 by pins 97 carried by flange 98 secured to the outer end of sleeve 85, which pins are slidable in openings 99 in a head 100 which is secured to the outer end of clutch element 96 by means of which it may be axially shifted.

Journaled in sleeve 85 is a shaft 105 to the outer end of which is secured a flange 106 having a perforation 107 in which is slidably mounted a pin 108 carried by a head 109 slidably connected with the hub of flange 106, pin 108 being so arranged that its free end may be projected into any one of a series of circumferentially spaced notches 110 formed in flange 98, whereby the angular relation between shaft 105 and sleeve 85 may be adjusted. Notches 110 are circumferentially distributed, conveniently at equal distances to provide for various time intervals of magnet current maintenance, so that different energizing-current intervals may be provided for

energization of the magnet, depending upon the speed of the engine and the saturation lag of the magnet.

Secured to the inner end of shaft 105 is a pinion 115 which meshes with a gear ring 116 journaled on a series of circumferentially spaced lugs 117 carried by head 90, pinions 95 and 115 being of the same pitch diameter and gear 94 and gear ring 116 being of the same pitch diameter.

The inner surface of ring 116, between two of the supporting lugs is provided with a cam 119 (Fig. 5) which is engaged by the free end of an arm 120 carried by a rock shaft 121 which is parallel with shaft 71 and is journaled in heads 90 and 91. Shaft 121 carries an arm 122 provided with a pin or roller 123 which takes into a notch 124 in a plate 125 which is pivoted on a rod 126 which extends between heads 90 and 91. A similar plate 125' also pivoted on pin 126, is arranged adjacent head 91 and the two plates 125 and 125' are connected by a grounded bar 130 which carries a plurality of contact points 131 one corresponding to each cam surface 73. Pivoted on a rod 126 is a series of contact fingers 132 which are relatively insulated and which are arranged in registry with the contact points 131, each arm 132 having a bearing block 133, conveniently of insulated material, for engagement with the aligned cam surface 73. Each contact arm 132 is spring pressed toward contacting position with its aligned contact point 131 by a suitable spring 134, said springs conveniently acting as current-carrying members to which the external connection to the magnet current supply are connected. These several wires may be supported by a drum 140 connected to head 91, as will appear.

The construction just described is such that, by shifting gear ring 116 on head 90, by manipulation of head 109 relative to flange 98, the relation of contacts 131 to the contact arms 132 may be varied to vary the time of contact of the several contact arms 132 with the contacts 131. This is necessary because, as compared with the speed of the engine, an appreciable time is required to properly energize the electromagnets to actuate the sampling valves, and hold them open for the desired length of time.

In order to drive the paper supply roll 51 in synchronism with the engine, I provide the following mechanism:

Secured to gear 84, so as to rotate therewith, is a pinion 150 which meshes with a gear 151 secured to a sleeve 152 which carries two gears 153 and 154 of different diameters. Splined upon a shaft 155 is a sleeve 156 which carries two gears 153' and 154' capable of being meshed with the adjacent gears 153 and 154, the sleeve 156 being provided with a head 157 by which it may be manipulated and retaining means 158 of well known form being provided to hold the gear pair 153'—154' in either one of its adjusted positions. Shaft 155 is connected by gears 160 and 161 with a shaft 162 which leads to the paper feed roll, which, as is usual, is provided with pins capable of engaging the paper and feeding it in synchronism with engine speed.

The operation of the circuit maker is as follows:

When clutch 76 is separated from clutch 75 pinions 94 and 95 will be stationary and the cam surfaces 73, coacting with the contact arms 132, will energize the electro-magnets 30 at a predetermined time in the cycle of each working cylinder, thereby opening each sampling valve at the same phase period with relation to the several cylinders. The working cylinder pressure thus obtained, as an average of a multiplicity of operations of each sampling valve will be built up against the appropriate pistons 61 so that the drawing tools 10 will be appropriately positioned. By manipulating head 109 and rotating gear 115 relative to gear 95, the relative position of cam 119 to the free end of arm 120 may be modified so as to shift the contacts 131 toward or from the free ends of the contact arms 132, thereby increasing the contact period of the manget circuit when the bar 130 is set closer to said free ends, and decreasing the contact period when bar 130 is set further away from said free ends. The desired and necessary period of energization of the electromagnets may thus be nicely adjusted relative to the engine speed to not only assure energization of the magnets but to determine the period of energization and thus control the time interval during which the pressure sample is being obtained.

So long as clutch element 96 is out of engagement with clutch element 86, the phase relation of the sampling period will remain the same, and by manual rotation of head 100, pinion 95 acting on gear 94 will angularly shift structure 90—91 so as to change the phase relation of the circuit controlling elements relative to the cam surfaces 73 and thus determine the point in a working cycle at which sampling occurs. By shifting clutch element 96 into engagement with clutch element 86, this phase relation is progressively advanced automatically, thus permitting the automatic production of a complete indicator card. The speed change gears 153'—154', and associate parts are provided in order that the speed of movement of the paper relative to engine speed may be varied.

It will be noted from the preceding description that I have provided mechanism by which indicator cards relating to all of the cylinders of an engine under test, will be simultaneously produced under pressure sampling conditions which are exactly co-

related in all of the indicator diagrams. By shifting the drawing tools 54 to any desired position, datum lines exactly comparable, as to phase relationship, in all of the diagrams may be simultaneously produced, thus greatly increasing the possible accuracy of interpretation of the diagrams.

It will be noted that the time period required for the production of the diagram record of one complete working cycle extends over a period of time occupied by a considerable number of crank shaft revolutions, although the actual time required in the production of a complete pressure cycle record is so comparatively short. That is to say, a diagram may be produced in, say, anywhere from a quarter of a minute to a minute, more or less, while the crank shaft of the engine is making several hundred revolutions. The record sheet will of course be divided longitudinally in time interval indications and a continuous series of indications may be produced throughout a test period, during which test period various changes in carburetor adjustment, spark conditions etc., may be changed and the effect of these changes readily observed because of the relatively slow production of the indicator cards. Various inlet and exhaust manifolds may be substituted one for the other, changes in cylinder head constructions, valve arrangements and combustion spaces may be changed and the effects of these various changes may be readily recorded, observed during the production of the records and subsequently compared. As a consequence, it has been found possible, from records produced with this instrument, to reach much more accurate conclusions as to the effect of various structural characteristics of high speed engines than has heretofore been considered possible.

I claim as my invention:

1. Recording means for concurrent pressure conditions in the several cylinders of a multi-cylinder engine, comprising a plurality of substantially simultaneously actuable recording means, one for each engine cylinder, a coordinated plurality of pressure-affected means interposed between said recording means and cylinders, and a single means synchronized with the engine for activating all of said pressure-affected means in common phase relation with the engine.

2. Recording means for concurrent pressure conditions in the several cylinders of a multi-cylinder engine, comprising a plurality of substantially simultaneously actuable recording means, one for each engine cylinder, a coordinated plurality of pressure-affected means interposed between said recording means and cylinders, and a single means coordinated with all of said pressure-affected means for determining the activity of said pressure-affected means relative to their recording means at various phase relations in the working cycle of the engine.

3. Recording means for concurrent pressure conditions in the several cylinders of a multi-cylinder engine, comprising a plurality of substantially simultaneously actuable recording means, one for each engine cylinder, and each comprising a pressure-affected element, a plurality of sampling valves interposed one between each cylinder and its associated pressure-affected element, and a single means for controlling the opening of all of said sampling valves at successive intervals for relatively short periods in concurrent phase relation with the engine cycle.

4. A pressure sampling valve comprising a tubular main body formed at one end for immediate connection with an engine cylinder and having therein a valve seat closely adjacent said end, a normally closed valve seating on said seat, and means pressure-isolated from the valve by which said valve may be momentarily opened, said means being carried by and transportable with the tubular main body.

5. A sampling valve of the character defined in claim 4 wherein the means for opening the valve is an electro-magnet.

6. A sampling valve of the character defined in claim 4 wherein the means for opening the valve is an electromagnet pneumatically isolated from the valve by a non-magnetic diaphragm.

7. A sampling valve of the character specified in claim 4 wherein sparking terminals are arranged therein on the engine cylinder side of the valve seat and closely adjacent thereto.

8. A sampling valve comprising a tubular body provided at one end with a threaded portion formed for reception in a standard spark plug opening of an internal combustion engine, a passage through said main body having a valve seat closely adjacent the free end of said threaded portion, a normally closed valve associated with said seat, and ignition means arranged in said body between the valve seat and the engine cylinder end of the body.

9. A circuit controller comprising a plurality of independently movable relatively insulated terminals, a common terminal arranged to be contacted by all of said first-mentioned terminals, means for actuating said first-mentioned terminals in a predetermined cycle, and means by which the common terminal may be adjusted to simultaneously vary the contacting relation between it and the plurality of terminals.

10. Recording means for concurrent pressure conditions in several cylinders of a multi-cylinder engine, comprising a record-receiving element and means for driving the same, a plurality of record-producing elements arranged to act upon predetermined

portions of the receiving element, a second plurality of record-producing elements spaced in the predetermined relationship of the first-mentioned plurality of record-producing elements, and means for simultaneously and equally adjusting said second plurality of record-producing elements transversely of the line of movement of the record-receiving element.

11. A pressure-sampling valve comprising a tubular body formed at one end for threaded insertion in a standard spark-plug opening of an internal combustion engine, a valve seat formed within said body closely adjacent said threaded end, a valve co-operating with said valve seat, means for normally holding said valve upon its seat, an electro-magnet mounted on said tubular body and pneumatically isolated from the valve and its seat and an armature carried by the valve within the field of said magnet.

12. A pressure-sampling valve comprising a tubular body formed at one end for threaded insertion in a standard spark-plug opening of an internal combustion engine, a valve seat formed within said body closely adjacent said threaded end, a valve cooperating with said valve-seat, means for normally holding said valve upon its seat, an electro-magnet mounted on said tubular body and pneumatically isolated from the valve and its seat, an armature carried by the valve within the field of said magnet and sparking terminals carried by and within said tubular body on the inlet side of the valve seat.

13. A pressure-sampling valve comprising a tubular body formed at one end for threaded insertion in a standard spark-plug opening of an internal combustion engine, a valve seat formed within said body closely adjacent the threaded end, a non-magnetic diaphragm closing the other end of the tubular body, a valve mounted in the bore of said body between the diaphragm and said valve seat, an electromagnet mounted on said body with its poles outside but closely adjacent the diaphragm, and an armature carried by the valve closely adjacent the diaphragm and within the field of the magnet poles.

14. A pressure-sampling valve comprising a tubular body formed at one end for threaded insertion in a standard spark-plug opening of an internal combustion engine, a valve seat formed within said body closely adjacent the threaded end, a non-magnetic diaphragm closing the other end of the tubular body, a valve mounted in the bore of said body between the diaphragm and said valve seat, an electro-magnet mounted on said body with its poles outside but closely adjacent the diaphragm, an armature carried by the valve closely adjacent the diaphragm and within the field of the magnet poles and sparking terminals carried by and within said tubular body on the inlet side of the valve seat.

In witness whereof, I, CLAUDE E. COX, have hereunto set my hand at Indianapolis, Indiana, this 6th day of July, A. D. one thousand nine hundred and twenty-nine.

CLAUDE E. COX.