

Aug. 22, 1961

S. B. SILVERSCHOTZ

2,997,552

PRINTED CIRCUIT DISTRIBUTOR

Filed Sept. 1, 1959

2 Sheets-Sheet 1

Fig. 1

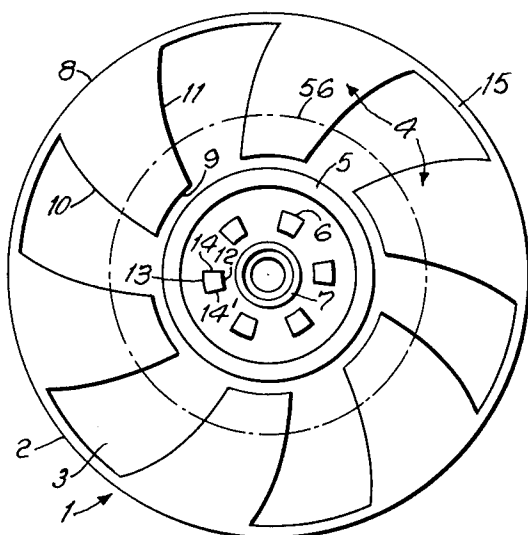


Fig. 5

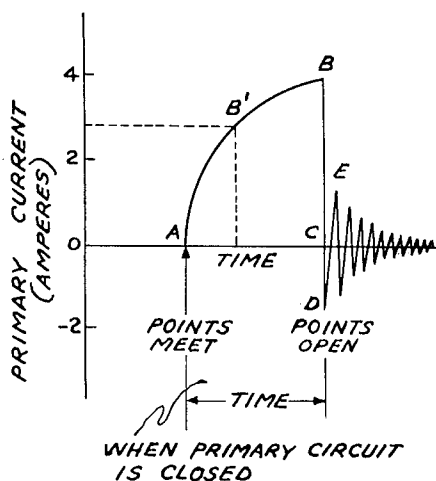
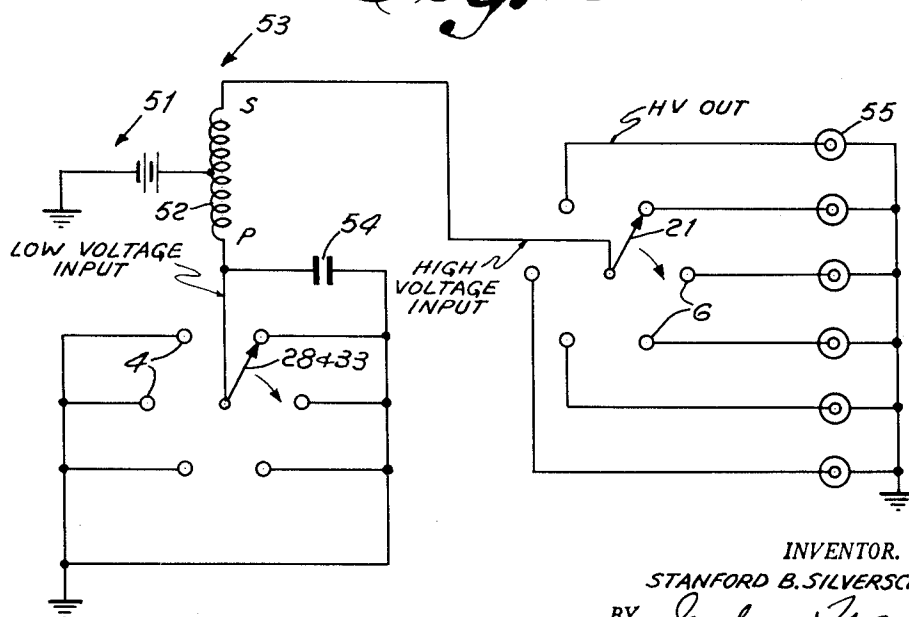


Fig. 4



INVENTOR.

STANFORD B. SILVERSCHOTZ

BY *Indes Fogut*

ATTORNEY

Aug. 22, 1961

S. B. SILVERSCHOTZ

2,997,552

PRINTED CIRCUIT DISTRIBUTOR

Filed Sept. 1, 1959

2 Sheets-Sheet 2

Fig. 2

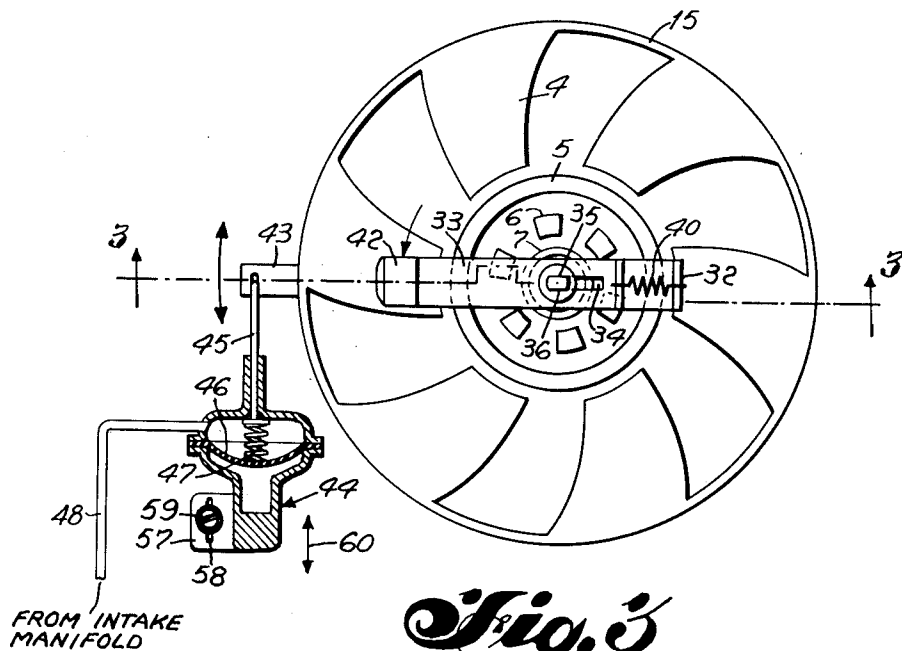
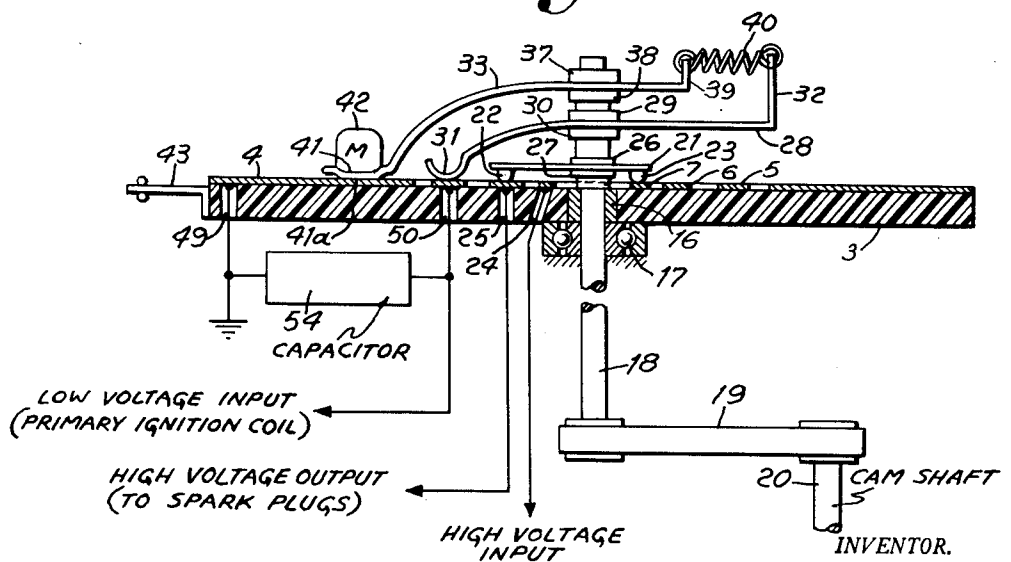


Fig. 3



1

2,997,552

PRINTED CIRCUIT DISTRIBUTOR

Stanford B. Silverschotz, Manhattan, N.Y., assignor to International Telephone and Telegraph Corporation, Nutley, N.J., a corporation of Maryland
Filed Sept. 1, 1959, Ser. No. 837,410
14 Claims. (Cl. 200—24)

This invention relates to automobile distributors and more particularly to a printed circuit automobile distributor.

In an automobile ignition system, the distributor which contains the moving parts and causes the generation of the spark in the cylinders is the unit that undergoes most deterioration in the ignition system. The distributor necessarily is a somewhat complicated and expensive unit to manufacture. The high rate of rotation of the cam and the consequent rapid reciprocating action of the breaker point in making and breaking contact will cause rapid deterioration of the breaker point and consequently, necessitate frequent repairs and adjustments. The moving parts, such as the cam and the breaker points, require careful and precise machining in the manufacture and also require precise adjustment for the proper functioning of the distributor. One of the most common defects in the distributor is the rapid pitting and deterioration of the breaker points due to arcing if the spacing is improperly adjusted or to impurities which enter the distributor and interfere with the proper functioning of the breaker points. The design of the distributor has been fairly conventional during the period since the automobile was introduced. In view of the rising costs of automobiles and the parts that are used therein and also repairs which are required periodically or as the need therefor arises, there is need for an improved distributor which is durable and more economical to produce.

An object of this invention therefore is to provide a more economical and durable distributor.

Another object is to provide an automobile distributor which is capable of low cost production and does not require expensive moving parts such as cams.

Still another object of this invention is to provide for a printed circuit automobile distributor which is both economical and durable in operation.

A feature of this invention is a circuit switch comprising a dielectric member, a plurality of conductive members carried thereby, a contact and means sequentially coupling and decoupling the contact with respect to the conductive members, and means to vary the starting time of the decoupling.

Another feature is an automobile distributor which comprises a dielectric member, a plurality of conductive members carried thereby, means to couple a source of low voltage to a first conductive member, means sequentially coupling and decoupling the first conductive member to the conductive members of a first group, means to couple a source of high voltage to a second conductive member, means to couple sequentially said second conductive member to the conductive members of a second group, means coupling the second member to any one conductive member of the second group when the first member is decoupled from any conductive member of the first group and means to vary the starting time of the decoupling.

A further feature is that the distributor comprises a dielectric member which carries on one surface thereof a plurality of conductive members having both the high voltage and the low voltage contacts and means to couple sources of low voltage and high voltage to the respective contacts in a sequential fashion.

Still another feature is that the number of low voltage contacts equals the number of high voltage contacts.

2

The above-mentioned and other features and objects of this invention will become more apparent by reference to the following description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a plan view of the printed circuit card or disk of this invention;

FIG. 2 is a plan view of the assembled distributor;

FIG. 3 is a cross section view along line 3—3 of FIG. 2;

FIG. 4 is a circuit diagram of the distributor with other component portions of the conventional ignition system; and

FIG. 5 is a diagram of the magnetic field change in an ignition coil.

Referring to FIG. 1, there is shown the plan view of the printed circuit disk 1 used in the distributor of this invention. On the surface 2 of a dielectric member 3 are shown a plurality of low voltage contacts 4 which are disposed adjacent the periphery of the disk 1. Interiorly of the low voltage contacts 4 is disposed an arcuate conductive member 5. Inside the arcuate conductive member 5 are disposed high voltage contacts 6 which are equally spaced from each other and at the same distance from the center of the disk 1. Inside the high voltage contacts 6 is disposed another arcuate member 7. Each of the low voltage contacts 4 are identical and equally spaced on the disk 1 and are of substantially trapezoidal configuration, the first and second sides 8 and 9 being outer and inner arcs concentric with the center of the disk 1. The third side of the contact 4 is a concave curve 10 with the fourth side being a convex curve 11, both curves if extended meeting at the center of the disk 1. The inner arc 9 is shorter than the outer arc 8. Each of the contacts 6 are of identical trapezoidal shape, the first and second parallel sides being inner and outer concentric arcs 12 and 13, and the non-parallel sides being radial lines 14 and 14'. With reference to the low voltage contacts 4, each boundary 11 thereof represents the beginning of the conductive portion and the point at which the circuit of the primary of the ignition circuit will close. The boundary 10 represents the point where the primary circuit is broken. The low voltage contacts 4 are all electrically and mechanically joined together by means of the annular conductive member 15.

In FIGS. 2 and 3, there is shown the disk 1 assembled with the other component portions of the completed distributor. The disk 1 is mounted upon a journal 16 about which it is free to rotate. The journal 16 is connected to a bearing, preferably a ball bearing 17. A shaft 18 rotates within and is positioned by the bearing 17 and the journal 16. Shaft 18 is rotated by means of a belt 19 which is coupled to the cam shaft 20 of the automobile engine. The rotation of the cam shaft 20 in the conventional four-stroke engine is at one-half the engine speed so in two revolutions of the engine there will be induced, in this case, six sparks. A contact arm 21 is fixedly connected to the shaft 18, but insulated therefrom, so that it will rotate with shaft 18. The contact arm 21 has two brushes or contacts 22 and 23 which couple the arm respectively to the high voltage contacts 6 and the annular member 7. Connections are made to the annular member 7 and the high voltage contacts 6 through hole 24 and multiple holes 25 (only one of which is shown for the contact 5 illustrated) in the disk 1. The connections from the high voltage contacts 6, of course, go to the hot side of the respective spark plugs of the motor. The contact arm 21 is retained in its position on the shaft 12 by means of fastenings 26 and 27. A second contact arm 28 is fastened to shaft 18 by means of members 29 and 30. The contact arm 28 is formed in a loop 31 at one end thereof and contacts the

annular ring 5 during the rotation of the shaft 18. The other end 32 of the contact arm 28 is bent up at right angles. Another contact arm 33 is fastened to the shaft 18 in such a manner that it can move radially with respect to the shaft 18 by means of a slot 34 in the arm 33 parallel with the flattened portions 35 and 36 of the shaft 18. The arm 33 is retained in place on the shaft 18 by means of fastening members 37 and 38. Contact arms 28 and 33 are insulated from the rotating shaft 18. The end 39 of the arm 33 is mechanically and electrically coupled to the end 32 of the arm 28 by means of tension spring 40 which urges the arm 33 towards the end 32 of the contact arm 28. The other end of the arm 33 is formed into a loop 41 which thereby constitutes the contact surface of the arm 33 as it rotates over the low voltage conductive members 4. A weighted member 42 is disposed on the end 41 of the contact arm 33 to provide for the centrifugal advance of the distributor. A bracket 43 is fastened to the perimeter of the disk 1 and a vacuum advance mechanism 44 is coupled by means of linkage 45 to the bracket 43. A diaphragm 46 in the mechanism 44 is biased by means of the spring 47 and the mechanism 44 is connected by means of the tube 48 to the carburetor of the automobile in the usual manner to provide for the vacuum advance as required. Connections are made to the low voltage conductive members 4 through holes 49 and connection is made to the low voltage arcuate member 5 through the hole 50.

FIG. 4 shows the conventional circuit of the automobile ignition system but modified in accordance with the principles of this invention. A battery 51 provides the energy for the ignition system and is connected to the primary 52 of an ignition coil 53. The other end of the primary coil is connected to the low voltage contact arm 28. All the low voltage conductive members 4 which are connected together by means of the arcuate sections 15 are coupled to ground. A condenser 54 conventionally connects the primary coil to ground. The secondary output is connected to the contact member 21 by means of the arcuate ring 7 and the contact arm 21 carries the high voltage sequentially to the high voltage contacts 6 during the rotation of the shaft 18. The casing of the spark plugs 55 is connected to ground to complete the high voltage circuit.

Whereas the conventional distributor uses one set of breaker points which are broken for initiation of the spark in every cylinder, this distributor utilizes one low voltage contact for every cylinder in the engine. While the distributor as shown in the drawing provides for six-cylinder operation, it is obvious that the number of contacts thereon can be increased or decreased in accordance with the engine utilized in the automobile. The distributor of this invention utilizes both centrifugal and vacuum advance mechanism. When engine speed increases, the spark must be introduced in the cylinder earlier in the cycle in order that the fuel charge can be ignited and will have time to burn and deliver its power to the piston. To provide this spark advance based on engine speed, the centrifugal mechanism shown here consisting of the mass 42 and the spring 40 is used. In this centrifugal advance mechanism, as the speed increases the centrifugal force throws out the mass 42 which operates against the tension of the spring 40. Let it be assumed that when the engine is at rest the contact of the arm 33 with the low voltage contacts is at the position denoted by the circumferential line 56. At that point on each of the boundary lines 10 of the low voltage contacts 4, the starting time of decoupling can be at the time denoted by T_0 . As the engine speeds up, it is necessary that the spark ignite earlier. Therefore, the contact arm 33 will move radially outward in accordance with centrifugal force and as it leaves the line 11 farther out from the center the decoupling of the arm 33 with the low voltage contact 4 will occur at an earlier time than T_0 . The line 11 is so designed that the farther out from the center that

the contact surface 41 of the arm 33 travels, the starting time of decoupling will be less than T_0 . The weight of the mass 42 and the tension of the spring 40 must, of course, be adjusted respectively in accordance with the speed of the engine so that the starting time of the decoupling and thereby the breaking of the primary circuit will occur at the appropriate time for efficient operation of the engine. When the engine is operated under part throttle, there is vacuum in the intake manifold of the engine and consequently the fuel taken into the cylinder is not so highly compressed. With lower compression in the cylinder, the spark must enter the cylinder earlier so that the mixture can be ignited, burn and give up its power to the piston. Lower compression means a slower rate of flame spread in the cylinder as the spark occurs. If the spark occurs earlier in the cycle, that is, if there is some additional spark advance, full burning of the fuel and maximum economy is achieved. This additional advance is obtained by the vacuum advance mechanism 44.

When the throttle is open, vacuum from the intake manifold is introduced into the vacuum advance mechanism 44 and the diaphragm 46 is pulled against the spring 47 and in turn rotates the disk 1 so that the boundary lines 11 of the low voltage conductive members 4 are advanced relative to the contact surface 41 of the low voltage contact arm 33. Therefore, the spark will occur at an earlier time no matter what position the contact surface 41a occupies on the disk. To provide means for adjusting the spark advance initially or as the case may be independent of the vacuum advance and the speed advance the mechanism 44 is provided with a bracket 57 which has a slot 58 which is movable about the fastening screw 59. In this manner, the vacuum advance mechanism 44 can be moved in the direction of the arrow 60 to provide for adjustment of the spark as stated before independently of both the vacuum advance mechanism and the speed advance mechanism. It is also, of course, possible to provide for retarding the spark by means of the vacuum advance mechanism when the mixture is too rich because in that case pressure from the intake manifold would be introduced into the vacuum advance mechanism 44 and move the diaphragm forward and thereby rotate the card in a direction opposite to that utilized for rotating the card for spark advance. Therefore, the boundary of the low voltage contact 4 will be moved forward relative to the contact arm 33 and thereby initiate the spark at a later time. The cam angle, or the dwell time as it is otherwise designated, is the number of degrees of rotation of the arm 33 during which the primary circuit is closed for each of the low voltage contacts. In this invention, the dwell time or the cam angle can be varied as the contact surface 41a of the arm 33 moves radially. The effect of dwell time on the magnetic field of the ignition coil is shown by the diagram of FIG. 5 which illustrates the magnetic field change in the ignition coil. As shown therein, when the primary circuit is closed, the strength of the flux field slowly increases from A to B. When the circuit is broken at the boundary 11, the field strength falls while the condenser is charging (B to C), and continues to fall sharply while the condenser is discharging (C to D). An oscillating current (BCDE etc.) flows in the resonating circuit with a frequency of about 3,000 cycles per second (basically a sine wave). The spark at the plug usually occurs between B and C and before the rate of change of flux is a maximum (C), in order to have a safe voltage margin for emergency. Usually, the induced primary voltage is of the order of 150 volts and the maximum secondary potential of about 13,500 volts could be induced. However, as the potential builds up at the spark gap, breakdown of the air or mixture occurs at voltages in the neighborhood of 8,000 volts, and with an arc established, the potential decreases to a value of several hundred volts. The breakdown of the spark gap occurs ap-

proximately 0.001 second after the primary circuit is broken and represents over 2 crank degrees of lag at 3600 r.p.m. of the engine. The duration of the arc is of the order of 0.001 second or 22 crank degrees at 3600 r.p.m. engine speed. The ignition system is timed by insuring that, when one of the cylinders is near TDC (top dead center) of the compression stroke, the primary circuit is on the verge of being broken. The high voltage contact arm 28 should then be on the high voltage contact 6 which is connected to the spark plug of the cylinder being timed. The contact arms are driven at cam shaft speed and therefore, the decoupling of the low voltage contact arm 33 with the low voltage contacts 4 will induce a spark as many times in two revolutions of the engine as determined by the number of low voltage contacts 4 on the disk 1. The strength of the flux field depends upon the length of time that the primary circuit is closed, that is, the length of time that the contact arm 33 is in contact with any of the low voltage conductive members 4, and the battery voltage. Since the latter is constant, the building time for the flux field in the conventional distributor decreases directly with speed. Thus, if the flux variation ABCD in FIG. 5 corresponds to a speed of 2,000 r.p.m., a flux strength of only B' will be available at a speed of 4,000 r.p.m. For this reason, it is impractical in conventional distributors to have more than eight lobes on the cam. In the distributor of this invention, there is much more flexibility in regulating the duration of time during which the primary circuit is closed. This can be done by varying the conductive area between the boundaries 10 and 11 without unduly encroaching on the length of time that the primary circuit must be opened for the generation of the spark and the dissipation thereof as described above.

It is obvious that the conductive contact between the contact surface 41a of the low voltage contact arm 33 and the conductive area of each of the low voltage conductive members 4 which lie between 10 and 11 provide a much greater contact surface than is available in the conventional distributor where only one set of points is used. Furthermore, in one revolution of this distributor for each closing of the primary circuit, there is a separate contact area available for each spark plug while in the conventional distributor, the points must be closed for every generation of the spark thereby increasing the wear and tear on the breaker points and consequently making it necessary to have frequent replacements and repairs thereto.

The conductive members on the surface of the disk 1 can be imprinted thereon by any of the conventional techniques now current in the printed circuit manufacturing and the conductive members may be either raised above the surface of the dielectric or may be embedded therein to provide a more efficient surface over which the contact surfaces of the contact arms 33 and 28 can move with a minimum of sparking.

While I have described above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of my invention as set forth in the objects thereof and in the accompanying claims.

I claim:

1. A circuit switch comprising a flat dielectric member, a plurality of conductive members carried on one surface thereof, each of said conductive members comprising an element with a pair of parallel sides constituting arcs concentric with the center of said disk and the other sides of said element being curves which if extended would meet at said center of said dielectric member, a contact, means sequentially coupling and decoupling said contact with respect to said conductive members and means to vary the starting time of said decoupling.

2. A circuit switch comprising a dielectric disk, a plurality of identical conductive members carried on the sur-

face of said disk and equally spaced thereon, each of said conductive members comprising a substantially trapezoidal element, the first and second parallel sides being inner and outer arcs concentric with the center of said disk, the third side of said conductive member comprising a convex curve and the fourth side comprising a concave curve, said convex and concave sides if extended meeting at said center of said disk and said inner arc being shorter than said outer arc, a contact, means sequentially coupling and decoupling said contact with respect to said conductive members by causing relative rotary movement between said contact and said conductive members, and means to vary the starting time of said decoupling.

3. A circuit switch according to claim 2 wherein said contact comprises an arm rotatable over the surface of said disks in end contact relation with said conductive members, and means to vary the radial distance of said contact end from the center of said disk whereby said contact arm is decoupled from contact relation with each of said conductive members at said convex side at a time proportional to the said radial distance of said contact end thereby varying the starting time of said decoupling.

4. A distributor comprising a dielectric member, a plurality of conductive members carried thereby, certain of said conductive members being arranged into first and second groups, means to couple a source of a first voltage to a first conductive member, means sequentially coupling and decoupling said first conductive member to the conductive members of a first group, means to couple a source of a second voltage to a second conductive member, means to couple sequentially said second conductive member to the conductive members of a second group, means coupling said second member to any one conductive member of said second group when said first member is decoupled from any conductive member of said first group, and means to vary the starting time of said decoupling.

5. A distributor according to claim 4 wherein said dielectric member comprises a disk, and each said conductive members of said first group comprises substantially a trapezoidal element, wherein the first and second parallel sides are inner and outer arcs concentric with the center of said disk, the third side of said conductive member comprises a convex curve and the fourth side comprises a concave curve, said convex and concave sides if extended meeting at said center of said disk, and said inner arc being shorter than said outer arc, said conductive members being equally spaced on said disk.

6. A distributor according to claim 5 wherein the conductive members of said first group are connected together.

7. A distributor according to claim 4 wherein the conductive members of said second group are equal in number to the conductive members of said first group, and each of said conductive members of said second group comprise a trapezoidal element, wherein the first and second parallel sides are inner and outer arcs concentric with the center of said disk and the third and fourth sides are radial lines.

8. A distributor according to claim 7 wherein said first conductive member is a first annular element disposed on said disk intermediate the conductive members of said first group and the conductive members of said second group, and said second conductive member is a second annular element disposed intermediate said conductive members of said second group and the center of said disks.

9. A distributor, for spark ignition internal combustion engines comprising a dielectric disk, a plurality of conductive members forming a first group, a first conductive member, a plurality of conductive members forming a second group, a second conductive member, all said conductive members being disposed on the surface of said disk, means to couple a source of a first voltage to said first conductive member, means sequentially coupling

and decoupling said first conductive member to said conductive members of said first group, means to couple a source of a second voltage to said second conductive member, means to couple sequentially said second conductive member to said conductive members of said second group, means coupling said second member to any one conductive member of said second group when said first member is decoupled from any conductive member of said first group and means to vary the time of decoupling.

10. A distributor according to claim 9 further including a rotating member at the center of said disk and wherein said means sequentially coupling and decoupling said first conductive member to the conductive members of said first group includes a contact device coupled to and rotating with said rotating member, said contact device comprising a first contact arm coupled to said rotating member and having one end adapted to move in contact relation over the surface of said first conductive member, a second contact arm coupled to said rotating member and having one end adapted to move in contact relation over the surface of said conductive members of said first group, spring means electrically and mechanically coupling the other ends of said first and second contact arm and a weight member disposed on said second contact arm of the contact end thereof, said second contact arm being intermediate said weight member and said surfaces of said conductive members of said first group.

11. A distributor according to claim 10 wherein said means sequentially coupling said second conductive member to said conductive member of said second group comprises a third contact arm coupled to said rotating member and having one end adapted to move in contact relation with said second conductive member and the opposite end adapted to move in contact relation with the conductive members of said second group.

12. A distributor according to claim 11 wherein said second contact arm is adapted to move in a radial direc-

tion relative said rotating member in response to the centrifugal force caused by the rotation of said rotating member upon said weight member and in opposition to the restraint of said spring means to thereby vary the starting time of decoupling of said second contact arm from the conductive members of said first group.

13. A distributor according to claim 11 further comprising means responsive to the vacuum condition of the intake manifold of said internal combustion engine to rotate said disk relative said second contact arm and thereby vary the starting time of the decoupling of said contact surface of said second contact arm and the surfaces of said conductive members of said second group.

14. A distributor according to claim 13 wherein said means responsive to said vacuum condition to rotate said disk comprise journal means disposed intermediate said rotating shaft and said disk and adapted for rotation of said disk therearound, a housing, a diaphragm disposed within said housing, a spring disposed within said housing to bias said diaphragm, means coupling said intake manifold to said housing whereby said diaphragm is moved in response to the vacuum condition of said intake manifold, a linkage coupling said diaphragm to said disk, whereby said disk is rotated about said journal in response to the movement of said diaphragm when said diaphragm is actuated by the vacuum condition of said intake manifold.

References Cited in the file of this patent

UNITED STATES PATENTS

2,096,294	Bryant	Oct. 19, 1937
2,243,269	Von Tavel	May 21, 1941
2,700,076	Goods	Jan. 18, 1955
2,717,286	Bales	Sept. 6, 1955
2,740,006	Drugan	Mar. 27, 1956
2,821,584	Monack et al.	Jan. 28, 1958
2,853,564	Gahagan	Sept. 23, 1958
2,912,529	Leibold	Nov. 10, 1959