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(71) Applicant: Bengt, Ovelius
Järnvägsgatan 12
S-330 27 Hestra(SE)

(71) Applicant: Nilsson, Rune
Box 132
S-330 27 Hestra(SE)

(72) Inventor: Bengt, Ovelius
Järnvägsgatan 12
S-330 27 Hestra(SE)

(74) Representative: Hopfgarten, Nils et al,
Bergenstrahle & Lindvall AB Svartensgatan 6
S-116 20 Stockholm(SE)

(54) Method and apparatus in electronic ignition systems for internal combustion engine.

(57) In a method of improving the ignition for electronic ignition systems of the multiple spark type, particularly for difficult operational conditions, the energy required for ignition is stored in the form of magnetic energy in the magnetic core of the ignition coil. The first spark is furthermore given longer duration than the following sparks in every shower of sparks during an ignition period. An apparatus in electronic ignition systems for providing multiple sparks of different durations, particularly during the starting sequence, includes a logical circuit (4) adapted to control a transistor (TR3) to ON and OFF at predetermined times. The transistor is coupled in series with the primary winding of the ignition coil (2), whereby the magnetic energy stored in the magnetic core of the ignition coil generates a spark via the secondary winding of the coil during each opening interval of the transistor. The logical circuit is further arranged to keep the transistor open during an ignition period with a first interval which is longer than succeeding intervals. In order to make closing and opening of the contact breaker points more reliable in an electronic ignition system which contact breaker points for internal combustion engine, a circuit (TR3, D1, C1, R1, R2, C2) is arranged to generate a high voltage, considerably exceeding the battery voltage (12V) across the points (BR) and send a high current through the points when they are closed.

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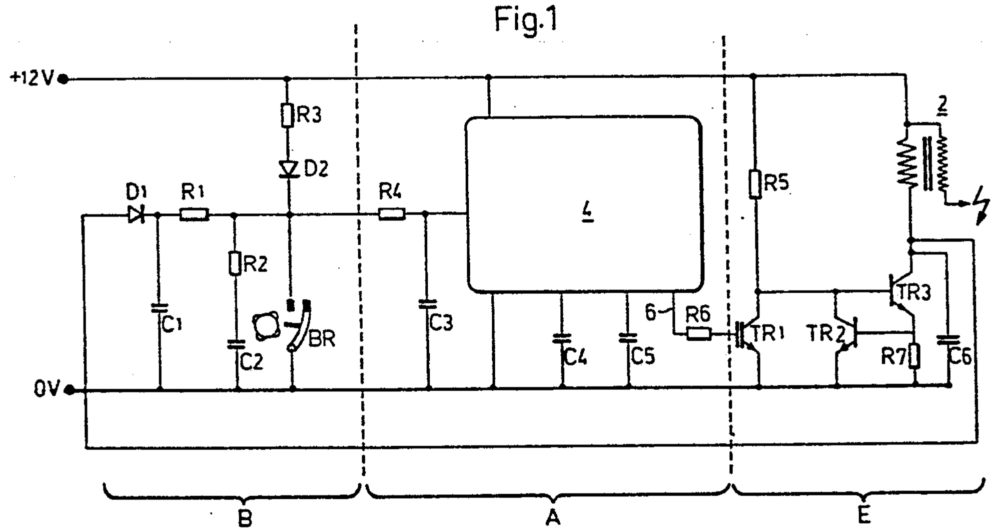
EP 0 142 478 A1

Fig.1


+12V
0V
D1
R1
R2
R3
D2
C1
C2
BR
R4
C3
4
C4
C5
6
R6
R5
TR1
TR2
TR3
R7
C6
2
B
A
E

Method and apparatus in electronic ignition systems for internal combustion engine.

The present invention relates to a method of improving ignition in electronic ignition system of the multiple spark type intended for internal combustion engines, particularly in difficult operating conditions, and an apparatus in electronic ignition systems for providing multiple sparks of different durations, particularly during the starting procedure, from magnetic energy stored in the ignition coil magnetic core. The invention further relates to an apparatus in an electronic ignition system provided with a contact breaker for obtaining more reliable opening and closing of the contact breaker points.

To improve the performance of internal combustion engines, particularly during difficult operating conditions such as when the engine is cold, has got too much petrol or is affected by moisture, as well as when it is operating with an inhomogenous fuel mixture, such as when it is idling, there have been ignition systems on the market which generate multiple sparks by so-called capacitive discharge.

One object of the present invention is to further improve the function of such an ignition system and to provide a device for this purpose which is simpler and cheaper to produce, and which can be easily fitted to existing mechanical ignition systems to improve their operation.

This object is achieved by a method in accordance with claim 1 and by an apparatus in accordance with claim 3.

By making the first spark in the shower of ignition sparks longer, the fuel mixture is generally already ignited by this spark. Practical tests have shown that engines provided with the device in accordance with the invention have good starting properties at temperatures right down to -30^{o}C. However, should the first pulse not ignite the fuel mixture, there follows a succession of pulses which do so reliably. The spark frequency is selected in this case such that maximum ignition energy is supplied to the spark plug.

In this way there is enabled with the method and device in accordance with the invention the provision of many times higher spark energy than in ordinary "mechanical" ignition with a contact breaker. This provides a great improvement in the willingness of the engine to start under difficult conditions, the need for choking being reduced, or dispensed with entirely. Petrol (gas) consumption is furthermore decreased with the aid of the hotter, energy-rich sparks and there is a decrease in wear on start motor, battery and spark plugs as well as contact breaker, where applicable.

The method and apparatus in accordance with the invention are particularly attractive for automobiles having exhaust gas cleaning, since relatively lean fuel mixtures are still desirable for conditions of low revolutions and cold engine. This easily leads to backfiring, uneven running and high emissions of uncombusted hydrocarbons as a result of uncertain ignition.

The invention may be utilized in ignition systems with a contact-free electronic timing means as well as conventional "mechanical" ignition systems with contact breakers.

The apparatus in accordance with the invention is suitably implemented such that a spark shower is generated during the engine starting sequence, the first spark being longer and stronger than the subsequent ones and striking at exactly the right ignition angle, while the remaining sparks follow rapidly while the piston moves the first fifth of its stroke downwards. A triple spark is generated for idling to give uniform operation without the risk of a sudden stop, in spite of the fuel mixture often being uneven. With high engine revolutions the turbulence is so great that the fuel mixture will be fairly homogenous, and the single spark, as with a normal ignition system, is sufficient.

The multiple strikes on starting normally revert automatically to triple strikes during idling and single strikes at high revolutions, since the contact breaker or electronic timer opens and closes more rapidly so that fewer and fewer strikes or sparks have room per ignition period, with similar engine revolutions and a constant spark frequency.

The apparatus in accordance with the invention can be switched between a multiple spark mode, a single spark mode (which can be desirable in areas with difficult radio reception conditions and for setting the ignition) and to "mechanical" ignition (where applicable) in an emergency situation if the transistor ignition should fail.

A second object of the present invention is to provide more certain opening and closing of the contact breaker points in an ignition system provided with them.

This object is achieved with an apparatus according to claim 9.

Satisfactory contact is namely not achieved before the current has broken through oxides and dirt on the contact surfaces and provided a microscopic weld between them. Even contacts of the best material such as silver and gold have this problem with low voltages and low currents.

An embodiment of the apparatus in accordance with the invention, selected as an example and applied to an ignition system with a contact breaker, will now be described in detail with reference to the accompanying drawings, on which Fig. 1 is a sketch of an electronic ignition system with the apparatus in accordance with the invention, Figures 2 and 3 are diagrams illustrating how the system functions, and Fig. 4 is a diagram illustrating a possible operational mode of the logical circuit in the inventive device.

The apparatus in accordance with the invention illustrated in Fig. 1 is made up from three parts, part A for providing different durations for the multiple sparks, the contact breaker part B and a final power step E.

Turning now to Figures 2 and 3 to describe the function of the apparatus, it will be noted that Fig. 2 illustrates the crankshaft revolutions of the engine, where a point on the circle corresponds to the position of the piston in the cylinder bore (sinus curve).

The cam controlling the contact breaker BR (see Fig. 1) is disposed such that the points are closed for typically 58^{o} (the dwell is 58^{o}) and open for 90 - 58 = 32^{o}. The crankshaft moves at double the rate of the cam and the points are closed during the time corresponding to the arc x in Fig. 2, which corresponds to an angle of 2 x 58 = 116^{o}. This is the period during which magnetic energy is stored in the ignition coil 2.

The points BR open at the point y in Fig. 2, the ignition spark being generated and the points being open for a period corresponding to the arc z in Fig. 2. The point y is at a suitable pre-ignition, e.g. 10^{o} for idling.

It takes a comparatively long time to give the ignition coil 2 a full charge of magnetic energy, and thus the period x should be comparatively long. Maximum energy is stored in the ignition coil 2 at the point y, the angular position of y being the one desired for ignition. The gas fuel mixture is often inhomogenous, however, and when the spark comes to a layer with an unsuitable mixture ratio, ignition does not take place, which is quite a usual phenomenon in the cars of today, and contributes to injurious emissions and higher fuel consumption. It is therefore one of the objects of the present invention to let the energy-rich, first spark exist for as long as possible. Its duration can be of the order of magnitude 1>ms, and the size of the spark current at the first instant of the order of magnitude 50 mA, current then decreasing substantially linearly with time, see also Fig. 3.

If this strong, first ignition spark should be unsuccessful in igniting the gaseous fuel mixture, a plurality of succeeding sparks are generated during the period z, which unfailingly results in ignition of the gaseous fuel mixture. This corresponds to the period during which the points BR are open, see Fig. 3.

If the coil 2 is to be charged to maximum energy after the first strong ignition spark, this takes such a long time that no further spark has time to be generated during the period z. On the other hand, if it is attempted to take out a very large number of sparks during this period z, each spark will have such a poor energy content that it cannot ignite the mixture. However, between these two extreme cases there is an optimum spark frequency which gives maximum ignition energy to the spark plug in the prevailing conditions. The optimum mode of driving the ignition coil means that the lifetime of the succeeding sparks is made shorter to enable longer magnetic charging of the coil 2 between each spark, see Fig. 3. The time it takes to charge the coil 2 with magnetic energy is dependent on the driving voltage and primary inductance. There are special "sports" coils with a large number of turns for providing a very rapid charging time, but the principle described above also applies to these, although the subsequent sparks can be fired with a higher frequency.

In previously known silicon controlled rectifiers (SCR) or thyristor ignition systems of the multiple spark type, the energy is namely stored in a capacitor, which is connected in parallel with the SCR across the ignition coil, the coil then only serving as a transformer. With this method it is possible only to achieve sparks of comparatively short duration, however, and combustion often appears to be insufficient, with the actual result being high emissions. In the present invention, the energy is stored in the form of magnetic energy in the ignition coil core, resulting in that the duration of a spark will be increased by a factor of 10. The magnetic ignition principle is recommended more and more today in professional circles.

The ignition coil 2 is driven via the transistor TR3, which in turn is controlled by a logic circuit 4.

The logic circuit 4 sends an output pulse train U_{out} through the resistor R6 and transistor TR1 to the base of the transistor TR3 such that this transistor is controlled in a desired manner, i.e. it opens during a series of intervals, the length of the first interval t2 being greater than the succeeding intervals t4 during the period when the contact breaker points BR are open, see Fig. 3. An ignition spark is generated during each opening interval of the transistor TR3.

The logic circuit 4 for controlling the transistor TR3 can be a customer-suited monolitic curcuit and can for instance have the following function.

When the contact breaker points BR are open and the first spark is generated, a voltage U_4 across the capacitor C4 occurs in the logical circuit 4, this voltage rising from an initial level U_0 during the duration of the spark, as a result of charging the capacitor C4, see below. During the rising part of the voltage U_4 the logical circuit sends a pulse on its output 6. When U_4 reaches a predetermined threshold value U_1 the logical circuit is switched such that the output voltage U_{out} goes to zero.

After U_4 has reached the level U_1 U_4 begins to fall, and when it reaches a second predetermined threshold value U_2 the logical circuit switches once again so that the output 6 will be high, and the input voltage will begin to rise again as a result of charging the capacitor C4, the sequence then being repeated until the points BR close.

By arranging for U_4 to start from an initial level U_0 which is lower than the initial level U_2 for the succeeding pulses, the first pulse in the train of pulses will be longer than the succeeding ones. The pulse times are determined by C4 and an internal current generator in the monolitic circuit 4, and by suitable dimensioning of time constants the distance t3 between the pulses can be made considerably longer than the individual pulses t4 to enable optimum re-charging of energy into the ignition coil 2.

The value of the capacitor C5 determines the longest time for which multiple sparks can be emitted with a statically open contact breaker. The number of sparks in a spark shower can thus be maximized to 30, for example. This limitation occurs when the engine is not turning over although the ignition switched on, or when the engine turns over very slowly during starting. This function is important since the engine will otherwise be able to run without contact breaking (cable rupture).

As mentioned above, the output pulses from the logical circuit are fed to the base of the transistor TR3 to trigger it, the transistor TR1 then serving to amplify the output pulses from the logical circuit 4, while the transistor TR2 and the resistor R7 serve as current limiters if short-circuiting should occur in the ignition coil 2.

The transistor TR3 serves as a very rapid switch, and the ignition capacitor C6 may therefore be made considerably smaller than is usual with "mechanical" ignition systems. The capacitance of the capacitor C6 may be reduced by typically a factor of 10 which means that this component "steals" 10 times less energy from the primary pulse, which gives higher potential and more energy to the ignition spark.

With the present invention it is suitable to adjust the sequence so that the first spark will be stronger than in "mechanical" ignition, while the subsequent multiple sparks will be just as strong as for "mechanical" ignition.

When an ignition spark occurs, a voltage spike is obtained across the transistor TR3. With a spark voltage of 30 kV and a transformation ratio in the ignition coil 2 of 1:100 this voltage spike will be about 300V. This spike or pulse is taken through the diode D1 and a direct voltage of the same order of magnitude will be stored in the capacitor C1, which is thus charged up to about 300 V by the multiple sparks.

So as not to load the ignition sequence, the capacitor C1 is connected across the contact breaker BR via a large resistor R1.

The capacitor C2 is charged via the resistors R1 and R2 to the same voltage as the capacitor C1, and when the points BR close the capacitor C2 is discharged rapidly via the resistor R2, which has a low value. A short current shock of the order of magnitude 30 A thus occurs, which breaks through oxide and dirt on the contact surfaces of the points and achieves a microscopic welded point. The capacitor C1 will here remain at a substantially constant level (approximately 300 V) due to the high-ohmic resistor R1.

Examples of suitable component values are:

C1 = 1 μF

R1 = 680 kohms

R2 = 10 ohms

After the points BR have been closed effectively, a relatively large current is fed from +12V via the resistor R3 and diode D2 and through the points BR to earth.

By thus applying a high voltage of about 300 V to the points BR and a high current of about 30 A in an initial current shock, and thereafter 0.5 A, there is obtained reliable contact function which can compete with that of electronic timing means.

The advantages with a mechanical contact are 1) low price, 2) simple design and large operational reliability, 3) insensitiveness to high temperatures and 4) the option of switching the ignition system to a conventional "mechanical" ignition should the electronics fail, which allows the vehicle to be driven to a repair workshop.

The ignition system described above can be easily arranged switchable between a multiple spark mode, a single spark mode and ordinary "mechanical" ignition mode.

Claims

1. A method in electronic ignition systems of the multiple spark type for improving the ignition, particularly for difficult operating conditions, c h a r a c t e r i z e d in that the energy required for ignition spark generation is stored as magnetic energy in the core of the ignition coil and in that the first spark is given longer duration than succeeding sparks in every shower of sparks during an ignition period.

2. Method as claimed in claim 1, c h a r a c t e r i z e d in that the length of said succeeding sparks and their mutual spacing are adapted to the rates of discharging the stored magnetic energy during sparking and restoration between the sparks, so that total maximum ignition energy is supplied to the spark plug.

3. Apparatus in electronic ignition systems for providing multiple sparks of different durations from the magnetic energy stored in the magnetic core of the ignition coil, c h a r a c t e r i z e d in that a logical circuit is adapted to control a transistor for opening and closing at predetermined times, said transistor being coupled in series with the primary winding of the ignition coil, the magnetic energy stored in the magnetic core of the ignition coil generating a spark via the secondary winding of the ignition coil, during each opening interval of the transistor, and in that the logical circuit is adapted to keep the transistor open during a first interval of an ignition period, said first interval being longer than subsequent intervals.

4. Apparatus as claimed in claim 3, c h a r a c t e r i z e d in that the logical circuit is adapted to generate an output pulse train during each ignition period, with the first pulse of the train longer than the succeeding pulses, said pulse train being fed to the base of the transistor coupled in series with the primary winding of the ignition coil, such that the transistor will open during the pulses from the logical circuit.

5. Apparatus as claimed in claim 3 or 4, c h a r a c t e r i z e d in that the logical circuit is adapted to send an output pulse during rising portions of a voltage U_4, and that said voltage is equal to a basic level U_0, outside the ignition period and starts from this level U_0 at the beginning of an ignition period, to vary thereafter between two levels U_1 and U_2 until termination of the ignition period, where $U_1 > U_2 > U_0$.

6. Apparatus as claimed in claim 3 or 4, c h a r a c t e r i z e d in that the logical circuit has a master timing function limiting the number of sparks in a shower of sparks to a suitable number, e.g. 30 sparks.

7. Apparatus as claimed in any of claims 3 - 6, c h a r a c t e r i z e d in that the logical circuit is a monolitic circuit.

8. Apparatus as claimed in any of claims 3 - 7, in which the ignition system is of the mechanical type with contact breaker points, c h a r a c t e r i z e d in that the input of the logical circuit is connected across the points, whereby the start and termination of the ignition period is determined by opening and closing, respectively, of the points.

9. Apparatus as claimed in any of claims 3 - 8, c h a r a c t e r i z e d in that means are provided for protecting the transistor coupled in series with the primary winding of the ignition coil, should there be a short-circuit in the ignition coil.

10. Apparatus in electronic ignition systems provided with contact breaker points in internal combustion engines for ensuring opening and closing of the points, c h a r a c t e r i z e d in that a circuit is arranged to generate a high voltage across the points, said high voltage considerably exceeding the battery voltage, and to conduct a high current through the points when they close.

11. Apparatus as claimed in claim 10, c h a r a c t e r i z e d in that the circuit includes a capacitor connected in parallel to the points, this capacitor being adapted for being charged to said high voltage from the primary pulses of the ignition coil and to be rapidly discharged by a low-ohmic connection through the points when they are closed.

12. Apparatus as claimed in claim 10 or 11, c h a r a c t e r i z e d in that the circuit includes a transistor serving as a switch and connected in parallel with a capacitor, said transistor being coupled in series with the primary winding of the ignition coil, whereby said high voltage occurs over this parallel circuit in the generation of an ignition spark, said high voltage being fed via a large resistor to the capacitor connected in parallel with the points so as not to affect the ignition process.

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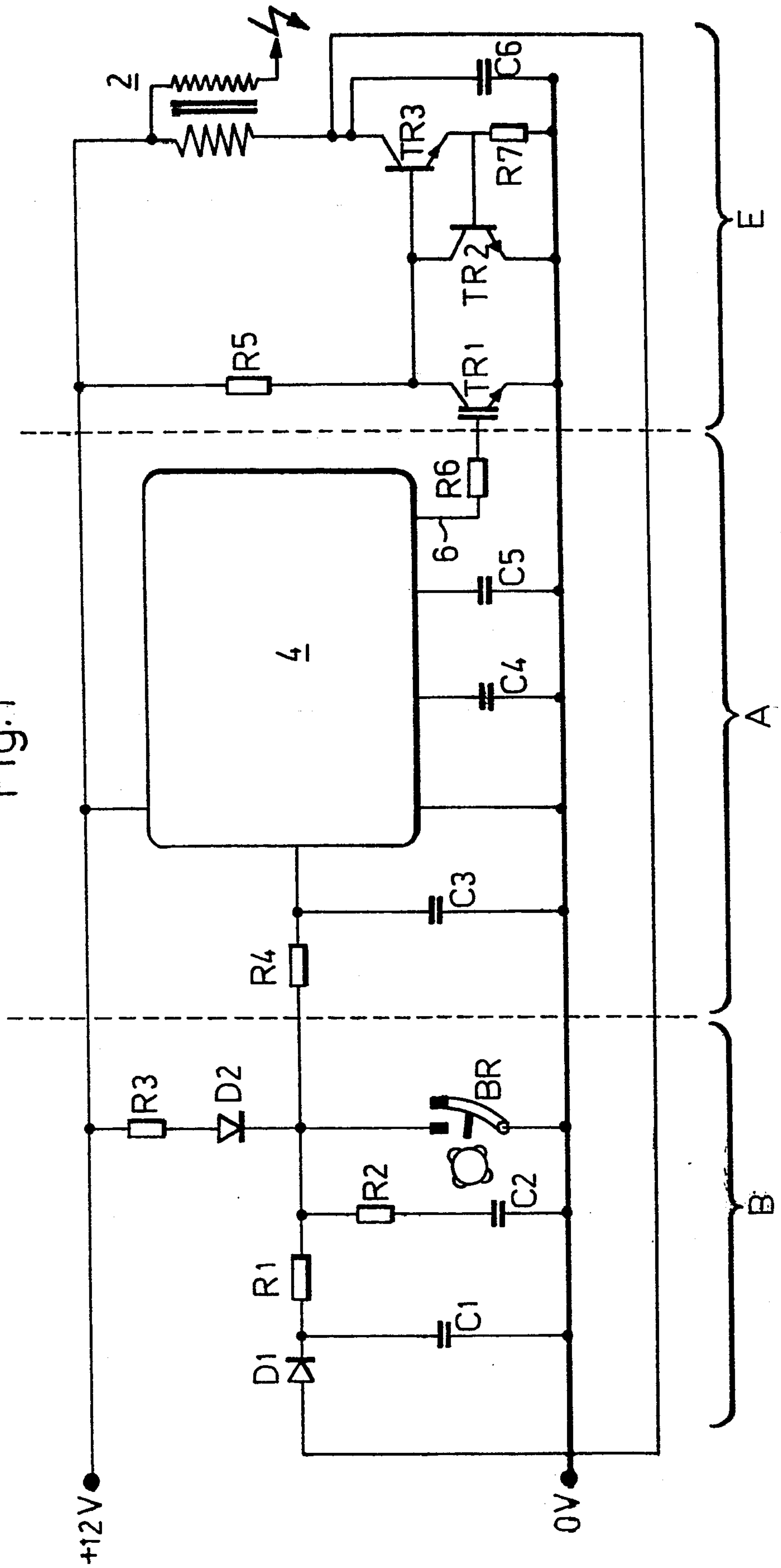


Fig.1

Fig. 2

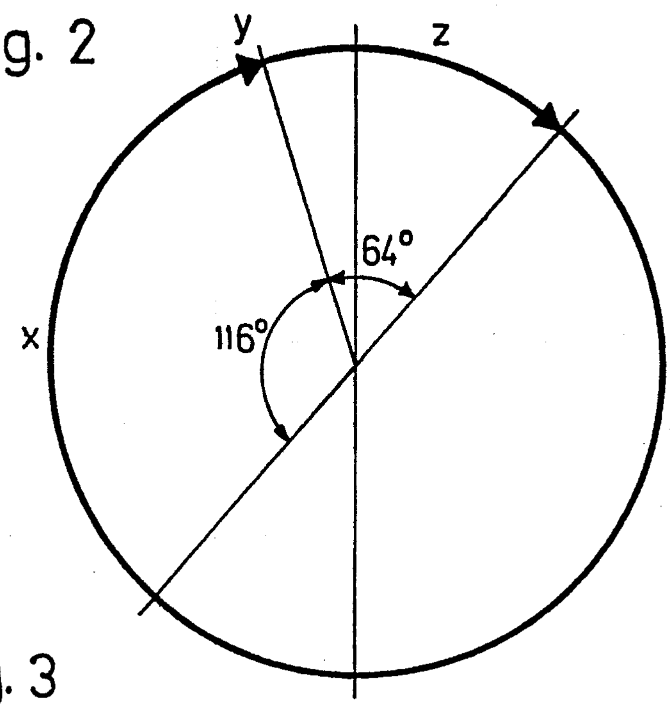


Fig. 3

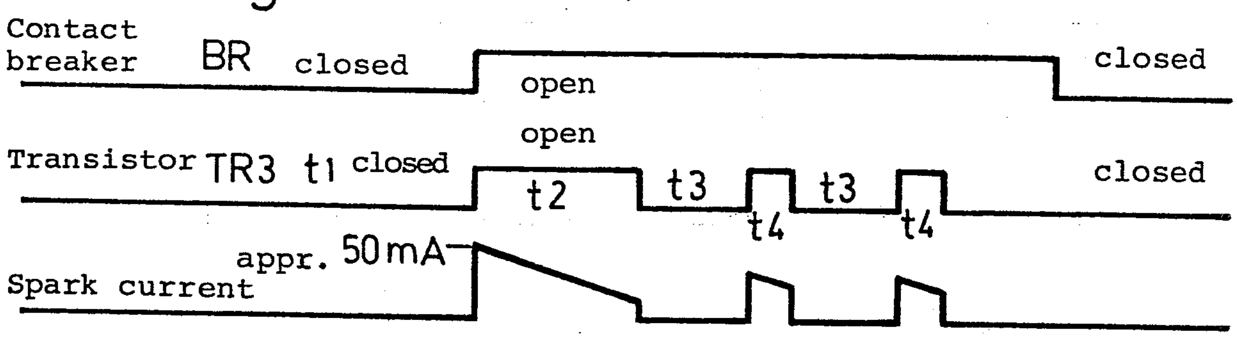
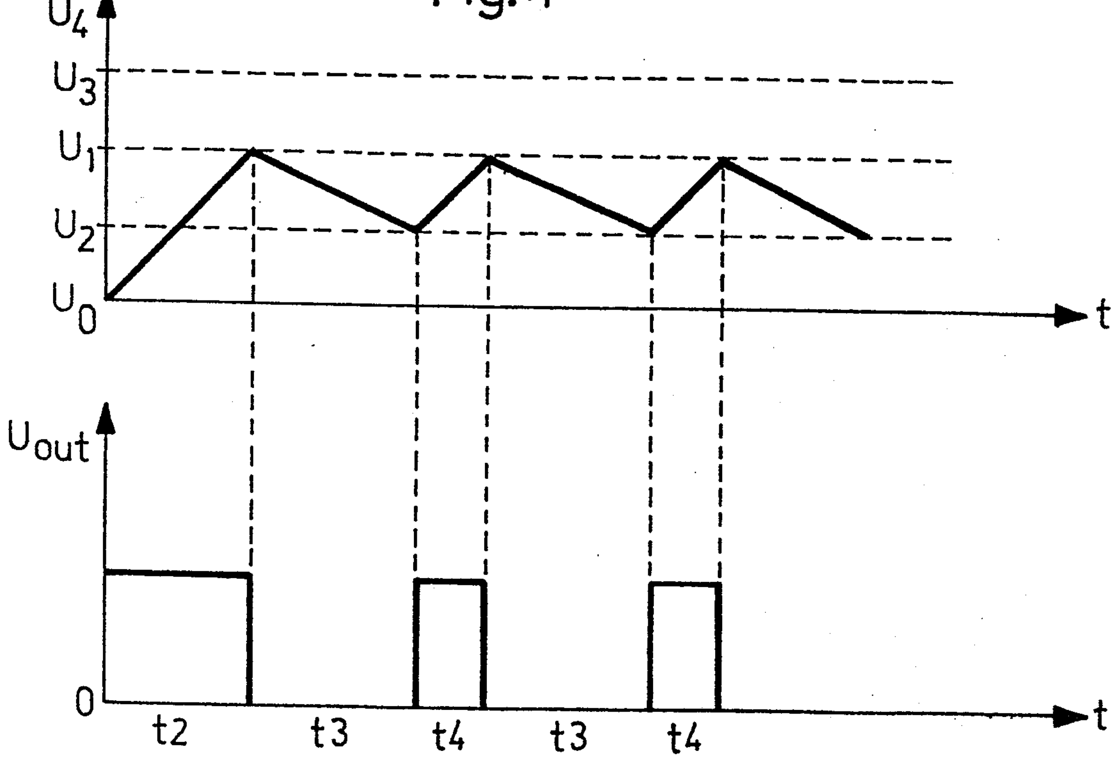


Fig. 4



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EUROPEAN SEARCH REPORT

Application number

EP 84 85 0178

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	EP-A-0 070 572 (SIEMENS) * figures 1-4; front-page, abstract; page 3, line 12 - page 4, line 20; page 6, line 7 - page 7, line 32 * ---	1-6,7-12	F 02 P 9/00 F 02 P 15/10
A	US-A-3 945 362 (J.G. NEUMAN et al.) * figures 1-5; column 2, line 16 - column 3, line 65; column 8, line 45 - column 13, line 25 * ---	1-6,7-12	
A	DE-A-2 817 786 (M.J. WALTER) * whole document * ---	1	
A	US-A-3 280 809 (J. ISSLER) * whole document * -----	1-6	TECHNICAL FIELDS SEARCHED (Int. Cl.4) F 02 P H 02 P

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	27-12-1984	GODIN CH.G.

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