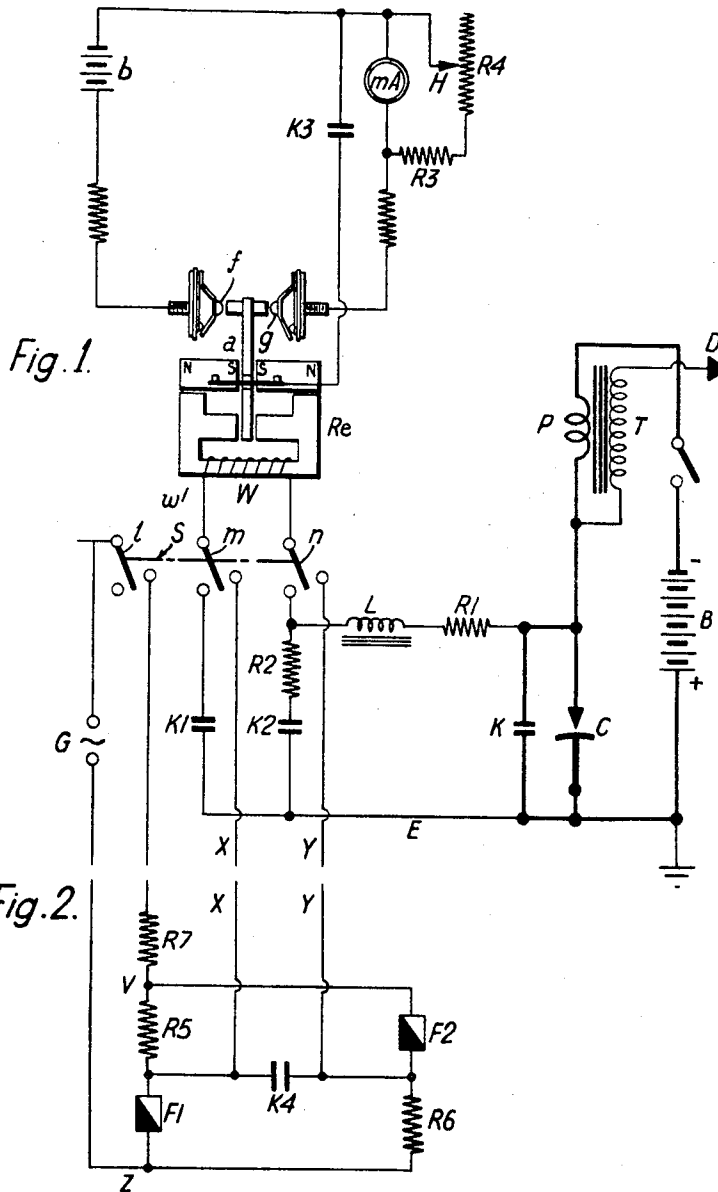


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ELECTRIC TACHOMETERS FOR OPERATION FROM THE IGNITION
SYSTEMS OF INTERNAL COMBUSTION ENGINES
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ELECTRIC TACHOMETERS FOR OPERATION FROM THE IGNITION SYSTEMS OF INTERNAL COMBUSTION ENGINES

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This invention relates to tachometers for indicating the rate of revolution of internal combustion engines having electric spark ignition, and is concerned especially with apparatus which can be connected to conventional coil ignition systems with the minimum disturbance either of the functioning or the connections of the system.

Electric tachometers for operation from the low tension side of ignition coil systems are well known in which a high speed non-polarised relay with change-over contacts and spring bias has its operating coil connected across the contact breaker of the spark coil, and the two side contacts are so connected that with the armature resting on one contact a small capacitor receives a charge from a source of low voltage such as a few dry cells; and on the armature changing over to the other contact, the capacitor discharges through a d'Arsonval type of measuring instrument. Now provided that the time of charge and discharge is less than the duration of contact of the relay, the mean current through the measuring instrument is proportional to the number of discharges per second and the instrument can therefore be calibrated in revolutions per minute if the number of contact operations per revolution is known.

Apparatus of the type described has not in practice given good results, the operation of the relay being frequently irregular, thus leading to faulty and unsteady indications of speed. Moreover the energy consumed by the relay is such that the intensity of the ignition spark may be reduced. The irregularity in operation referred to arises in part from the conditions obtaining in the ignition circuit from which the relay is driven and in part from the type of relay heretofore employed. As regards the driving circuit it will be seen that the relay winding receives zero current during the period of closure of the spark-coil contact breaker, and during the open period, gets a direct current pulse on which is superimposed the damped high frequency oscillation, exceeding in most cases one kilocycle per second in frequency, which is set up in the series circuit consisting of the coil, ignition capacitor and battery, by the opening of the contacts, and whose amplitude on the first oscillation may have a peak-to-peak value of the order of 300 volts or more.

Since the pulse relied upon to operate the relay is the unidirectional component of the complex described above, a one-side stable type of relay has to be employed, that is a relay having spring or magnetic bias sufficient, in the absence of operating current, to hold the armature on one contact. Relays of these types generally do not work regularly and without contact bounce at the high speeds encountered, and since they are operated positively by the exciting current only in one direction and depend typically on a spring for operation in the other direction, and since moreover the strength of the positive magnetic operation decreases greatly at the highest frequencies, the optimum values of the spring bias for high and low speeds respectively are very different; moreover their power consumption is relatively high.

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According to the present invention, these disadvantages are overcome by employing a polarised relay, preferably in substantially neutral adjustment—that is, one in which the armature will remain on either side contact, or float at some position between them—and connecting one end of the operating winding of this relay to the junction of spark-coil primary and contact-breaker, and the other end to a point whose mean potential lies between the potentials of the two poles of the battery, thus causing alternating pulses to flow through the relay winding.

This point of intermediate potential may be the junction point of two resistors connected in series across the battery, or the slider of a potentiometer type of resistor connected across the battery, or one of the inter-cell connectors of the battery itself, or instead of such a conductive connection of the relay winding, the said other end of the relay winding may be connected to one plate of a capacitor the other plate of which is connected to any part of the battery. Such a capacitor circuit is preferred.

The mean potential of the junction point between spark-coil primary and contact-breaker is a function of frequency, becoming nearer to that of the negative end of the battery (assuming that the latter has its positive pole earthed as is customary) as the speed of operation of the contact-breaker increases. Now for the best operation of the relay, the point of intermediate potential referred to above when using the conductive connections described should be so chosen as to be near that of the aforesaid junction point at the top end of the speed range where the relay needs most excitation; at the lower speeds where the conditions are less onerous, the resulting biased driving current in the relay coil will do no harm. In the case of the capacitor connection, the point does not arise since it is impossible for the relay to receive a biased driving current.

In order to minimise changes in the relay driving current with speed due to the inductive nature of the relay, a resistor may be connected in series with the relay winding, a somewhat lower number of turns being chosen for the coil than would otherwise be appropriate, and to protect the relay windings from the high potential oscillating voltages generated when the contact-breaker opens, a capacitor may be connected across the relay winding, or between some point on this resistor and earth (or any part of the battery) so as to form a simple low-pass filter. Instead of a plain resistor, an inductive resistor may with advantage be connected in series with the relay with a capacitor in shunt with the winding in order to provide a more efficient low-pass filter.

The relay contacts are connected in the well known manner so as to charge a small capacitor when the armature of the relay makes contact with one side contact, and to discharge it through a measuring instrument when on the other side contact, as already mentioned, it being desirable however to insert resistance in the charging circuit to limit the instantaneous value of current on the contacts to a safe value; usually the resistance of the meter is a sufficient limiter on the discharge side.

In order to explain the invention more fully, an example of a practical system in accordance with the invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a diagram of connections of the working circuit; and

Figure 2 is a diagram of a source of frequency suitable for use for calibration purposes.

Referring to Figure 1, the ignition system of an internal combustion engine is shown operated from a 12 volt battery B. The spark coil is shown at T and the contact breaker at C shunted by the ignition capacitor

K. The secondary winding of the coil T is connected at D to the distributor of the ignition system of the engine. The relay *Re* employed is of the kind known as Carpenter type 3E made in accordance with U.S. Patent No. 2,412,123 and having a winding W of 1,000 turns. The relay *Re*, which is fully described in this patent, includes a pair of magnets NS disposed with their like S poles toward armature *a*, for polarizing the relay. The lower end of the armature is positioned between a pair of inwardly projecting arms of the relay core. The armature is pivoted at a point between these arms of the core and the magnets NS. It will be understood therefore that as the current in coil W flows in one direction and then the other, the armature will be attracted to one side and the other. The junction point between the primary winding P of the spark coil T and the contact breaker C is joined through one pole *n* of a three-pole switch S to the right hand end of the winding W through a branch which contains resistance R1 of 400 ohms and an inductance L of 0.25 henry. The left hand end of the winding W is connected through another pole *m* of the switch S and a capacitor K1 of 12 mfd. to the earth line E which is, in effect, the positive pole of the battery B. The right hand end of the winding W is also connected to the earth line through a capacitor K2 of one mfd. and a damping resistor R2 of 100 ohms. The resistor R2 is a damping resistance in the sense that it damps out oscillations in the closed circuit containing the resistance R1 and the inductance L and the contact breaker C. With this connection, the capacitors K1, K2 and resistor R2 are connected in shunt with the relay winding W.

The working position of the switch S is clearly the left hand position when the above described connections are made.

The armature *a* of the relay *Re* makes contacts so that on the left hand contact *f*, a battery *b* of a few dry cells is connected to charge a capacitor K3 whilst when the armature *a* changes over to its right hand contact *g*, the capacitor K3 is discharged through a milliamperemeter *mA*.

The relay *Re* is normally connected to the ignition circuit by throwing the switch S to the left. The contact *n* will then be at a potential nearly equal to that of the negative terminal of battery B, when the contact breaker C is open. The contact *m*, which is the other terminal of coil W, is connected to ground through a large capacitor K1, which during operation will be charged to an average voltage which is less than the voltage of the battery B, so that the upper plate of this capacitor K1 will have a potential lying between the potentials of the two poles of this battery. Thus, when the contact breaker C is opened, contact *n* is at a higher negative potential than contact *m* and the current will flow through coil W in one direction. When next the contact breaker C closes, contact *n* is quickly brought to substantially ground potential and contact *m* is then at a higher negative potential than contact *n* causing the current through coil W to flow in the opposite direction. Thus alternating pulses are supplied to coil W for operating the polarised relay.

In order to calibrate the instrument *mA* to respond to the number of contacts made per second and hence to indicate the revolutions per minute of the engine, it is provided with a shunt consisting of a fixed resistor R3 and a variable shunting resistance R4 with a hand control H.

This control is set as follows:

A connection is taken from an alternating current source G of known frequency, say 50 cycles per second, and applied through a switch such as the switch S to the relay winding W and the variable shunt R4 is adjusted to bring the needle of the meter A to the appropriate mark on its scale. However, in the case of a 6

cylinder engine when running at 6,000 revolutions a minute, the number of relay contacts made is 300 per second, so that a frequency of 50 cycles per second will only give a deflection of the instrument *mA* of one-sixth of the full scale reading. Therefore, the mains frequency of 50 cycles per second may be applied to a frequency-multiplying circuit so as to double or treble the main frequency before applying it to the meter.

Such a double frequency may be obtained by employing a full wave rectifier feeding a resistor and applying the voltage across the resistor to the relay winding W from a capacitor which passes the double frequency but stops the direct current component.

An alternative circuit shown in Figure 2 may be used to generate a current of tripled or higher frequency. It consists of a bridge network having two resistors R5, R6, preferably equal, in two diagonally disposed opposite arms, and two non-linear resistors F1, F2 in the remaining pair of arms. These non-linear resistors may be, for example, silicon carbide discs such as those sold under the trade names of Metrosil and Atmite or they may be diodes.

The input terminals V, Z of the bridge, are connected to the mains at G through the resistor R7 and the left hand pole *l* of the switch S. In what follows the mains are assumed to be of a frequency of 50 cycles per second.

The function of the non-linear resistors F1, F2 is to create strong harmonics of the 50 cycles per second current, and since F1, F2 are disposed diagonally opposite in the bridge, these harmonics will appear at the output terminals X, Y. By proper choice of the value of the resistors R5, R6 and R7, the bridge may, however, be balanced for 50 cycles per second so that only the harmonics appear at X, Y.

Now to enhance the desired harmonic, usually the tripled frequency which is the strongest, and to attenuate the other harmonics, tuning is employed. To this end, the capacitor K4 is connected in parallel with the winding W of the relay when the switch S is thrown to the right, the value of the capacitor K4 being so chosen as to form with the winding W, a parallel-tuned circuit resonating approximately to 150 cycles per second.

In an alternative form of connection, the capacitor K1 of 12 mfd. is dispensed with and the left hand end of the relay winding W at W1 is connected to the slider of a potentiometer resistor of, say, a few hundred ohms connected across the battery B. The best compromise position for the slider to give a minimum bias at an operating speed of 300 cycles per second, is about 2 volts from the negative end of the battery B.

It should be mentioned that electrolytic condensers are not suitable for use as the capacitors K1, K2, K3 or K4.

It will be understood that when the system is employed with an engine having a 6 volt battery B, the values of the components in the circuit would be selected accordingly.

What I claim is:

1. In an electric engine ignition system including an ignition battery, an ignition contact breaker connected in series with said ignition battery and an ignition spark coil having its primary winding connected in series with said ignition battery and said contact breaker, an electric tachometer system comprising a polarised electromagnetic relay, means for connecting the winding of said relay to the low tension side of said ignition system for supplying from said ignition system to said winding pulses having the same frequency as that of the contact breaker and alternating in direction, and an electric circuit controlled by said relay, said circuit including a charging battery, a capacitor and a current-measuring instrument, said capacitor being connected by said relay alternately to said charging battery and to said instrument.

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2. An electric tachometer system according to claim 1, in which said relay is in substantially neutral adjustment.

3. An electric tachometer system according to claim 1, and also comprising a low-pass filter connected in the circuit supplying the said winding. 5

4. An electric tachometer system according to claim 3, said low-pass filter comprising a resistor and inductor connected in series with said winding of said relay and a second capacitor connected in shunt with said winding of said relay. 10

5. An electric tachometer system according to claim 4, and also comprising a second resistor connected in series with said second capacitor.

6. An electric tachometer system according to claim 1, and also comprising an alternating current calibration source of known frequency and a switch to connect the winding of said relay either to said source or to said ignition system. 15

7. An electric tachometer system according to claim 6, said source being provided with a bridge supplied at one pair of its opposite junction with low frequency current and having one pair of its opposite arms made of ohmic resistances, and its other pair of opposite arms made of non-linear resistances, all said resistances being balanced at said low frequency so that an output of multiple frequency is obtained across the second pair of opposite junctions of the bridge for application to the winding of said relay. 20

8. An electric tachometer system according to claim 7, 30

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the output circuit of said source being tuned to resonate at the said multiple frequency.

9. In an electric engine ignition system including an ignition battery, an ignition contact breaker connected in series with said ignition battery and an ignition spark coil having its primary winding connected in series with said ignition battery and said contact breaker, an electric tachometer system comprising means connected to said ignition battery and defining a point having a mean potential lying between the potentials of the two poles of said ignition battery, and a polarised electromagnetic relay having one end of its winding connected to the junction of said primary winding and said contact breaker, whilst the other end of said winding is connected to said point, and an electric circuit controlled by said relay, said circuit including a charging battery, a capacitor and a current-measuring instrument, said capacitor being connected by said relay alternately to said charging battery and to said instrument.

10. An electric tachometer system according to claim 9, said means comprising a capacitor having one plate connected to said ignition battery and the other plate connected to said point.

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