Our invention relates to an arrangement for producing an alternating magnetic field and it covers means for producing such a magnetic field and the principles underlying the operation of such means with a view to constraining the arrangements of the type considered to answer more satisfactorily than hitherto the various requirements of practice.

Our improved method consists in producing an alternating magnetic flux inside a magnetic circuit through reciprocation of at least one member connected with a piston of an internal combustion engine, said reciprocation modifying periodically the reluctance of the magnetic circuit. This engine may be of the self-ignition or controlled ignition type. In certain cases, the connection between said member and said piston includes preferably no leverage. On the other hand, said reciprocating member is preferably constituted by a magnetic part adapted to make and break said magnetic circuit.

Plants according to our invention may form e.g. power units incorporating speed-modifying means or alternators.

According to a preferred embodiment, the power unit executed in accordance with our invention includes an internal combustion engine and an electric motor which is self-energized at least as concerns its main circuit, said electric motor including a magnetic circuit the magnetic flux in which varies periodically as provided by the reciprocation of the piston of said engine.

The alternator which may be associated with a power unit

according to our invention includes at least one main winding and two energized windings, these three windings being stationary and surrounding parts of a magnetic circuit inside which the magnetic flux is rendered alternating in accordance with our invention.

Our invention will be more readily understood after a reading of the following disclosure, reference being made to accompanying drawings, which latter are given chiefly by way of exemplification and by no means in a limiting sense. In said drawings:

Fig.1 is a sectional view, through line I-I of Fig.2, of a power unit incorporating speed-modifying means executed in accordance with our invention.

Fig.2 is a view through a plane perpendicular to the plane of Fig.1 , as shown by line II-II of said Fig.1.

Fig.3 is a fragmentary sectional view, similar to that of Fig.1, of a modified embodiment of a magnetic circuit according to the invention as applied to an electro-mechanical speed-modifying system.

Fig.4 is a fragmentary cross-section through an alternator executed in accordance with our invention.

Fig.5, lastly, is a cross-section, similar to Fig.1, of a double power unit which is also executed in accordance with our invention.

In the embodiments illustrated in Figs.1, 2, 3, and 5, the plant producing an alternating magnetic field is associated with an internal combustion engine and with a speed-modifying system.

The power unit illustrated in Figs.1 and 2 includes three main sections, to wit: on the left hand side of the dot and dash line A-A, the cylinder of an internal combustion engine, between the dot and dash lines A-A and B-B electro-

mechanical speed modifying means and to the right hand side of the line B-B a compressor cylinder forming a sushion of compressed air so as to return the engine piston towards its upper idle centre, i.e. towards the left hand side of the figure.

The engine cylinder 1 is assumed to form part of a two-stroke engine, which engine may, furthermore, include only said single cylinder. Inside said cylinder 1 or associated therewith, there is provided an ignition plug 2, an admission port 3 (Fig.1), an exhaust port 4 (Fig.2) and a transfer channel 5 (Fig.1). Inside said cylinder is adapted to reciprocate the piston 6 of the two-stroke engine provided in its turn with a transfer port 7 and carried by the piston rod 8.

Said piston rod 8 is devoid of any linkage connected therewith and it is made rigid with two parallel bars or the like parts 9a and 9b of magnetic material, said bars forming parallel side members the outer ends of which are rigid with a compressor piston 10 to be described hereinafter.

The speed-modifying means include chiefly a magnetic circuit and a rotor. The magnetic circuit comprises two lateral uprights 11a and 11b, a central pillar 12 and two breeches 13a and 13b. The central pillar 12 is truncated and forms a widely flaring pole-piece 12a facing the breech 13a and surrounding the rotor revolving therebetween.

The lateral uprights 11a and 11b are cut through transversely so as to form a gap the breadth of which is such as will provide a practically complete break of the magnetic circuit throughout the cross-section of either upright 11a or 11b when the corresponding gap is filled with air only, throughout its volume.

Inside said gaps may be fitted without friction magnetic shims 14a or 14b, which shims are adapted to fill said gaps

as completely as possible without this leading to any friction. These shims 14a and 14b are carried by the magnetic side members 9a and 9b at points such that when one of the shims has accurately engaged the gap inside the upright corresponding thereto, the other shim has completely released the other upright and is positioned outside the magnetic circuit considered as a whole. The fact of providing for the alternate shifting of the shims outwardly to either side of the magnetic circuit allows reducing the size of the latter in the horizontal direction as seen in Figs.1 and 2.

Round each of the uprights 11a and 11b is fitted an energizing coil 15a or 15b, said coil being fed through a circuit 16a from an electric supply 16 shown by way of example as a storage battery, the direction of flow of current through the coils being such that the coils produce inside the central pillar 12 fluxes of opposite directions, having equal absolute values. It will be readily ascertained that the alternating closing of the magnetic circuits in the uprights 11a and 11b produces a reversal of the direction of the total flux passing through the rotor 17 described hereinafter, which rotor is positioned between the outer end of the central pillar 12 and the section of the breech 13a facing the latter, in other words, between the two pole-pieces enclosing the rotor 17.

The rotor 17 is a wound rotor of the repulsion motor type and the winding 18 thereof engages notches of the rotor in the conventionnal manner. The rotor 17 is carried by the driving shaft 19 which also carries the commutator 20 on which rub the brushes 21 connected by a short-circuiting member 22 and the angular setting of which is adjustable as well known per se in the case of repulsion engines, the means for adjusting said angular setting being shown diagrammatically at 23.

It is advantageous to provide a recess in the magnetic

recess 13a in register with the outer end of the central pillar 12, while the rotor 17 is located so as to engage said recess which defines the polar surface facing the pole-piece 12a on the other side of the rotor. Thus, the bulk of the magnetic circuit in the vertical direction, as shown in Fig.1, is comparatively small.

It is also of advantage to position the magnetic uprights 11a and 11b at a small distance from the central pillar 12, which arrangement reduces the number of magnetic layers to be used.

In all cases, the particular arrangement of our improved magnetic circuit results in that, when the upright 11a is closed by the engagement of the magnetic shim inside the gap therein, the magnetic flux passes through the rotor in the opposite direction as when the closed upright is that shown at 11b.

The alternating flux thus generated by mechanical means when the internal combustion engine is operative, produces a rotation of the rotor 17 in a direction and at a speed which depend on the angular location of the brushes 21, as well known per se in repulsion motors, said direction and speed also depending on the relative values of the driving power produced by the piston 6 and of the antagonistic torque applied to the shaft 19.

This provides simple and resistant means for continuously varying the output speed of a power unit which is thus adapted to operate under excellent conditions, particularly as concerns its efficiency, chiefly because it may operate constantly at optimum speed without it being connected necessarily with any power-transmitting leverage or the like gear.

As to the antagonistic piston 10 referred to hereinabove,

it is rigid with the outer ends of the side members 9a and 9b. It moves inside a chamber 23 acting mechanically in the same manner as the piston of a self-compressing cylinder while it serves simultaneously as a guide for the ends of said side members. It is of advantage in fact for said chamber not only to form a support for the ends of the side members but also to provide for the angular setting of the latter round the axis of symmetry of the side member. The angular setting of the cylinder may be provided in various manners. In the embodiment illustrated, it has been assumed that the piston 10 and the chamber 23 have a rectangular cross- section.

A plant producing an alternating magnetic field according to our invention, may be executed in various manners and for various applications.

Fig.3 illustrates a modification of the magnetic circuit which is assumed again to be applied to the execution of a speed-modifying device including a rotor similar to that illustrated in Fig.1. Likewise, the engine driving the magnetic shim 14 described hereinafter may be constituted as in the case of Figs.1 and 2, except for the fact that the compressor cylinder 10-23, if extant, is then positioned between the driving cylinder 1 and said shim 14.

The magnetic circuit of the arrangement illustrated in Fig.3 includes two uprights 11c and 11d inside each of which is provided a gap extending over a substantial height, said gap being adapted to be filled selectively without friction by the introduction of the single magnetic shim 14. The two uprights 11c and 11d extending in adjacent relationship in the embodiment considered, with the mere interposition of a separating air gap, the reciprocation of the shim 14 which is

the only shim provided, closes magnetically one of the two uprights 11c and 11d in alternation while it opens magnetically the other upright.

Each of said uprights is provided with an energizing coil 15c and 15d, said coils being fed through the circuit 16a by a supply 16.

The magnetic circuit includes as precedingly two large pole-pieces 12c and 12d to either side of the rotor 17, so that the magnetic flux passes through said rotor between said poles. The energizing coils 15c and 15d are fed in a manner such that they produce magnetic fluxes of opposite directions batween the pole-pieces 12c and 12d, the absolute values of said fluxes being equal. Thus, the reciprocation of the shim 14 produces an alternating field batween the pole-pieces 12c and 12d, which field produces in its turn the rotation of the rotor 17, provided the angular setting of the brushes 21 is correctely adjusted as required by the resistant torque applied to the shaft 19.

It is apparent that embodiments of the type illustrated in Fig.3, wherein the two energizing uprights such as 11c and 11d are adjacent, include a magnetic circuit the bulk of which is less than that of the arrangement illustrated in Fig.1.

Fig. 4 illustrates a further application of our improved arrangement producing an alternating magnetic field, said application leading to the execution of an alternator power unit, all the windings of which are stationary.

Generally speaking, the magnetic circuit of said alternator power unit is similar to the magnetic circuit of the above described adjustable power unit according to our invention, except

for the fact that the rotor is omitted and replaced by an extension of the magnetic pillar inside which it was fitted in the said above described embodiment. In the case of said Fig.4, it has been assumed that the magnetic circuit is of the type illustrated in Fig.1. Here again, the two uprights are shown at 11e and 11f, the spacing between which is less than between the uprights 11a and 11b of Fig.1, said uprights being associated with the two breeches 13e and 13f and the central pillar 12e connecting the latter with each other.

Round the two uprights are wound the two corresponding energizing or inductor coils 15e and 15f fed from a supply 16 through a circuit 16a, the current flowing in a direction such that said coils induce, inside the central pillar 12e, magnetic fluxes of opposite directions.

The main or induced winding of the alternator is shown at 24 as surrounding the main central pillar 12e, said winding being connected with the output terminals 25. The magnetic flux, which is alternating as provided by our improved arrangement, produces inside the winding 24 an alternating current.

The magnetic circuit, the coils or windings and the rotor, if any, of an arrangement or power unit executed in accordance with our invention, may be enclosed inside a casing 26 to which the magnetic circuit is secured by cross-bars 27 or the like.

It may be desirable to provide the arrangement with a speed regulator on the engine side, chiefly if the power unit is constituted as an alternator. Again it may be of advantage to benefit by the fact that the driving piston when devoid of any linkage or leverage, is submitted normally to no reaction beyond longitudinal reactions. Consequently, its lateral friction inside the cylinder may be reduced to a very small value, which allows providing for the sliding of

the piston without any fluid lubrication, possibly after a suitable treatment of the contacting surfaces such as the so-called sulphinization process. The cutting out of all fluid lubrication allows also reducing considerably or even omitting the conventional means used for cooling the cylinder If no liquid lubricant is provided, it is, in fact, possible to operate with a cylinder the temperature of the inner wall of which is above 150°C.

On the other hand, it may be of advantage to execute a double power unit according to our invention, wherein two driving pistons, each similar for instance to that illustrated in Figs.1 and 2, operate in antagonism. This may lead on one hand to a better dynamic balance for the moving parts. On the other hand, if the two pistons are mounted for operation in opposition inside a single cylinder, each of said pistons acting on a magnetic circuit cooperating with a corresponding motor, the two rotors may operate at different speeds or under different torque conditions, the power being transmitted by a single cylinder. This latter arrangement may be of special interest, for instance if the two rotors are to actuate respectively one of the driving wheels of a vehicle to either side of the latter; the double power unit according to our invention allows thus the speeds of said wheels to be different without any conventional differential gear being required.

An embodiment of such a double power unit is illustrated in Fig.5. The driving cylinder 1b which is assumed to form the single driving cylinder is mounted between two magnetic systems which are advantageously similar, each of the antagonistic pistons 6a and 6b of the driving cylinder acting on one of the magnetic systems in the same manner as the piston

6 acts on the magnetic system illustrated in Fig.1. It is possible to synchronize the two pistons, or any equivalent movable antagonistic gears, for instance by means of a system of links as shown at 27a, 27b, 27c.

The above disclosure shows that, whatever embodiment is resorted to, it is possible to obtain alternating magnetic fields through the operation of an internal combustion engine without any further disclosure being required.

The advantages of the arrangements referred to are chiefly as follows:

- when they are incorporated into power units, their resistance and adaptability of operation under various conditions of use;

- in the case of their incorporation into alternator units, their resistance as precedingly and the cutting out of any rotary electric winding.

Obviously and as already mentioned, our invention is by no means limited to the applications and embodiments and to the structures proposed for its different parts, as described hereinabove and it covers in particular various modifications, such as:

- the modification according to which the energization of the circuit is obtained through permanent magnets.

- the modifications relating to the shape and/or size of the magnetic circuit and its components and/or the location of the gaps extending through the magnetic circuit and/or the arrangement of the energizing windings and/or of the magnetic shims.

- and lastly those modifications wherein the member or members modifying the reluctance of the magnetic circuit are controlled by two driving cylinders acting in oppositions