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ELECTRIC SWITCHING APPARATUS

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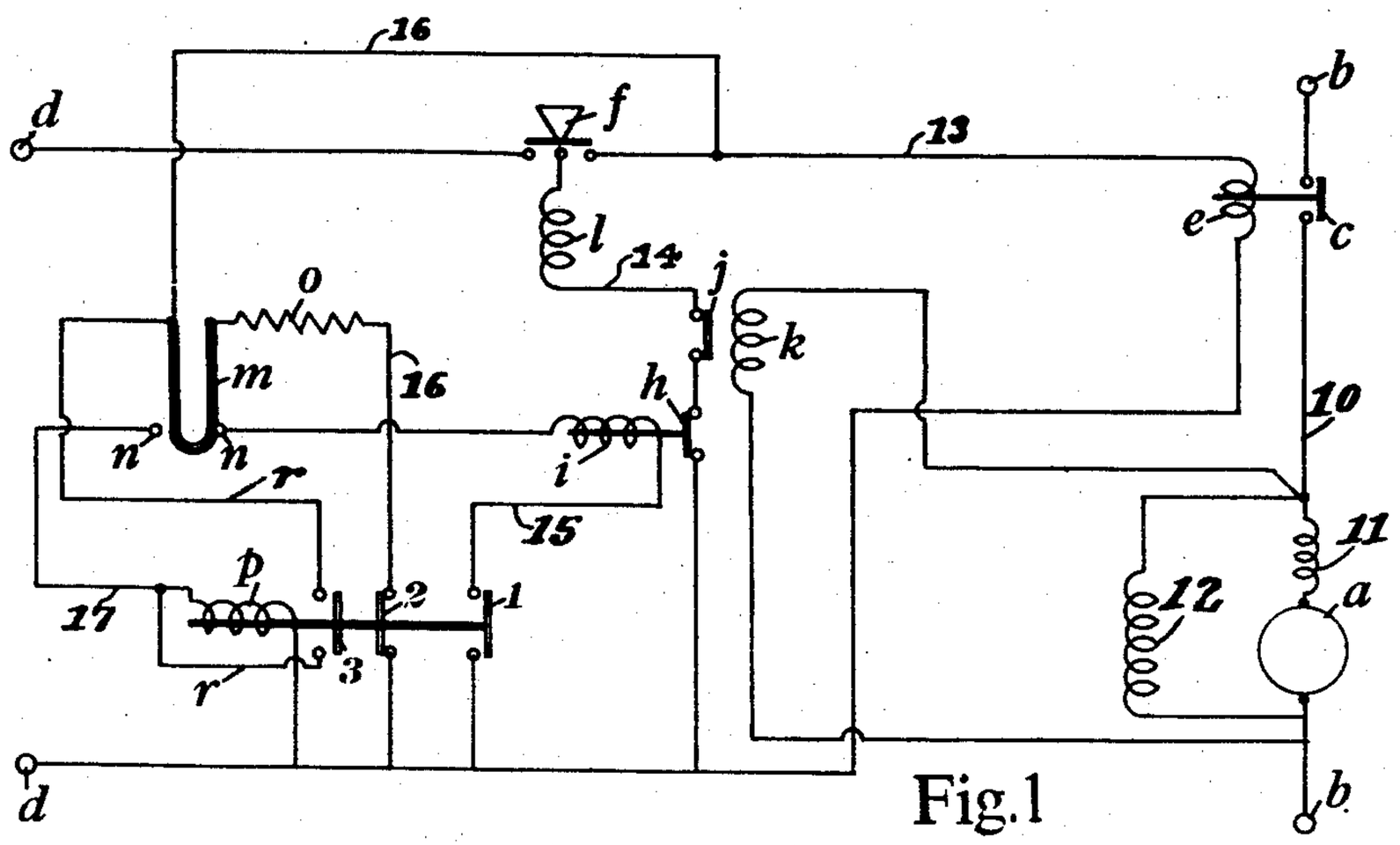

Fig.1

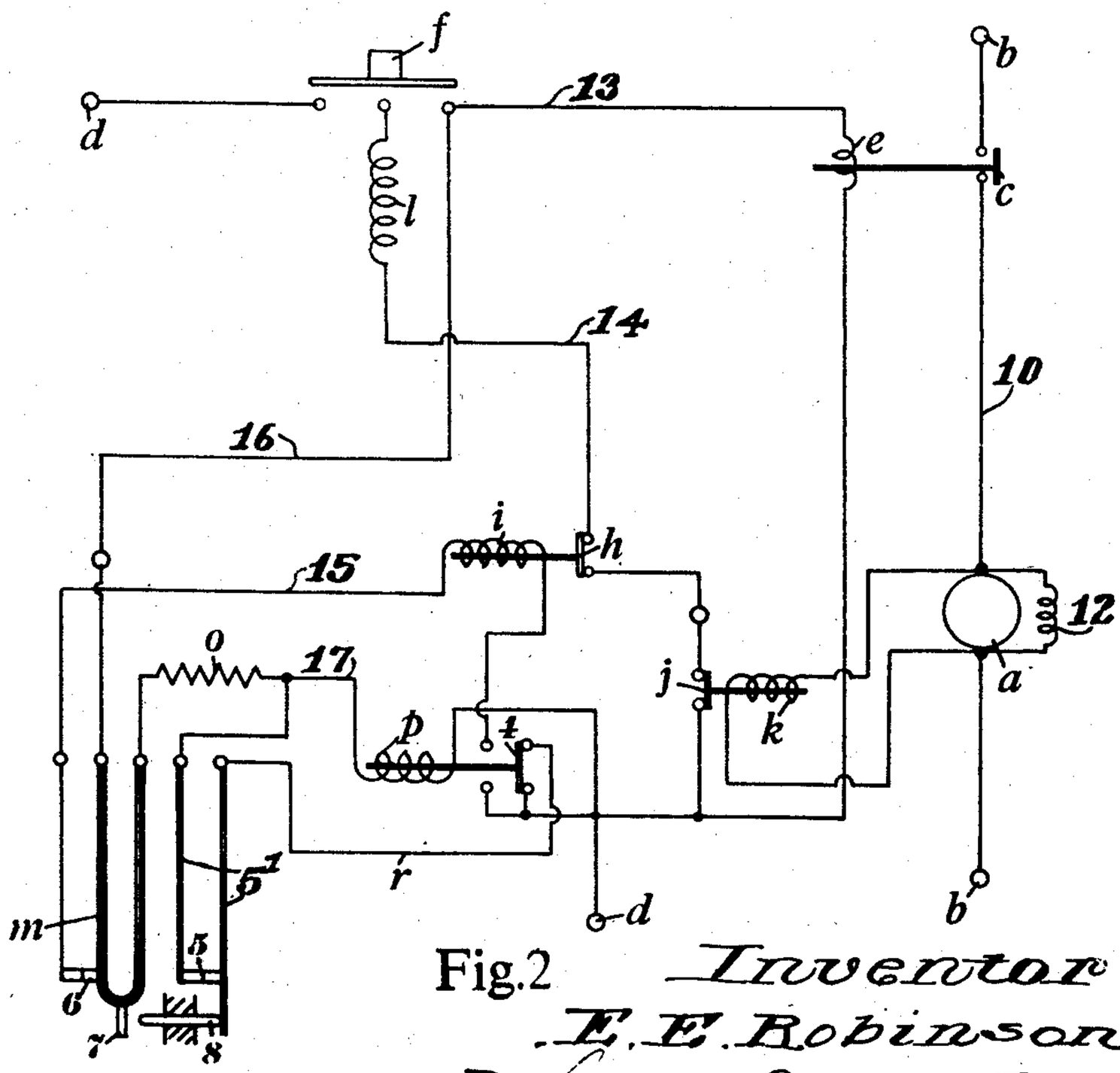

Fig.2

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ELECTRIC SWITCHING APPARATUS

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This invention has for its object to provide improved electrical switching apparatus, more particularly for controlling an electric motor used for starting an internal combustion turbine, or a jet propulsion or other prime mover, but it may be applied to other analogous uses in which the duration of an operation is required to be automatically controlled.

The invention comprises the combination of a manually operable switch having an associated electromagnet for holding it in the closed position, an electromagnetically operable switch under the control of the manually operable switch for controlling the electric engine-starting motor or other apparatus, a two-way electrically-heated timing switch, and electromagnetically operable switching means associated with the timing switch for controlling the timing switch and the manually operable switch.

In the accompanying drawings:

Figures 1 and 2 are diagrams respectively illustrating two embodiments of the invention.

Referring to Figure 1, which represents an apparatus for controlling the electric starting motor *a* of a turbine, jet-propulsion or other internal combustion prime mover, this motor is arranged in an electric circuit 10 provided with terminals *b* through which current from a storage battery (not shown) can be supplied to the circuit for energising the motor, the latter being provided with field windings 11, 12. For controlling the motor *a* there is also arranged in the circuit 10 a normally-open switch *c* which is movable to the closed position by an electromagnet *e*, this latter being arranged in a circuit 13 which can be supplied with current from the storage battery through terminals *d*. The circuit 13 is controlled by a push-button or other convenient manually operable switch *f*.

In association with the manually operable switch *f* is arranged an electromagnet *l* which serves to retain it in its closed position, this electromagnet being arranged in a circuit 14 which is controlled in part by the manually operable switch itself and in part by a switch *h* operable by an electromagnet *i* in a circuit 15 which is under the control of the timing switch to be hereinafter described. In addition the circuit 14 may also be controlled by another switch *j* under the control of an electromagnet *k* connected across the motor *a* this switch being opened when (after the engine has been started) the voltage across the motor rises above a predetermined value, or alternatively the electromagnet of this switch is directly responsive to the current in the motor circuit.

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The timing switch (arranged in a circuit 16 which is closed by the closing of the manually operable switch *f*) may be of any convenient kind which is operable thermally under the action of heat generated by an electric current. In one convenient form it comprises as shown a bi-metal strip *m* which is movable between a pair of fixed contacts *n* under the deforming effect created by the heating action of current flowing through the strip, or through an associated heating coil. In series with the strip *m* there is arranged in the circuit 16 a resistance *o* for restricting the current supplied to the strip, and this resistance may be the heating coil above mentioned. Normally the strip rests on one of the contacts *n*. Movement of the strip to the other contact *n* is effected by deformation of the strip by heat. Return to the first contact results when the strip is cooled. The contact *n* on which the strip *m* rests when cool, is arranged in the circuit 15 containing the electromagnet *i*. The other contact *n* is in a circuit 17 containing an electromagnet *p* for actuating a switch, herein termed a three-way switch having parts 1, 2, 3 which respectively control (*a*) the circuit 15 of the electromagnet *i* associated with the one contact *n*, (*b*) the timing switch circuit 16, and (*c*) a branch circuit *r* connected to the circuits 16, 17.

The apparatus above described is adapted to operate in the following manner:

Closing of the manually operable switch *f* completes the circuits 13 and 14, and enables these circuits to be supplied with current through the terminals *d*. The current flowing through the circuit 13 energises the electromagnet *e*, causing the switch *c* to close the circuit 10, and thereby enabling the motor *a* to be set in motion by current supplied to the latter circuit through the terminals *b*. The current flowing through the circuit 14 energises the electromagnet *l* which serves to hold the manually operable switch *f* closed. Current also flows from the circuit 13 through the circuit 16 containing the bi-metal strip *m* and resistance *o*, causing the bi-metal strip to be heated either by the current flowing through it, or by the heating effect of the resistance when the latter is a heating coil. The bi-metal strip *m* is deformed by the heating action in a relatively short time interval, and is thereby caused to move to its other position in which it co-operates with the second contact *n* to close the circuit 17 of the electromagnet *p* associated with the three-way switch 1, 2, 3. The latter then (*a*) closes the branch circuit *r* through the part 3 and thereby enables current from the circuit 16 to flow through the branch

circuit and energises the electromagnet *p* independently of the strip *m*, so that this electromagnet can remain in action after the strip, on cooling, leaves the second contact; (*b*) opens the circuit 16 of the bi-metal strip *m* through the part 2; and (*c*) closes the part of the circuit 15 connected to the first contact *n* of the timing switch. With the cooling of the bi-metal strip *m* the latter returns at a controlled rate (which may be regulated by enclosing the strip in a heat insulating cover) to the first contact *n*. On reaching this contact it closes the circuit 15, and current flowing through this circuit from the circuit 16 energizes the electromagnet *i* which causes the switch *h* in the circuit associated with the electromagnet *l* of the manually operable switch *f* to be opened. This electromagnet is thus de-energised and allows the manually operable switch *f* to open under the action of a spring (not shown) and interrupt the supply of current to the electromagnet *e* of the motor switch *c* and to the electromagnet *p* of the triple-switch 1, 2, 3 which on opening completes the restoration of the system to its initial condition in readiness for a repetition of the cycle of operations.

The modification illustrated by Figure 2 is essentially similar to the example shown in Figure 1 and differs only in the following details. Instead of the three-way switch 1, 2, 3 of Figure 1 there is employed a two-way switch 4 under the control of the electromagnet *p* in the circuit 17, and in the position shown this switch closes the branch circuit *r*. In its other position it closes the adjacent part of the circuit 15 of the electromagnet *i*. In the circuit *r* is arranged a normally closed switch 5 comprising a pair of spring blades 5^1 which are separable by the bi-metal strip *m* through a tappet 7 and push piece 8, either or both of the parts 7, 8 being made wholly or in part of insulating material. Also in the circuit 15 of the electromagnet *i* is arranged a normally closed switch 6 formed in part by the bi-metal strip *m*. in other respects the example shown in Figure 2 is essentially similar to that shown in Figure 1 and is indicated by the same reference characters.

Initially the various parts of the system are in the condition shown. On closing the manually-operable switch *f*, the motor switch *c* is closed as in the previously described example. Also current flows through a part of the circuit 16, the bi-metal strip *m*, resistance *o*, switch 5, circuit *r* and switch 4, causing the bi-metal strip *m* to be heated. With the consequent deformation of the strip *m* the switch 6 is opened and also the switch 5 is opened (through the push piece 8). The effect of this is to open the circuit *r* and cause the current which previously passed through the switch 5 to flow through the electromagnet *p* which is thereby brought into action for moving the switch 4 to its other position in which it closes the adjacent part of the circuit 15. The ohmic resistance of the electromagnet *p* reduces the heating effect of the current on the bi-metal strip *m* sufficiently to allow the latter to return to its initial position where it closes the switch 6 and completes the circuit 15, thus bringing electromagnet *i* into action. The switch *h* is thereupon opened by the electromagnet *i* and the system brought back to its original condition as in the previously described example.

Whilst the invention is primarily intended for controlling an engine starting motor, or a group of such motors, it may also (as already stated) be applied to other analogous uses, and subordinate details may be modified to suit different requirements.

Having thus described my invention what I claim as new and desire to secure by Letters Patent is:

1. Electric switching apparatus comprising in combination a main electric circuit, an electromagnet arranged in said main electric circuit, a second electric circuit, a manually operable switch arranged to establish and interrupt both said main electric circuit and said second electric circuit, a second electromagnet arranged in said second electric circuit and serving, when energised, to hold said manually operable switch in its closed position, a third electric circuit connected to said main electric circuit so that current can flow through said third electric circuit when said manually operable switch is closed, a thermal time switch member connected to said third electric circuit so that said member is responsive to the heating effect of current flowing through said third electric circuit, and electromagnetically operable switching means controllable by said thermal time switch member for interrupting said second circuit, and thereby enabling said manually operable switch to reopen.

2. Electric switching apparatus comprising in combination a main electric circuit, an electromagnet arranged in said main electric circuit, a second electric circuit, a manually operable switch arranged to establish and interrupt both said main electric circuit and said second electric circuit, a second electromagnet arranged in said second electric circuit and serving, when energised, to hold said manually operable switch in its closed position, a third electric circuit connected to said main electric circuit so that current can flow through said third electric circuit when said manually operable switch is closed, a thermal time switch member connected to said third electric circuit so that said member is movable from its normal position to a second position by the heating effect of current flowing through said third electric circuit, a fourth electric circuit arranged to be completed by said member when the latter occupies said second position, a third electromagnet in said fourth electric circuit, a branch circuit whereby current can be supplied to said third electromagnet independently of said member, a fifth electric circuit which is connected by said member to said third electric circuit when said member occupies its normal position, a fourth electromagnet in said fifth electric circuit, another switch arranged to control said second electric circuit and operable by said fourth electromagnet, and switching means operable by said third electromagnet for controlling said third, fifth and branch electric circuits.

3. Electric switching apparatus comprising in combination a main electric circuit, an electromagnet arranged in said main electric circuit, a second electric circuit, a manually operable switch arranged to establish and interrupt both said main electric circuit and said second electric circuit, a second electromagnet arranged in said second electric circuit and serving, when energised, to hold said manually operable switch in its closed position, a third electric circuit connected to said main electric circuit so that current can flow through said third electric circuit when said manually operable switch is closed, a thermal time switch member connected to said third electric circuit so that said member is mov-

able from its normal position to a second position by the heating effect of current flowing through said third electric circuit, a fourth electric circuit connected to said third electric circuit, a third electromagnet in said fourth electric circuit, a branch circuit for short-circuiting said third electromagnet, a third switch arranged in said branch circuit and operable by said thermal time switch member, a fifth electric circuit which is connected by said member to said third electric circuit when said member occupies its normal position, a fourth electromagnet in said fifth electric circuit, another switch arranged to control said second electric circuit and operable by said fourth electromagnet, and switching means operable by said third electromagnet for controlling said branch and fifth electric circuits.

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