

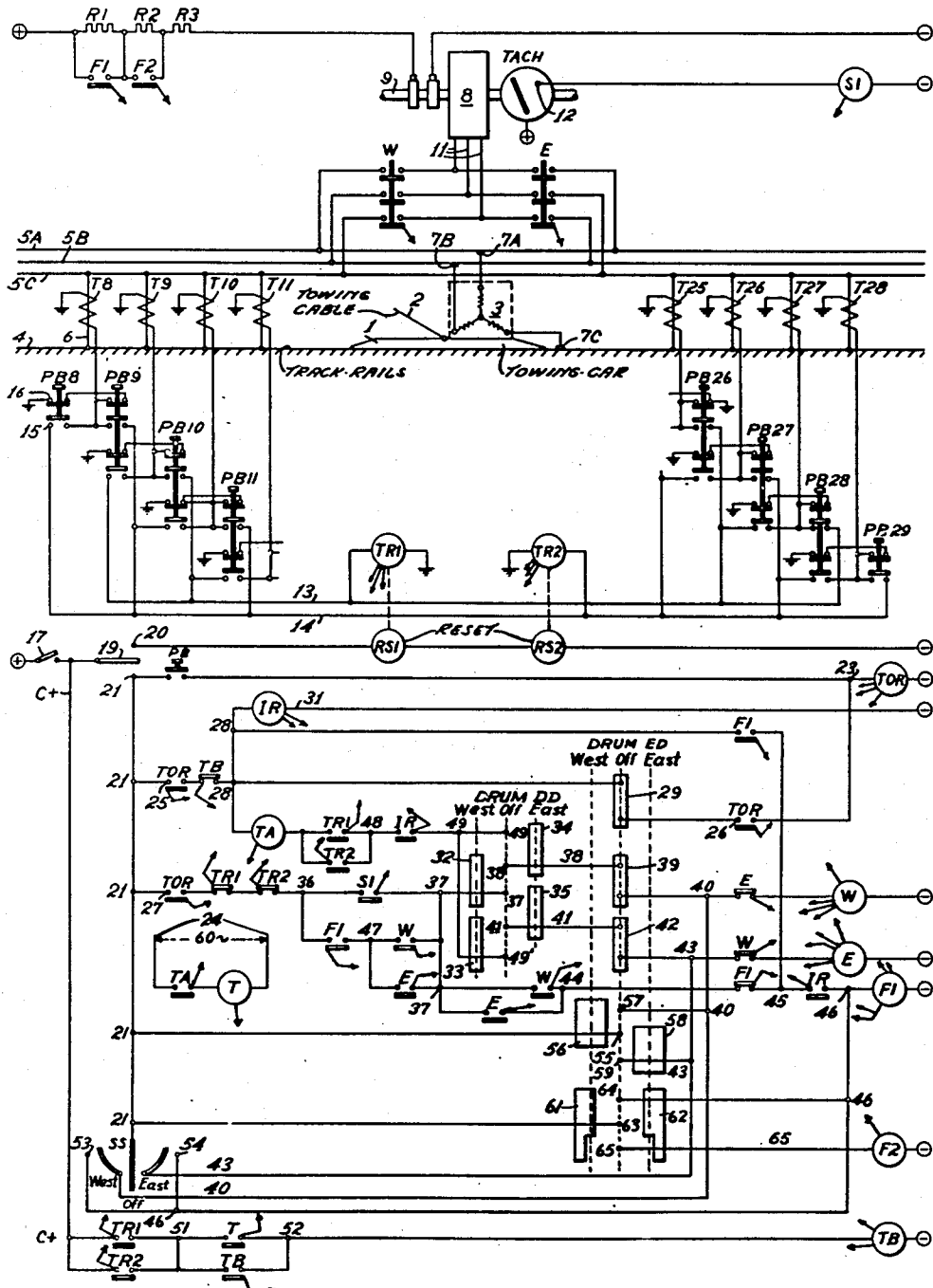
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ALTERNATING CURRENT MOTOR CONTROL SYSTEM

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WITNESSES:

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ALTERNATING CURRENT MOTOR CONTROL SYSTEM

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My invention relates to an electric aircraft-launching catapult of the type utilizing a linear-motor towing-car, and it has particular relation to improvements in the control-means therefor.

The control of a linear-motor catapult presents particularly difficult design-problems because it involves a short time, of the order of 6 seconds, more or less, a large towing-car mass, which may be of the order of several tons, and a high maximum speed, necessary for aircraft-launching, which may be of the order of 90 miles per hour, more or less. Added to these problems is the danger of the possibility of a false start, without a proper connection between the towing-cable and the aircraft to be launched, and the ever-present danger of a serious wreck, if there is any mishap during the launching or if the automatic adjustments, for predetermining any particular launching-run, should prove to be wrong.

The general object of my present invention is to provide improved control-means for safeguarding the launching of aircraft with electric linear-motor catapults.

A more specific object of my invention is to provide improved means for responding to any one of a large number of pre-selected positions of the car, along the length of the track, so that the length of the accelerating run may be predetermined or pre-selected without requiring the utilization of a large number of track-responsive selector-switches. The high launching speeds frequently make impractical the use of simple track-switches having parts which are adapted to be struck by the car when it passes any particular point, because the forces of such impacts, at speeds exceeding 50 miles per hour, more or less, is usually such as to overtax the strength of any readily available structural material. My present invention provides simple and improved means for responding to a pre-selected one of a plurality of positions along the trackway, involving the use of a plurality of position-responsive means, for developing relaying-energy at each of their several positions, during the progress of an aircraft-launching accelerating-run, a single run-controlling relay-means, and pre-selector means for making the relaying energy of a pre-selected one or more of said position-responsive means effectively available in said run-controlling relay-means.

A further object of my invention has to do with means for initially energizing the towing-car at a low voltage, and increasing the voltage of energization only after the initial energization has taken place.

With the foregoing and other objects in view, my invention consists of the methods, systems, circuits, combinations, structures, apparatus and parts, hereinafter described and claimed, and illustrated in the accompanying drawing, where-

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in the single figure is a diagrammatic view of circuits and apparatus involving my invention in an illustrative form of embodiment, with the parts not shown in proper scale in order to facilitate the illustration.

My invention is illustrated in connection with an aircraft-launching catapult involving a self-propelled, polyphase-motored, aircraft-launching electric towing-car 1, having a towing-cable 2 and a polyphase propulsion-motor, the primary winding of which is indicated at 3. The towing-car 1 rides on track-rails 4, along the side of which is disposed a three-phase third-rail bus 5a, 5b and 5c. One of said three-phase supply-busses, 5c, is connected to the track-rails 4 at each of a plurality of spaced points along the trackway, by means of a large number of spaced connectors 6. Energy for the towing-car motor 3 is supplied by means of current-collectors 7a, 7b and 7c, making electrical connection, respectively, with the bus 5a, the bus 5b, and the track 4.

The car-borne primary-winding 3 may represent any kind of propulsion-motor: in a preferred form of construction, it is the primary-member of a linear-motor construction, as set forth in my application Serial No. 500,639, filed August 31, 1943, patented December 10, 1946, No. 2,412,514, or in an application of Maurice F. Jones and Lee A. Kilgore, Serial No. 506,198, filed October 14, 1943, patented December 10, 1946, No. 2,412,512, and assigned to the Westinghouse Electric & Manufacturing Company.

Propulsion-power for the towing-car 1 is supplied to the third-rail-busses 5a, 5b and 5c from a variable-voltage three-phase source which is shown in the form of a three-phase synchronous generator 8, which is driven from any suitable prime-mover shaft 9, and which is provided with exciting-field resistors R1, R2 and R3, the first two of which may be short-circuited by field-relays F1 and F2, respectively.

In the drawing, the control is shown by schematic or "across the line" diagram. The various relays which are shown are of the electromagnetic type, and the same reference-character is utilized to apply to the relay-coils, shown diagrammatically as circles, and to the relay-contacts, which are invariably shown in their non-energized positions, thus sufficiently designating and correlating both parts of each relay, that is, both its energizing-coil and its contact-member or members. Arrows or dotted lines are also used, as a further convention, for symbolically indicating how the various parts of each relay are connected together. When I speak of an energizing-coil for a relay, I mean to refer to any kind of actuating-coil which causes the relay to be moved from its normal position, regarded as its non-actuated position, to its ac-

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tuated or control-responsive position, whether the actuating or moving-force is actually produced by the relay-actuating coil, or merely controlled, or unlatched, or tripped off, by said relay-actuating coil.

In the drawing, I am also showing only the circuits which seem to be necessary to convey an understanding of my present invention, omitting many of the interlocks and safeguards and other well-known features which make such control-diagrams extremely complicated, and which would be readily understood and applied by any control-engineer.

The terminal leads 11 of the generator 8 constitute a variable-voltage polyphase supply-means, the voltage of which can be controlled through the field-switches F1 and F2. The electrical energy of the polyphase supply-line 11 is fed, in either the positive phase-sequence or the negative phase-sequence, to the polyphase third-rail assembly 5a, 5b, 5c, through the main contacts of either one of two main contactor-switches or relays designated W and E respectively, contemplating, for the sake of convenience in description, an east-and-west runway 4, with main contactor-relays W and E for energizing the motor 3 in a phase-sequence for developing a driving-force in a westerly direction, or in an easterly direction, respectively.

The power-plant shaft 9 is also illustrated as being provided with a contact-making tachometer TACH, or other speed-responsive device, which makes a contact 12 when the generator 8 is being driven at a speed high enough to provide adequate accelerating-power for any particular aircraft-launching operation. If desired, the contact-point 12 of the tachometer TACH may be adjustable, so as to provide for different generator-speeds depending upon different starting-conditions for aircraft of different mass and take-off speeds. The tachometer-contact 12 is illustrated as being utilized to energize an auxiliary speed-responsive switch S1.

My special control-means is illustrated by various equipments which are diagrammatically indicated in the drawing. Referring to this apparatus in the order in which it appears on the drawing, reference may now be made to a plurality of track-transformers T8 to T28 which are shown in the form of current-transformers associated with the respective connectors 6 which are spaced along the trackway at frequent intervals, for feeding power into the track-rails 4 from the third-rail 5c. When heavy take-off accelerating-energy is fed into the towing-car 1, the larger part of this energy flows into the track-rails 4 at the point where the car makes contact with the rails, and the current-transformers T8 to T28 are designed to develop an adequate predetermined amount of relaying-energy when this heavy propulsion-current is flowing through their particular connectors 6.

In accordance with my invention, I provide a suitable selector-means for pre-selecting a particular one or more of the current-transformers T8 to T28, and for making its energy available for exciting a suitable run-controlling relay-means, which is illustrated in the form of two track-relays TR1 and TR2. Two track-relays TR1 and TR2 are shown, so that the second track-relay can serve as a safeguard or back-up relay against a possible failure of the first relay, the second track-relay being energized from the next succeeding track-transformer, selected from the group T8 to T28, as will now be described.

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Energy for the two track-relays TR1 and TR2 is applied to the respective relay-terminals 13 and 14, respectively, by means of any suitable selector-means, which is diagrammatically indicated in the form of push buttons numbered PB8 to PB29, which may be of the "stay where put" type, and which are intended to represent any selector-switch means, whether of the push-button type, or of the knife-switch type, or of the drum-type, or of the sliding-contact type, or of any other suitable type, with any desired or suitable interlocks (not shown). The first and last push buttons PB8 and PB29 are provided, as shown, with only one pair of contacts, namely a make-contact 15 and a back-contact 16. All of the other push buttons, PB9 to PB28 inclusive, are provided with two pairs of such contacts. In each case, the back-contact 16 is utilized in a normally closed short-circuit around one of the track-transformers T8 to T28, while the corresponding front-contact 15 is utilized to connect that particular track-transformer to one or the other of the two terminals 13 and 14 of the two track-relays TR1 and TR2.

The construction is such that the two end push buttons PB8 and PB29, respectively, connect the track-transformers T8 and T28 to the track-relay TR2, so that only this single track-relay TR2 is energized when the car reaches the position corresponding to the selected track-relays T8 or T28, if either one of these end push buttons PB8 or PB29 is depressed or selected. If any one of the intermediate push buttons PB9 to PB28 is selected, then two successive track-transformers, selected from the group T8 to T28 are connected respectively to the two track-relays TR1 and TR2, so that both of these track-relays will be energized, one after the other, when the car reaches the selected point in its accelerating-run. The two track-relays TR1 and TR2 thus supplement each other and make sure that at least one of them will be very certainly operated, in response to the position of the towing-car 1 along the trackway 4.

My main direct-current control-circuits are under the control of a control-switch 17, which energizes a control-bus C+ from the positive terminal (+) of any suitable direct-current control-source, the negative terminal of which is indicated at (-). From the control-bus C+ a circuit is completed to a reset-switch 19 which is capable of making either a contact 20 or a contact 21. The contact 20 is utilized only for the purpose of energizing two reset-coils RS1 and RS2 which are associated with the respective track-relays TR1 and TR2. These track-relays are of the position-maintaining type, which remain in whichever position they occupy, even after the controlling-force has been removed therefrom. The reset-coils RS1 and RS2 are for the purpose of causing these track-relays TR1 and TR2 to be reset to their normal non-actuated, or non-selected positions, whereas the actuating-coils TR1 and TR2 are utilized for the purpose of causing said track-relays to move to their actuated or controlled or selected positions.

The other contact, 21, of the reset-switch 19 is the main relaying-contact of this switch, energizing a relaying bus which is designated by the same numeral 21. Various relaying circuits are energized from this relaying bus 21. The first such circuit, shown on the drawing, is a push-button circuit under the control of a starting switch which is shown, diagrammatically and schematically, in the form of push button PB,

although it is to be understood that I am not by any means limited to a push-button form of a starting-switch. The push button PB energizes a relay-circuit or terminal 23 of the operating-coil of a take-off relay TOR, the other terminal of which is connected to the negative bus (-).

In addition to the take-off relay TOR, I provide a direction-selecting drum DD, and an emergency drum ED, both illustrated in the form of drum-type controllers having a central "off" position, and right-hand and left-hand "east" and "west" positions.

I also provide a timer T, which is illustrated in the form of a motor, energized from a 60-cycle supply-circuit 24.

When the take-off relay TOR is energized, it picks up its make-contacts 25, 26 and 27, immediately closing a holding circuit around the starting push button PB. This holding circuit may be traced from the conductor 21, through the TOR make-contact 25, and a back-contact TB of an auxiliary timer-relay TB, to a conductor 28, and thence through an "off" drum-contact 29 of the emergency-drum ED, and through the TOR make-contact 26, to the TOR relay-terminal 23. The conductor 28 is also utilized to energize the actuating coil of an interlock-relay IR, as shown at 31, and also to energize other circuits which will be described later on.

Before actuating the starting-button PB to energize the take-off relay TOR, the direction-selecting drum DD will ordinarily be actuated to either its "west" or "east" position, although the direction-selecting drum DD could be moved subsequently to the energization of the take-off relay TOR. This direction-selecting drum DD has two contact-members 32 and 33 which are effective in its "west" position, and two contact-members 34 and 35 which are effective in its "east" position.

The picking up of the third contact 27 of the take-off relay TOR serves to energize the actuating coil of either the "west" or "east" contactor-switch W or E, according to the position of the direction-drum DD. A partial circuit for these contactor-relays W and E may be traced from the conductor 21, through the TOR make-contact 27, and back-contacts TR1 and TR2 of the two track-relays TR1 and TR2, to a conductor 36, and thence through a make-contact S1 of the speed-responsive relay S1, to a conductor 37, which leads to a correspondingly numbered contact-point 37 on the drum DD. If the drum DD is in its "west" position, its contact-member 32 energizes a contact-point 38, from which a correspondingly numbered conductor 38 leads, through an "off" drum-contact 39 of the emergency drum ED, to a conductor 40, from which a circuit is completed to the operating coil of the main contactor W, through an interlocking back-contact E of the other main contactor E. If the direction-drum had been in its "east" position, its contact-member 35 would have joined the contact-point 37 to a contact-point 41, which leads, through a correspondingly numbered conductor 41, and through an "off" drum-contact 42 of the emergency-drum ED, to a conductor 43, which energizes the contactor-coil E through a back-contact W of the contactor W.

The conductor 37 is utilized also to energize the operating coil of the first field-controlling relay F1, in a circuit which can be traced from the conductor 37, through parallel-connected make-contacts W and E of the main contactors

W and E, to a conductor 44, and thence through a back-contact F1 of said field-relay F1, to a conductor 45, and thence through a make-contact IR of the interlock-relay IR, to a conductor 46, which energizes the operating coil of the field-relay F1. The field-relay F1 immediately seals itself in, in a circuit which can be traced from the relaying conductor 28, through a make-contact F1 of said field-relay F1, to the conductor 45 which energizes the operating coil F1 through the make-contact IR and the relaying circuit 46.

The effect of the energization of this field-relay F1 is to increase the excitation of the three-phase generator 8, changing the excitation from its minimum value which it had with all three of the field-resistors R1, R2 and R3 in circuit, and causing the field-excitation to increase to a value corresponding to only two of the field-resistors R2 and R3 in the exciting circuit of the generator. It is noted that this increase in the generator-excitation occurs only after, and in response to, the picking up or completed response of one of the main motor-starting contactors W or E from the same control-circuit 37 which is also utilized to energize the field-relay F1.

Since the generator-flux cannot change instantly, in response to an increase in its exciting-field current, but changes only gradually, according to the time-constant of the generator, this mode of field-circuit control insures that the generator-voltage shall start out at a low value, upon the initial energization of the towing-car motor 3, thereafter increasing according to the time-constant of the generator-field, if the field-relay F1 is quick in its operation, or involving any slowness of action, or other time-delay (if any) which may be built into the field-controlling relay F1, as will be readily understood by those skilled in the art. It will be readily understood, of course, that other, and more elaborate, field-control means may be utilized, for cutting out the field-resistances R1, R2 and/or R3 in two or more steps, if desired, and in any desired time-sequence, my field-controlling means being intended to be broadly indicative of any suitable voltage-increasing means for increasing the voltage of the supply-circuit 11, or the output-terminals 11 of the generator 8, after the initial energization of the motor 3.

When the field-relay F1 picks up, a make-contact F1 closes a bypass-circuit around the speed-responsive contact S1. This bypass circuit can be traced from the conductor 36, through the field-relay contact F1, to a conductor 47, and thence through a make-contact of either the "west" or "east" contactor W or E, as the case may be, to the conductor 37, thereby bypassing the speed-responsive contact S1. This bypassing circuit thus assures the maintenance of the energization of the main contactor W or E throughout the aircraft-launching accelerating-run of the towing-car 1, even though the large amount of energy which is withdrawn from the generator 8 should cause the prime-mover shaft 9 to slow down below the point at which the tachometer-contact 12 will be maintained, the speed-responsive relay S1 being dependent upon said tachometer-contact 12.

The towing-car 1 is now well started on its aircraft-launching accelerating-run, and the automatic controls are locked in, so that the run will normally be completed, regardless of the starting push button PB, or of the speed-responsive relay-contact S1.

The accelerating-run of the towing-car 1 continues until the car reaches a previously-selected

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position along the trackway, at which time one of the track-relays TR1 or TR2 becomes energized from the selected one of the track-transformers TR8 to TR28. The response of the track-relay opens its back-contact in the energizing-circuit for the conductors 36 and 37, thus de-energizing the main contactor W or E, whichever one was energized.

When one of the track-relays TR1 or TR2 responds, it also closes a corresponding make-contact TR1 or TR2, which is to be found in series with the operating coil of an auxiliary timer-relay TA, in a circuit 48 which is energized from the relaying conductor 28. This circuit may be traced from the conductor 28, through the auxiliary timer-relay coil TA, and thence through either one of the make-contacts TR1 or TR2, which are connected in parallel with each other, to the conductor 48, and thence through a make-contact IR of the interlock relay IR, to a conductor 49, and to correspondingly numbered drum-contacts 49 and 49' of the direction-drum DD.

If the direction-drum is standing in its "west" position, the drum contact-member 33 connects the point 49' to the conductor 41, which energizes the "east" main contactor E, as soon as the previously energized "west" contactor W drops out and closes its back-contact W. If the direction-drum DD had been standing in its "east" position, the drum contact-member 34 would have connected the contact-point 49 to the conductor 38, which would energize the "west" main contactor W, as soon as the "east" main contactor E opened its main contacts and closed its back-contact E. The effect, in either case, is to plug-reverse the towing-car motor 3, by applying power thereto in the reverse phase-sequence. It will be understood that the towing-line or cable 2 is cast off from the launched aircraft (not shown) as soon as the towing-car motor 3 is plug-reversed, the towing-cable connections being such that the towing-cable is released by the aircraft when it soars ahead of, or above, the towing-car 1.

The auxiliary timer-relay TA, which has been energized in this plug-reversing process, picks up its make-contact TA and energizes the timer T from its 60-cycle source 24. This timer T can be set to close its contact T at the expiration of any predetermined time-interval, which is usually chosen to be such as to leave the full reverse power on the car-motor 3 long enough to bring it to standstill and to start the car moving back, towards its starting-point, the timing being chosen, however, so that the car will not have accelerated to a dangerously high speed, in the reversed direction, at the expiration of the pre-selected time-setting of the timer T.

It will be recalled that the track-relays TR1 and TR2 are position-maintaining relays, which remain set in whichever position they occupy, even after the removal of the force or impulse which caused the relays to move to that position. At least one, and usually both, of the track-relays TR1 and TR2 will now be "set" in their actuated position, responsive to the pre-selected one, or two, of the track-transformers T8 to T28.

As shown at the bottom of the drawing, these track-relays TR1 and TR2 have additional make-contacts TR1 and TR2, which are connected, in parallel with each other, to complete a circuit from the auxiliary control-bus C+ to a conductor 51, and thence through the timer-contact T, which closes at the expiration of the pre-

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selected time-interval, as just described, energizing a conductor 52 which energizes the operating coil of the auxiliary timer-relay TB.

This auxiliary timer-relay TB instantly picks up and closes a make-contact TB which provides a "holding" circuit around the timer-contact T, between the conductors 51 and 52, so as to hold this auxiliary timer-relay TB in its energized position. At the same time, said relay opens its back-contact TB which deenergizes the circuit 28 which had been maintaining a holding-circuit for the take-off relay TOR, thus deenergizing this take-off relay TOR, assuming that the starting push button PB has meanwhile been released or opened. The deenergization of the relaying circuit 28, in response to an energization of the auxiliary timer-relay TB, also results in the deenergization of the field-relay holding circuit 28—F1—45, and in the deenergization of the interlock relay IR, thus again opening the field-relay circuit at 45—IR—46, deenergizing the field-relay F1, and at the same time opening the plug-reversing circuit at 48—IR—49, thus deenergizing the main contactor E or W, as the case may be, and discontinuing the reversed-phase-sequence energization of the towing-car motor 3, and usually leaving the towing-car coasting more or less slowly back toward its starting-point.

At this point, the operator usually takes over, with the aid of a spotting-switch S, which is energized from the relaying conductor 21 which remains energized after the take-off relay TOR is deenergized. The spotting-switch SS, has a central "off" position, and "west" and "east" positions which energize the conductors 40 and 43, respectively, which in turn respectively energize the "west" and "east" main contactors W and E.

It will be noted that the energization of the towing-car motor 3, which is effected by the spotting-switch SS, is at a low voltage, because the field-relay F1 was deenergized, simultaneously with the discontinuance of the automatic operations, prior to the manipulation of the spotting-switch SS. In this way, because of the reduced voltage, only small amounts of power are fed into the towing-car motor 3, in the normal manipulation of the spotting-switch, in order to give the operator an accurate control over the towing-car, enabling him to bring it back to its starting-point, and accurately "spot" it in any desired position.

The spotting-switch SS is provided with second "west" and "east" positions, however, in which the respective conductors 40 or 43 are still energized, but additional contact-points 53 or 54 are engaged, energizing the conductor 46 which energizes the field-relay F1, thus increasing the field-excitation, and hence the generator-voltage, to provide more power, when necessary in the "spotting" control of the towing-car 1.

The take-off relay TOR, the control-drums DD and ED, and the spotting-switch SS, cooperate with the east and west reversing-contactors or power-switches E and W, to constitute relatively stationarily located control-means, by which I mean that the control-means is stationary or non-movable with respect to the towing-car while the towing-car is moving, without intending to imply that the control-means may not be portable or movable independently of the towing-car.

In the operation of my invention, as thus far described, provision is made for the automatic

control of the aircraft-launching accelerating-run of the towing-car 1, in such manner as to cause the car to accelerate through a predetermined length of run, or distance along the runway, or to a predetermined car-position along the runway, after which the accelerating energization of the towing-car is automatically discontinued, and the car is plug-reversed in order to quickly bring it to standstill, or even to slightly reverse its speed, without requiring any more length of runway than necessary, in the stopping process. The operation of this automatic control has been outlined, during the progress of the description, so that no further summary is believed to be necessary. It may be noted that I have thus provided a position-responsive or distance-selective automatic control which necessitates the utilization of only a single track-relay TR1 or TR2, or the two track-relays can be utilized, one to supplement or safeguard the other, if desired, as already explained.

Another important feature of my improved control involves the use of the emergency-drum ED, the construction and operation of which have not yet been described, except in connection with the three interlocks 29, 39 and 42 which are closed when the emergency-drum ED is in its "off" position. When the emergency-drum ED is in its "west" position, it has a contact-member 56 which connects the contact-point 55 to a contact-point 57. The contact-point 55 is connected to the normally energized relay-circuit 24, while the contact-point 57 is connected to the relaying conductor 40 which energizes the "west" main contactor W. In the "east" position of the emergency-drum ED, a movable contact-member 58 connects the contact-point 57 at contact-point 59, which is connected to the relaying conductor 43 which energizes the "east" main contactor E.

The emergency-drum ED also has other "west" and "east" contact-members 61 and 62, which connect the contact-point 63 to contact-points 64 and 65, preferably in steps, first connecting the point 64, and then, as the movement of the emergency-drum is continued still further away from its "off" position, connecting the contact-point 65. The contact-point 63 is connected to the normally energized relaying conductor 21. The contact-point 64 is connected to the relaying conductor 46, which energizes the field-relay F1, for increasing the voltage applied to the towing-car motor 3. The contact-point 65 is connected to a similarly numbered relaying conductor 66, which energizes the second field-relay F2, for short-circuiting the second field-resistance R2, and still further increasing the excitation and the output-voltage of the generator 8.

The field-controlling contact-members 61 and 62 of the emergency-drum ED may preferably be stepped back, with relation to the contactor-controlling contact-members 56 and 58 of the drum, so that the contactor W or E is first energized alone, without any energization of the field-relays F1 or F2, and then, as the movement of the emergency-drum is continued, further away from its "off" position, contact is made, first with the contact-point 64, which energizes the first field-relay F1, and then with the contact-point 65 which energizes the second field-relay F2. It will be understood, of course, that variations in the precise details of these arrangements may be made within the skill of the skilled worker.

In the normal aircraft-launching operation of the electric catapult, the emergency-drum ED is

not utilized. When the officer in charge initiates an aircraft-launching run, or sets the stage for such initiation, by depressing the push button PB or equivalent starting-means, he keeps one hand alertly on the emergency-drum ED, ready to move it instantly, in the event of any mishap of any nature.

As soon as the operator moves the emergency-drum ED out of its "off" position, in either direction, he breaks the interlocking circuits 29, 39 and 42, thus locking out the automatic control-equipment. The interlocking "off" position drum-contact 29 breaks the holding-circuit of the take-off relay TOR, when the emergency drum is moved to either its "west" or "east" position, thus deenergizing the take-off relay TOR, assuming that the push button PB has meanwhile been released or opened. In like manner, the emergency-drum contacts 39 and 42 deenergize the automatic control-circuits for the "west" and "east" main contactors W and E, whenever the emergency-drum ED is moved, in either direction, away from its "off" position. When these interlocking emergency-drum contacts 29, 39 and 42 are once opened, the take-off relay TOR is thus deenergized, and no further automatic control-operation will be obtained thereafter, even though the emergency-drum ED is returned again to its "off" position, because of the opening of the TOR contacts 25 and 27, which effectually lock out any further automatic operations, on that run.

The energization of the towing-car motor 3 is thereupon under the sole control of the emergency-drum ED, the motor being energized only when, and as long as, the emergency-drum ED is held in either its "west" or its "east" position. After the operator has controlled the energization of the towing-car motor, in any desired manner, by the manipulation of the emergency drum ED, he will usually bring the car to a stop, or at least to a relatively slow speed, by means of the emergency-drum, after which the operator may either utilize the emergency-drum itself as a spotting-switch, or he may change over to the spotting-switch SS, and utilize the latter to bring the car back to a controlled spot at either end of the runway.

While I have illustrated my invention in a single preferred form of embodiment, I wish it to be understood that many features of such illustration are only symbolic, and many interlocks and other complications, such as would normally be utilized, have been omitted, in the interests of clarity of illustration and explanation. I desire, therefore, that the appended claims shall be accorded the broadest construction consistent with their language.

I claim as my invention:

1. An electrically controlled system, comprising an electrically driven self-propelled movable body, a trackway therefor, electrical supply-means therefor, and a relatively stationarily located control-means therefor, characterized by said control-means comprising run-controlling relay-means, a plurality of position-responsive means, disposed at a plurality of positions along the trackway, for developing relaying-energy at each of their several positions during the progress of a forward run of the movable body, pre-selector means for making the relaying-energy of a pre-selected one or more of said position-responsive means effectively available in said run-controlling relay-means, to the substantial exclusion of all others of the position-responsive means, for

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actuating said run-controlling relay-means only in response to said pre-selected position-responsive means, means for initiating a forward run of the movable body, and means for terminating said forward run in response to an actuation of said run-controlling relay-means.

2. An electrically controlled system, comprising an electrically driven self-propelled movable body, a trackway therefor, feeder means for supplying electric propulsion-energy to the movable body at each of a plurality of points distributed all along the trackway, and a relatively stationarily located control-means for said movable body, characterized by said control-means comprising run-controlling relay-means, a plurality of current-responsive means for developing relaying-energy in response to a substantial flow of electric energy into the movable body at each of a plurality of said points where said electric propulsion-energy can be supplied to said movable body, pre-selector means for making the relaying-energy of a pre-selected one or more of said current-responsive means effectively available in said run-controlling relay-means, to the substantial exclusion of all others of said current-responsive means, for actuating said run-controlling relay-means only in response to said pre-selected current-responsive means, means for initiating a forward run of the movable body, and means for terminating said forward run in response to an actuation of said run-controlling relay-means.

3. The invention as specified in claim 1, characterized by said movable body being polyphase-motored, said supply-means being polyphase, and said run-terminating means being adapted to energize said movable body in a reversed phase-sequence in response to an actuation of said run-controlling relay-means.

4. The invention as specified in claim 2, characterized by said movable body being polyphase-motored, said feeder-means being polyphase, and said run-terminating means being adapted to energize said movable body in a reversed phase-sequence in response to an actuation of said run-controlling relay-means.

5. An electrically controlled system, comprising a self-propelled, polyphase-motored movable body, variable-voltage supply-means therefor, and a relatively stationarily located control-means therefor, characterized by said control-means comprising main starting-contactors for energizing said movable body from said supply-means in the one phase-sequence or the other, starting-means for selectively energizing one of said contactors to initiate a forward run of the movable body in a selected phase-sequence, and means responsive to a completed response of said selected contactor for effecting an increase in the voltage of said supply-means.

6. The combination with a trackway, and electrical supply-means therefor, of control-means comprising automatic relay-means, a plurality of position-responsive means, disposed at a plurality of positions along the trackway, for developing relaying-energy at each of their several positions during the progress of a movable member along said trackway, pre-selector means for making the relaying-energy of a pre-selected one or more of said position-responsive means effectively available in said automatic relay-means, to the substantial exclusion of all others of the position-responsive means, for actuating said automatic relay-means only in response to said pre-selected position-responsive means, means for initiating the energization of said supply-means for the

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trackway, and means for automatically terminating the aforesaid energization of said supply-means in response to an actuation of said automatic relay-means.

7. The combination with a trackway, and supply-means for supplying electrical energy at each of a plurality of points distributed all along the trackway, of control-means comprising automatic relay-means, a plurality of current-responsive means for developing relaying-energy in response to a substantial flow of electric energy into the trackway at each of a plurality of said plurality of points where energy is supplied, pre-selector means for making in the relaying-energy of a pre-selected one or more of said current-responsive means effectively available in said automatic relay-means, to the substantial exclusion of all others of said current-responsive means, for actuating said automatic relay-means only in response to said pre-selected current-responsive means, means for initiating the energization of said supply-means for the trackway, and means for automatically terminating the aforesaid energization of said supply-means in response to an actuation of said automatic relay-means.

8. The invention as specified in claim 6, characterized by said supply-means being polyphase, and said automatic terminating-means being means for automatically causing said supply-means to be energized in a reversed phase-sequence in response to an actuation of said automatic relay-means.

9. The invention as specified in claim 7, characterized by said supply-means being polyphase, and said automatic terminating-means being means for automatically causing said supply-means to be energized in a reversed phase-sequence in response to an actuation of said automatic relay-means.

10. The combination with a polyphase supply-line, and a variable-voltage polyphase energy-source therefor, of control-means comprising main starting-contactors for energizing said supply-line from said energy-source in the one phase-sequence or the other, starting-means for selectively energizing one of said contactors to initiate the energization of said supply-line in a predetermined phase-sequence, and means responsive to a completed response of said selected contactor for effecting an increase in the voltage of said energy-source.

11. An electrically controlled system, comprising a self-propelled, polyphase-motored movable body, variable-voltage supply-means therefor, and a relatively stationarily located control-means therefor, characterized by said control-means comprising main starting-contactors for energizing said movable body from said supply-means in the one phase-sequence or the other, and starting-means operative to selectively energize one of said contactors to initiate a forward run of the movable body in a selected phase-sequence and also operative to effect an increase in the voltage of said supply-means.

12. The combination with a polyphase supply-line, and a variable-voltage polyphase energy-source therefor, of control-means comprising main starting-contactors for energizing said supply-line from said energy-source in the one phase-sequence or the other, and starting-means operative to selectively energize one of said contactors to initiate the energization of said supply-line in a predetermined phase-sequence and also operative to effect an increase in the voltage of said energy-source.

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13. In combination, a polyphase energy-circuit, a polyphase load-circuit, polyphase switching-means for connecting and disconnecting said polyphase load-circuit to and from said polyphase energy-circuit in a desired forward phase-sequence, other switching-means for performing one or more other controlling operations affecting said polyphase load-circuit, operation-presetting means for presetting the termination of the forward-phase-sequence energization of the polyphase load-circuit, an operation-maintaining relay-means, starting-means for initially actuating said operation-maintaining relay-means, an operation-relay holding-circuit, responsive to the actuation of said operation-maintaining relay-means, for maintaining the actuation of said operation-maintaining relay-means, forward-controlling means, responsive to the actuation of said operation-maintaining relay-means, for closing said forward-phase-sequence switching-means, forward-terminating means, responsive to the operation-presetting means, for opening said forward-phase-sequence switching-means, additional control-means, responsive to the opening of the forward-phase-sequence switching-means and responsive also to a continued actuated condition of said operation-maintaining relay-means, for setting in motion some one or more operations of said other switching-means, and means, including a relay-contact in said operation-relay holding-circuit, for interrupting said operation-relay holding-circuit after the conclusion of the operation.

14. In combination, a polyphase generator having a field-winding circuit, a polyphase load-circuit, polyphase switching-means for connecting and disconnecting said polyphase load-circuit to and from said polyphase generator in either the forward or reverse phase-sequence, field switching-means for performing a controlling operation on said field-circuit, operation-presetting means for presetting the termination of the forward-phase-sequence energization of the polyphase load-circuit, an operation-maintaining relay-means, starting-means for initially actuating said operation-maintaining relay-means, an operation-relay holding-circuit, responsive to the actuation of said operation-maintaining relay-means, for maintaining the actuation of said operation-maintaining relay-means, forward-controlling means, responsive to the actuation of said operation-maintaining relay-means, for closing said polyphase switching-means in a desired forward phase-sequence, field-controlling means, responsive to an actuated condition of said forward-controlling means and responsive also to an open condition of said field switching means, for closing said field switching-means, a field-controlling holding-circuit, responsive to the closing of said field switching-means and responsive also to a continued actuated condition of said operation-maintaining relay-means, for maintaining the closed condition of said field switching-means, forward-terminating means, responsive to the operation-presetting means, for opening said forward-controlling means, reverse-controlling means, substantially simultaneously responsive to the operation-presetting means and responsive also to an open condition of the polyphase switching-means in the forward phase-sequence, for closing said polyphase switching-means in the reverse phase-sequence, reverse-power presetting-means for presetting the reverse-power operation, and reverse-terminating means, responsive to the reverse-

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power presetting-means, for opening the polyphase switching-means and the field-controlling holding-circuit, the apparatus also including operation-terminating means, including a relay-contact in said operation-relay holding-circuit, for interrupting said operation-relay holding-circuit after the conclusion of the operation.

15. In combination, a self-propelling, polyphase-motored, movable body, a track therefor, a polyphase motor-energizing circuit which is continuously connected to said polyphase-motored body, a polyphase energy-circuit, polyphase switching-means for connecting and disconnecting said polyphase motor-energizing circuit to and from said polyphase energy-circuit in a desired forward phase-sequence, other switching-means for performing one or more other controlling operations affecting said polyphase motor-energizing circuit, track-relay means which is selectively responsive to a predeterminable position of the polyphase-motored movable body at any one of a plurality of selectable points along the track, operation-presetting means for utilizing said track-relay means for terminating the forward-phase-sequence energization of the polyphase motor-energizing circuit, an operation-maintaining relay-means, starting-means for initially actuating said operation-maintaining relay-means, an operation-relay holding-circuit, responsive to the actuation of said operation-maintaining relay-means, for maintaining the actuation of said operation-maintaining relay-means, forward-controlling means, responsive to the actuation of said operation-maintaining relay-means, for closing said forward-phase-sequence switching-means, forward-terminating means, responsive to the operation-presetting means, for opening said forward-phase-sequence switching-means, and additional control-means, responsive to the opening of the forward-phase-sequence switching-means and responsive also to a continued actuated condition of said operation-maintaining relay-means, for setting in motion some one or more operations of said other switching-means, said additional control-means including a timer-means, responsive to the initiation of a predetermined operation of said other switching-means and responsive also to a continued responded condition of said track-relay means, for interrupting said operation-relay holding-circuit, said timer-means including a self-energized holding-circuit which is responsive to a continued responded condition of said track-relay means.

16. In combination, a self-propelling, polyphase-motored, movable body, a track therefor, a polyphase motor-energizing circuit which is continuously connected to said polyphase-motored body, a polyphase energy-circuit, polyphase switching-means for connecting and disconnecting said polyphase motor-energizing circuit to and from said polyphase energy-circuit in either the forward or reverse phase-sequence, track-relay means which is selectively responsive to a predeterminable position of the polyphase-motored movable body at any one of a plurality of selectable points along the track, operation-presetting means for utilizing said track-relay means for terminating the forward-phase-sequence energization of the polyphase motor-energizing circuit, an operation-maintaining relay-means, starting-means for initially actuating said operation-maintaining relay-means, an operation-relay holding-circuit, responsive to the actuation of said operation-maintaining relay-means, for

maintaining the actuation of said operation-maintaining relay-means, forward-controlling means, responsive to the actuation of said operation-maintaining relay-means, for closing said polyphase switching-means in a desired forward phase-sequence, forward-terminating means, responsive to the operation-presetting means, for opening said forward-controlling means, reverse-controlling means, substantially simultaneously responsive to the operation-presetting means and responsive also to an open condition of the polyphase switching means in the forward phase-sequence, for closing said polyphase switching-means in the reverse phase-sequence, reverse-power presetting-means for presetting the reverse-power operation, and reverse-terminating means, responsive to the reverse-power presetting-means, for opening the polyphase switching-means, the apparatus also including an operation-terminating relay having a relay-contact in said operation-relay holding-circuit for interrupting said operation-relay holding-circuit, said operation-terminating relay including a self-energized holding-circuit which is responsive to a continued responded condition of said track-relay means.

17. In combination, a self-propelling polyphase-motored, movable body, a track therefor, a polyphase motor-energizing circuit which is continuously connected to said polyphase-motored body, a polyphase generator having a field-winding circuit, field switching-means for performing a controlling operation on said field-circuit, polyphase switching-means for connecting and disconnecting said polyphase motor-energizing circuit to and from said polyphase generator in either the forward or reverse phase-sequence, track-relay means which is selectively responsive to a predetermined position of the polyphase-motored movable body at any one of a plurality of selectable points along the track, operation-presetting means for utilizing said track-relay means for terminating the forward-phase-sequence energization of the polyphase motor-energizing circuit, an operation-maintaining relay-means, starting-means for initially actuating said operation-maintaining relay-means, an operation-relay holding-circuit, responsive to the actuation of said operation-maintaining relay-means, for maintaining the actuation of said operation-maintaining relay-means, forward-controlling means, responsive to the actuation of said operation-maintaining relay-means, for closing said polyphase switching-means in a desired forward phase-sequence, field-controlling means, responsive to an actuated condition of said forward-controlling means and responsive also to an open condition of said field switching-means, for closing said field switching-means, a field-controlling holding-circuit, responsive to the closing of said field switching-means and responsive also to a continued actuated condition of said operation-maintaining relay-means, for maintaining the closed condition of said field switching-means, forward-terminating means, responsive to the operation-presetting means, for opening said forward-controlling means, reverse-controlling means, substantially simultaneously responsive to the operation-presetting means and responsive also to an open condition of the polyphase switching-means in the forward phase-sequence, for closing said polyphase switching-means in the reverse phase-sequence, reverse-

power presetting-means for presetting the reverse-power operation, and reverse-terminating means, responsive to the reverse-power presetting-means, for opening the reverse-controlling means and the field-controlling holding-circuit, said reverse-terminating means including a self-energized holding-circuit which is responsive to a continued responded condition of said track-relay means, the apparatus also including an operation-terminating relay having a relay-contact in said operation-relay holding-circuit for interrupting said operation-relay holding-circuit, said operation-terminating relay including a self-energized holding-circuit which is responsive to a continued responded condition of said track-relay means.

18. The invention as defined in claim 15, characterized by the track-relay means being of the retained-contact type having a reset-coil, and the combination including reset-means for energizing said reset-coil.

19. The invention as defined in claim 16, characterized by the track-relay means being of the retained-contact type having a reset-coil, and the combination including reset-means for energizing said reset-coil.

20. The invention as defined in claim 17, characterized by the track-relay means being of the retained-contact type having a reset-coil, and the combination including reset-means for energizing said reset-coil.

21. In combination, a load-circuit, power-supply means therefor, automatic control-means operative, once it is set in operation, to carry through a predetermined series of a plurality of successive switching-operations affecting the power-supply to said load-circuit, a plurality of presetting adjustment-means for said automatic control-means, a resetting means for resetting said automatic control-means after the completion of its operation, an operation-starting circuit for said automatic control-means, a holding-circuit for said automatic control-means, means including a relay-contact in said holding-circuit for interrupting said holding-circuit after the conclusion of the operation, and means responsive to a subsequent operation of said resetting means for reclosing said relay-contact in the holding-circuit.

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