THESIS

A DESIGN OF AN ELECTRO-DYNAMIC SYSTEM OF INTERLOCKING

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A Design of an Electro-Dynamic System
of
Interlocking

A Thesis Submitted to

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By

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PREFACE.

The author in the selection of this subject for a thesis did so with the following objects in mind. First, that by so doing he would become better acquainted with the theoretical working of a system in which he had some practical experience. Second, that he might leave the institution some compiled form whereby the incentive for further knowledge might be had by the students, on this subject.

The thesis itself comprises a system of interlocking which is very important and should claim the attention of all students interested in Electric Railway or Interlocking Systems. It comprises the theoretical part of interlocking with drawings, tables of data and calculations from these tables as to the size and capacity of a model plant, which was modeled after the one in use by the Michigan Central Railway in Detroit.

The author expresses his sincere thanks to the General Railway Signal Company of Rochester, New York; the Union Switch and Signal Company of Swissville, Pa; and the men in charge of the system at the Michigan Central in Detroit. Much data was received from these sources and due acknowledgment is made hereby.

Author

T. H. Reid.

Contents.

Part 1.

Historical and Explanation of the Different Kinds of Interlocking.

Interlocking is of English origin, and the earliest time for patents having been granted in England was about 1856. In less than twenty years or in 1873 over thirteen thousand mechanical interlocking levers were employed on the London and Northwestern Railway alone, at which time not a single lever was in use in the United States, the first experimental installation haveing been made in this country by Messers Toucey and Buchanan at Spuyten Duyvil Junction, New York City in 1874, and the first important installation on a commercial basis having been made by the Manhattan Elevated Lines of New York City with machine built by the Jackson Manufacturing Company, of Harrisburg, Pennsylvania in 1877-78.

Very soon the railroads saw that a very economic saving could be made by the installation of interlocking systems and this gave rise to the development of our modern interlocking systems.

Five distinct systems of interlocking are in use at the present time which are as follows;

Mechanical

Electro-mechanical

Electro-pneumatic

Electric D. C. and A. C.

Electro- Dynamic

of mechanical interlocking the most commonest at this time and the first in origin, I have very little to say as everyone is acquainted with this system, its good features and its failures.

Electro-Mechanical and Electro-Pneumatic the next step in the development are very well suited to certain localities, but are not as complete as either of the last mentioned. It consists of a system in which the functions are operated by electric currents controlled by levers in the interlocking plant. The signal or switch is operated by mechanical energy derived from air pressure or other sources. This necessitates, in the case where the energy for the movement is derived from compressed air, of having a compressed air machine and connecting pipes to all the different functions, also, batteries whereby indication that the function has performed its duty may be received at the interlocking plant.

The last and most modern of all interlocking plants are the electric and elcctro-dynamic systems. Of the purely electric there are the D. C. and A. C. systems each suited to the conditions under which they may be called upon to operate, but limited to the point that they do not give a positive indication that the function has performed its duties, except thru the breaking of a contact, while the function is in motion. The electro-dynamic system gives an indication when, and only when, the function has completed its duties. This is brought about by the regenerated energy of the motor, which after producing the switch movement acts as a generator and gives back to the line an indication that the function has completed its duties. Of the dynamic system much more can be found in the preceding pages in which I have undertaken to design a model plant.

Part 11.

Principles of Electro-Dynamic Interlocking.

In the consideration of a system of interlocking, two features of vital importance must be considered in order to insure reliability and absolute safety to the system. These are as follows;

1. Some means must be provided to check the correspondence of movement between lever, switch, signal or other function controlled by it.

2. The means for preventing unauthorized movement of switch, signal or other controlled functions.

In the system of electro-dynamic interlocking made by the General Railway Signal Company, these two requirements are fully met by means of dynamic indication, or counter E.M.F. for which, energy is furnished by a momnetary dynamic current generated by the motor of the operated function itself when, and only when, the actual operation shall have been properly completed.

The unauthorized movement of switch or derails or the improper clearing of signals is prevented by a simple and effective means of cross protection which I shall describe later.

The complete installation of this system of interlocking consists of the following elements;

1. Source of power, consisting of a storage battery with its charging unit.

2. Power control apparatus introduced between

the source of power and the interlocking machine.

3. An interlocking machine with levers for the control of the switch and signal mechanisms.

4. Switch mechanisms, their operating and indicating circuits.

5. Signal mechanisms, their operating and indicating circuits.

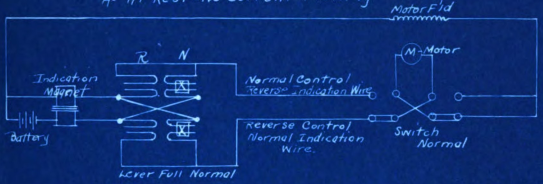
6. Means for the prevention of unauthorized movement of any function.

The source of power from which the system is operated is a storage battery with a working potential of 110 volts. This battery being charged by a motor generator, rotary convertor or rectifier. Power is delivered to the interlocking machine under control of protective apparatus located on the switch board.

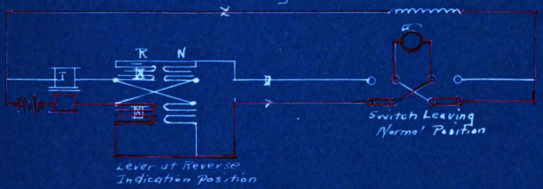
Interlocking Machine.

The operation of each switch and signal function is controlled by levers, which with their respective locking tappets indications magnets, and circuit controllers are mounted in a common frame, the whole being known as a interlocking machine. Starting with the lever in either of its extreme positions, the stroke of the lever is divided into two movements. The first movement locks all levers conflicting with its new position and operates the function. The second and final movement of the stroke releases such levers, hitherto locked as do not conflict with its new position. Except in the reverse position of a signal lever, this final

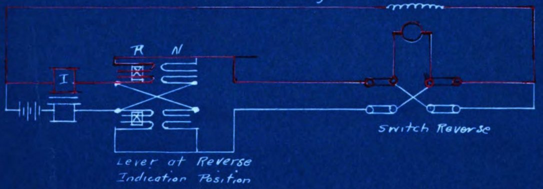
A- At Rest - No Current Flowing



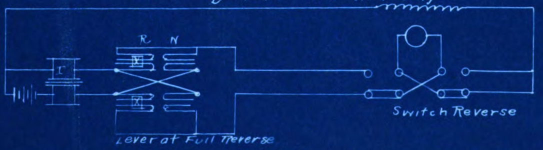
B- Operating



C - Indicating



D - At Rest - No Current Flowing



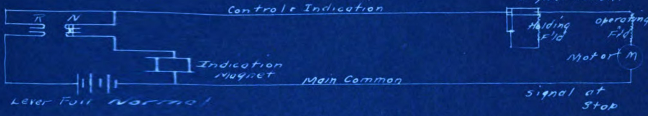
movement cannot be made, until the dynamic indication has been received certifing that the operated function has assumed a position corresponding with that of its lever.

Switch Mechanism ---------- operating and indicating.

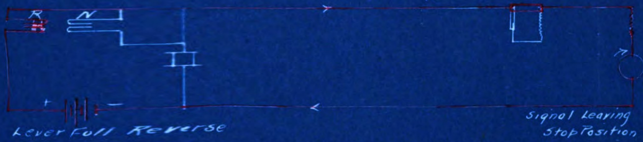
Each switch and derail is thrown and locked by a switch and lock movement driven by a series wound direct current motor. Two wires are used for its control, one for the normal and the other for the reverse operation. The same wires are used for indicating purposes, the normal control wire being used for reverse indications and the reverse control wire for normal indications. The circuit is connected to the main common at the switch location.

The circuits for the switch are shown in the following drawings, the operating and indicating currents in the different diagrams being shown by red lines. When the switch is to be operated, the first movement of the stroke of the controlling lever carries it as far asthe reverse indication position and permits current to flow as shown in Fig. B., which causes the mechanism to move the switch points to the reverse position and locks them in that position. When this movement has been completed, the circuit thru the switch motor is automatically changed, disconnecting the motor from the battery and connecting it in a closed circuit including the indication magnet, Fig. C., at the same time the armature terminals are reversed for indication purposes, thus, leaving the motor connections in the proper position for the next operation. The motor (now a generator)

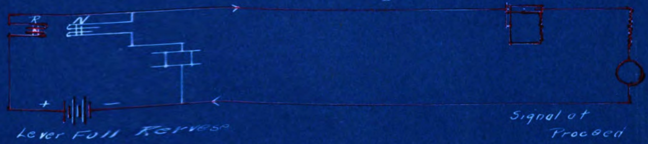
A.



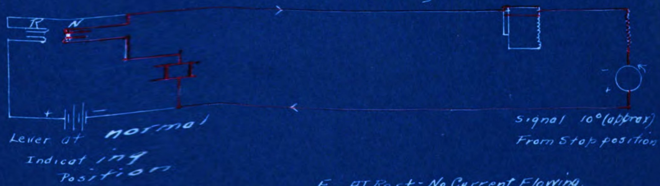
B- Operating



C- Holding



D- Indicating



E - AT Rest - No Current Flowing.

now a generator with a momentum acquired during the operation of the switch movement, generates a momentary current which energizes the indication magnet thus permitting the final movement of the lever to be completed, Fig. D.

The operation of the lever and function from the reverse to the normal position is accomplished in the same manner. The complete switch movement and final operation of the lever may be accomplished in from two to two and a half seconds, the indication being practically instantaneous with the completion of the switch operation.

Signal Operation.

The signal is operated by a mechanism in which the motor is directly connected to the sema-phore shaft thru a low reduction gearing. The signal is held at proceed during such time as its controlling lever is in the reverse position, soley by means of a dense magnetic flux thrown across the air gap between the motor armature and the field pole pieces, by cutting the windings on the holding field poles in series with the operating field windings. Each signal requires for its operation and indication, one wire and a connection to the common return wire.

Diagrammatic circuits are shown in the following drawings, the path taken by the operating, holding, and indicating current in the different diagrams being shown by red lines.

Upon reversal of the controlling lever, the signal mechanism will receive current as shown in Fig. B., this causing it to move the blade to the proceed position. When the signal blade has assumed this position the circuit breaker cuts in series with the operating field and armature, the high resistance holding field, holding the signal arm at proceed Fig. C. The holding field windings have a high resistance, which reduces the current to that employed for holding the signal at proceed. When the signal lever is plaeed in the normal indicating position,energy, is cut off from the motor and the blade returns to the stop position by gravity, causing the signal mechanism and motor armature to revolve backwards to the original p sition. Just as the blade reaches the stop position the action of the circuit breaker connects the motor armature and operating field into their original closed circuit Fig. D., in which is included the indication magnet. Do to its acquired momentum the motor (now a generator) produces an indicating current in this circuit which permits the controlling lever to be moved to the full normal position Fig. E.

Dynamic Indication.---------- Advantages.

1. The indication is not secured from energy existant at the function prior to the movement of the function, and dependent only on the closing of a single brake in the indication circuit, as in the A.C. and battery indication systems, but being a dynamic durrent generated by the momentum of the motor, it can be secured only after actual operating of the function.

2. The energy for the indication is developed at one end of the circuit and the indication magnet is located at the other, hence, a cross betwoen wires prevents indication, while in a system where a battery is used a cross in wires would cause an indication.

3. No extra power for indication.

4. Indication current ceases automatically with the stopping of the motor.

5. No addittional wires are required for indication.

Cross Protection.

The cross protection system prevents the unauthorized movement of any swithc, signal, or other function due to energy improperly applied to its circuit thru a cross between wires, by cutting off the current from the function inthe event of such an occurence.

All functions are normally on a closed circuit of low resistance. Connected with each of these circuits is a small polarized relay thru which all operating and indicating currents must pass in a direction to maintain the relay's contact closed, while all currents from an unauthorized source must pass in the opposite direction thus instantly opening the contact. (Part Vll explains the action of the relay more fully) Thru all the contacts in series is controlled the retaining magnet of an electro-mechanical circuit breaker. Hence a cross on the circuit of the function at rest, by opening the contact of its polarized relay, opens the circuit breaker and cuts off power from the interlooking machines, thereby preventing any improper movement of the function.

Part 111.

Design of Plant, Switch Board Circuit and Unit Interlocking System.

Drawing 1.

Fig. 1., shows how a system of electric interlocking can be applied to a railroad terminal. The system I have undertaken to design consists of five (5) Model 4 Switch Machines and three (3) Model 2 Dwarf Solenoid Signal Machines. The design itself is taken up further under the head of Design of Plant.

Operating Switch Board.

Fig. 2., on this drawing shows the operating switch board for an interlocking plant and consists, of a switch board on which are mounted only the apparatus essential to the circuit breaker control, shows the retaining magnet of the circuit breaker controlled thru the polarized relay on the switch board and those on the interlocking machine in such a manner, that, should any of them reverse their position the circuit breaker will immediately open. The polarized relay on the switch board is to guard against the effect of an accidental cross between the positive and indicating buss bars on the interlocking machine.

Fig. 3., on the same drawing shows the circuits for the operating switch board, interlocking machine, switch and signal function and gives a clear idea how the wiring drawing for a two lever plant would be. From this drawing a concise conception can be had of an interlocking plant

consisting of eight (8) levers

Part IV.

Electro-Dynamic Interlocking Machine.

The interlocking machine is usually designed so that each lever controls a signal or switch mechanism. But in some cases machines are made in which one lever operates both the switch and signal function. The design of an interlocking machine necessitates, that it be absolutetly safe in operation and indication of the different function movements. The machines are so designed that;

1. No lever can be moved from any given position, if any other lever mechanically interlocked with, is in such a position that its controlled function should conflict with the function of the lever itself.

2. The full movement of the lever cannot be completed until the function controlled by the lever itself has moved.

Model 2 Unit Interlocking Machine.

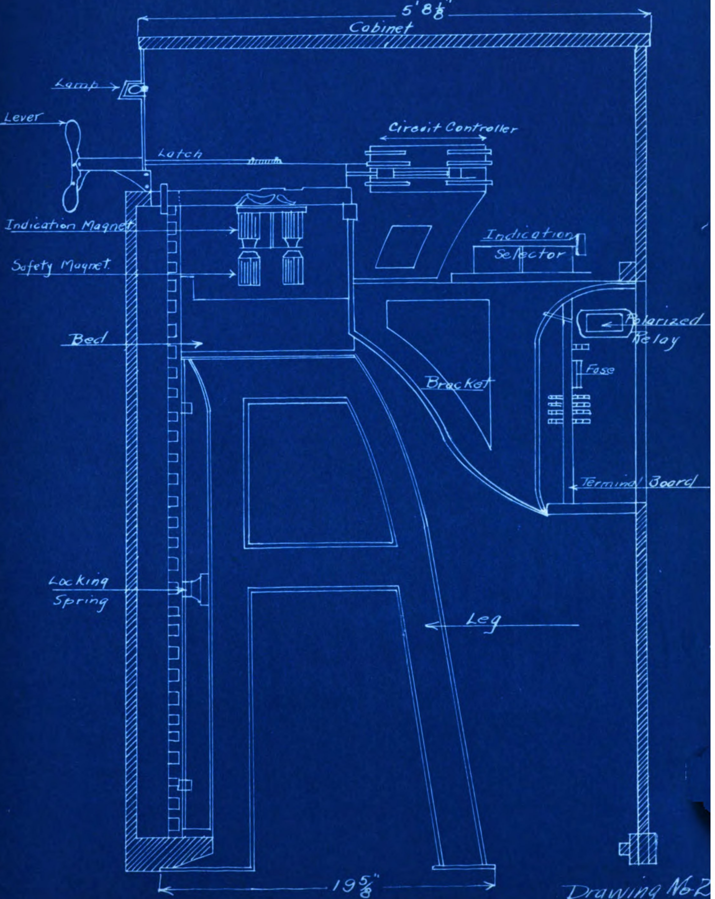
Drawing No. 2

The machine comprises the frame, levers with guides indic tion magnets, and circuit controllers. The locking plates and locking, the terminal board and a machine cabinet.

Levers. Each lever with its guide, indic tion magnet controllers, etc., comprises a complete unit in the interlocking machine which can be removed and replaced in the machine without disturbing adjacent levers in any way. This makes the machine very flexible and easy to repair.

The machine is equipped with a lamp, which receives the indication of the function and shows the lever man that the function has operated.

Model 2 Unit Lever Type Interlocking Machine.



Drawing No 2
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The indication selectors mounted on the machine, as shown on the drawing, consists of two electro-magnets and a contacting armature which throws in one direction when the lever is reversed and in the other when the lever is put normal.

Part V.

Model 4 Switching Machine.

The switch mechanism of the General Railway Signal Company's electro-dynamic system, are each under the control of a lever in the interlocking machine. For their operation there is required two wires only, one for normal and the other for reverse operation of the mechanism. The same wires are used for indicating purposes, the normal wire being used for reverse indication, while the reverse control wire is used for normal indication.

Drawing No. 3

When the lever is moved from A, to B, in Fig. 3 on the indication selector controller contacts, current is taken from the positive buss thru the safety magnet, S, indication selector, lever contacts and control wires thru the switch motor to the common. This causes the desired movement of the switch, which performs the following functions in the order given;

1. The detector bar S is raised and the switch unlocked

2. The switch points are thrown.

3. The switch points are locked and the bar lowered.

4. The current is cut off from the motor and the terminals of the armature reversed for indicating purposes, leaving the motor properly connected for the next movement.

The motor is now on a closed circuit which includes the indication magnet. Due to the momentum acquired during the switch operation, the motor armature continues on several revolutions for the generation of the momentary current which energizes the indication magnet and thereby permits the final movement of the lever to be completed.

The changing of the motor connections is affected by the mechanical shifting of the contact in the pole changer. In addition to being mechanically operated, this contact block is under the control of two sets of solenoid magnets, so that should the switch fail to complete its movement, the controlling lever may be shifted and thru the energizing of one set of the magnets cause the pole changer to set up the circuit for the operation of the switch in the opposite direction. This places the mechanism under the control of the lever man, so that should the switch points become blocked with snow, ice and so on, the points may be moved back and forth until the obstruction is dislodged.

Safe Guards.

The switch mechanism is safe at all times, from false operation and its lever from improper indication in the following manner;

1. By the cross protection apparatus.

2. By the mechanical design of the lever, false indication is prevented.

3. During the time the current is flowing thru the lever magnets for the operation of the function, the safety magnet insures against the possible receipt, of

any improper indication due to an accidental cross between the control wires of the function. The safety magnet is mounted under the indication magnet with the indication magnet's armature resting on its poles, some distance from the poles of the indication magnet. The safety magnet coils are so connected in the operating that the whole operating current flows thru them, hence any current flowing thru the indication magnet, due to a cross between the control wires of the function cannot exceed the current thru the safety magnet.

The indication selector insures against the possible receipt of improper indication, being so connected that the operating current will attract the armature and close the contact for the reverse indication only, when the lever is moved reverse, and the contact for the normal indication, when, the lever is moved normal. The indication and selector and safety magnet coils are connected in series with the control circuit, therefore, if the current thru them is not intact, operation of the function will be prefented.

The magnetic control of the pole changer prevents the switch from being moved by hand from the position occupied, except, thru breaking the operating circuits by some such means as removing the motorxbmmshes. Manipulation of the pole changer by hand will not cause movement of the switch out of correspondence with its lever.

Model 4 Switching Machine.

Drawing No. 3

Fig. 1. shows an end and top view of Model 4

Switch Machine. This type is extensively used in interlocking plants for its simplicity, and because the height of the entire machine is very small, thus allowing much clearance for the journal boxes of the locomotives and cars.

The operating parts are A, a series direct current motor, a train of spur gears, the main or cam gear D, the pole changer M, the throw rod J, and locking bar F. The motor thru the medium of the train of gears drives the cam gear D, from which gear, the various parts of the switch machine are operated. The intermittent movement of the locking bar and detector bar is accomplished by the engagement of rollers on the locking bar with the cam slot on the upper side of the main gear. The throw rod is operated in both extreme positions of the switch bolt operated from the cam movement. The cam gear is designed to permit a free run of the motor at the end of the operation of the mechanism for the purpose of generating a strong positive indication current. A fibre clutch, designed with large surfaces and lined with fibre protects the mechanism against shock should the mechanism become obstructed.

Part Vl.

Model 2 Solenoid Dwarf Signal.

The solenoid dwarf signal is designed to operate in two positions, upper or lower quadrant, with a 45, 60 or 90 degree travel of the arm. Two sets of magnet windings are provided, which consists of operating coils of low resistance and holding coils of high resistance. The movement of the solenoid magnet plungers is transmitted by means of suitable connection to the dwarf spectacle or arm.

Dwarf Signal Control.

Drawing 4.

Each of these mechanisms require for its operation a control wire, since it is impracticable to secure a dynamic indication from a signal of the solenoid type, an additional wire is required for indication purposes.

Reversing control lever in Fig. 3 (lever in position shown reversed), current is taken from the positive buss bar thru the lever contacts, the control wire solenoid operating coils A_1 and A_2 to the common. This causes the movement of the signal arm from stop to proceed position. As the arm reaches proceed position, the circuit breaker contact C opens, which connects the high resistance holding coils B_1 and B_2 in series with the operating coils, the flow of the current thereby being reduced to the minimum required to retain the arm at proceed.

When the signal lever is placed at its normal indicating position, all energy is cut off the coils and the signal arm returns to the stop position. As the arm reaches this position, contact D is closed, thus permitting the indication magnet to be energized by current taken from the main battery which affects the release of the controlling lever and allows its normal movement to be completed.

Model 2 Dwarf Solenoid Signal.

This signal consists of the solenoid magnets, A_1, A_2, B_1, B_2, a rack G and pinion movement H, and crank J, is mounted in a case which supports the dwarf spectacle shaft. The movement of the yoke F connecting the solenoid plunger E_1 and E_2 is transmitted thru the medium of the rack G and pinion H, to crank J, hence by means of the connecting shaft to the dwarf spectacle.

The circuits for the control are broken thru pairs of springs, which make contact at the proper time with metal pieces, fastened to a commutator mounted upon the same shaft as the pinion H. The operating contact C is designed to hold its circuit closed thruout the movement, until the blade has assumed the proceed position. The indicating contact D is closed only when the blade is in the stop position.

Note. The spectacle of the signal is the arm on the signal machine, which gives the engineer on the locomotive the indication that the track is either clear or blocked by the position that the spectacle is in.

Part V11.

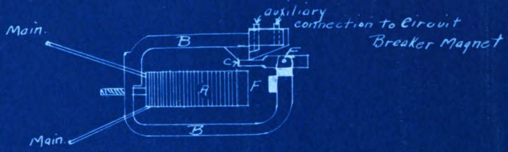
Polarized Relay.

The polarized relay as shown by the accompnaying drawing, is mounted on the terminal board of the interlocking machine, directly beneath the lever. It is made with a soft iron core(A) which lies lengthwise between the poles of a permanent magnet. The design of the relay is such, that as long as the current is flowing in one direction the contact (C) is maintained closed. Being a permanent magnet (B) one end is a north pole and the armature end (E) is a south pole or visa versa. Now if the soft iron coil is so designed that when normal flow of current, its end (F) is magnetized south or the same as that of the armature, it will repel the armature and the contact will be closed.

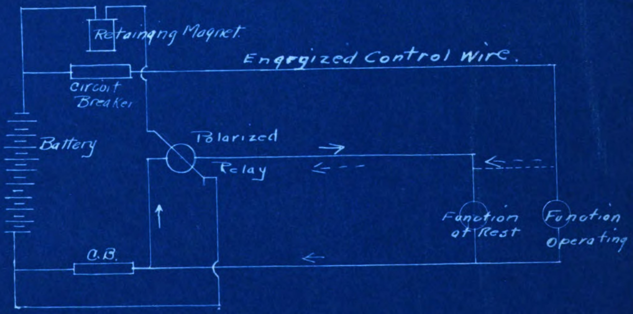
While if the current be reversed the polarity of the coil (E) will be changed to north and being of greater strenght, than that of the permanent magnet, it will attract the armature thereby breaking the auxiliary circuit and opening the circuit breakers. Because of the sensitiveness of the relay it is used in preference to any other type.

In order to understand why the current flows in the reverse direction when there is a cross on the interlocking machine or line, I have drawn the diagram as shown on the following page. This is a modified form of Figure 3 Drawing No. 1. By refering to Fig. 3, the direction of the normal indicating current is shown by heavy arrows. The current for generation is developed in the motor of the function (acting as a generator) and flows to the common main thru the polarized relay to the indicating brush bar, thru the polarized relay and indication magnet to the lever.

Polarized-Relay



Simplified Circuit Showing
the Principles of Polarized Relay.



If we had a cross between the buss bars or wires on the interlocking machine (shown on the drawing by dotted lines) the current would flow in the direction as shown by the dotted arrows which is opposite to the normal flow and would magnetize the coil of the polarized relay in the opposite direction and immediately open the circuit breaker.

The drawing on the following page shows the same action and as before, heavy arrows denote the normal flow of current, while the dotted arrows denote the flow if there was a cross on the line.

Part V111.

Lead Storage Batteries in use in Dynamic System.

The batteries used in this system consists of two lead plates or sets of lead plates suspended in a dilute solution of Sulphuric Acid. When the battery consists of two lead plates, the negative plates are one more in number than the positive.

Pilot Cell.

A cell in the battery is selected to be used to follow the daily operation of the battery. Specific gravity readings are taken each day of the electrolyte. The electrolyte of this cell is kept at a fixed height one half (½) inch above the top of the plates, by adding a small quantity of chemically pure water each day.

The battery is not charged till the specific gravity of the pilot cell has fallen at least ten (10) points below the preceding overcharge maximum, the battery being then about one third (1/3) discharged. The charging should be at normal rated amps, or as near as possible and continued until the specific gravity of the pilot cell has risen three (3) points below the maximum reached at the preceding overcharge, (which is about 1.207). Once every two (2) weeks prolong the regular charge until fifteen (15) minute readings of the specific gravity of the pilot cell and of the battery voltage, taken from the time the cell commences to gas shows no rise for five (5) successive readings, thus having been at a maximum for one hour. This overcharge should be given whether the batteries have been

Discharging.

The specific gravity of the pilot cell should never be allowed to fall thirty (.0) points below the preceding overcharge maximum (1.207). While the voltage should never be allowed to fall below 1.85 volts per cell.

Readings.

Readings should be taken of the specific gravity of the pilot cells and battery voltage just before starting and ending every charge, together with the temperature of the electrolyte. In comparing specific gravity readings, they should be corrected to a standard temperature of seventy (70) degrees Fahrenheit, by adding one (1) point for every three (3) degrees above and subtracting one (1) point for every three (3) degrees below.

Wires and Wiring.

Specifications.

1. Rubber covered wire smaller than No. 14 B.& S gauge shall not be used.

2. Hard drawn copper line wire shall not be smaller than No. 10 B.& S. gauge.

3. No common return shall be less than No. 12 B. & S. gauge

Numbers and sizes of track circuit wires shall be as follows;

Track Batteries to rail	1	conductor	No. 9	B.&S.
Relays to rail	"	"	"	"
Shunt connections	2	"	"	"
Switch circuit control	2	"	"	"
Wire trunking			" 12	"

These wires shall be laid loosely in the conduits without stretching or crowding and no more than two wires can be connected to one binding post.

Table No 1.

Size of Machine	Size of Battery
8-16 levers	40 amphr Battery
16-32 " "	60 " " " "
32-48 " "	80 " " " "
48-88 " "	120 " " " "
88-128 " "	160 " " " "
128-168 " "	200 " " " "

Table No 2.

Demensions, Weights of Lead Storage Battegy Cells.

Capacity of Battery	Normal Charging current 8hr Rate	Number of Plates /cells	Battery Jors			Sand Tray						Cell Covers		Approx Installation Height	Approx Weight Cell	Approx Weight Electrolyte
			Length	Width	Height	Min Lgth	Max Lgth	Min Width	Max Width	Min Height	Max Height	Width	Length			
Amp hr	Amps		in	in	in	in	in	in	in	in	in	in	in	inch	lbs	lbs
40	5	5	7 7/8	4 1/4	11	9	9 1/2	6	6 1/2	1 1/2	2	3 7/8	6	17	37.56	10.75
80	10	5	9 1/8	5 1/2	12 1/4	10 1/4	10 3/4	6 3/4	7 1/4	1 1/2	2	6 1/16	6 1/4	19 1/2	63.65	18.75
120	15	7	9 1/8	6 1/4	12 1/4	10 1/4	10 3/4	8	8 1/2	1 1/2	2	6 1/16	8	19 1/2	80.25	22.06
200	25	11	9 1/8	9 1/8	12 1/4	10 1/4	10 3/4	11	12	1 1/2	2	6 1/16	10 1/4	19 1/2	112.16	27.26
320	40	9	12 5/8	9	17	14	15	11	12	2	2 1/2	8 1/16	10 3/4	29 1/4	189.86	55.00
400	50	11	12 5/8	10 5/8	17	14	15	11 1/2	12 1/2	2	2 1/2	8 1/16	10 3/4	29 1/4	217.6	59.75

Table No 3

General Data Lead Storage Batteries.

Capacity of Battery	Normal charging current 8-hr rate	Required generator capacity at 160V machine	Required HP for Batt connected to Gas Engine	DC-DC Motor Generator Sets Imput	DC-DC Motor Generator Sets Floor space	AC-DC Motor Generator Sets Imput	AC-DC Motor Generator Sets Floor space	Mercury Arc Rectifier
Amp/hrs	Amps	KW	HP	KW	inches	KW	Inches	KW
40	5	1.00	1.5	1.25	45 x 18	1.50	39 x 18	1.00
60	7.5	1.25	2.25	1.75	47 x 19	2.00	41 x 19	1.50
80	10	1.75	3.00	2.50	49 x 21	2.75	43 x 20	2.00
120	15	2.50	4.25	3.25	52 x 23	3.75	46 x 22	3.00
160	20	3.25	5.75	4.25	55 x 24	5.00	49 x 23	4.00
200	25	4.00	7.00	5.50	58 x 26	6.25	51 x 25	5.00
240	30	4.75	8.50	6.00	60 x 28	7.00	54 x 26	6.00
280	35	5.75	10.00	7.00	63 x 30	8.00	56 x 28	7.00
320	40	6.50	11.25	8.00	63 x 31	9.25	58 x 29	8.00
400	50	8.00	14.00	10.00	70 x 33	11.50	60 x 31	10.00

Table No 4

Installation Data for DC-DC Motor Generator Sets.

Max capacity of Set in Kilowatts	When used for Charging Battery: Amphr. capacity Battery No. VIII	When used for Charging Battery: Motor Gen Imput at 220V Approx	Rev per Minute	Dimensions: Length	Dimensions: Breadth	Dimensions: Height
1.25	40	7	1500	39"	21"	20 3/8"
1.25	60	9	1500	39"	21"	20 3/8"
2.40	80	10	1500	42"	21"	20 3/8"
2.40	120	15	1500	42"	21"	20 3/8"
3.25	160	20	1500	50"	21"	21 5/8"

Design of Plant.

Ampere hour capacity required for operation of plant is obtained by multiplying the number of lever movements per day by the number of days between charges and by a function constant. This function constant is influenced mainly by two things;

1. Average lenght of time that signals are held in proceed position and ratio of number of signal movements to switch movements. This cinstant is taken usually as .006.

Capacity of Battery when Number of Movements is not known.

The data in the following table is sufficiently large enough to care for ordinary conditons.

Data and Calculations.

Model 4 Switch Machines --- --------------------- 5

Model 2 Solenoid Dwarf Signal ------------------- 5

Interlocking Machine ---------------------------- 8 levers

From tables on the following sheets we have these results for an eight lever plant.

Table 1.

Interlocking Machine ----- 8 levers

Capacity of Battery -------40 ampere hr. - 110 volts.

Number of Batteries ------55 to 57 and pilot cell.

Table 2.

Size of Battery capacity ---- 40 amp. hrs.

Normal charging current ----- 8 hr. rate- 5 amp.

Number of plates per cell --- 5

Dimensions of battery jar

Length -------- 7-7/8 inches.

Width --------- 4-1/4 inches.

Heigth -------- 11 inches.

Sand Tray

Length -------- 9-1/2 inches.

Width -------- 6-1/2 inches.

Thickness ----- 2 inches.

Cell Cover

Width --------- 3-7/8 inches.

Length -------- 6 inches.

Approximate Weight of cell complete ------------- 37.53 pounds

Approximate Weight of Electrolyte -------------- 10.75 "

From Table 3.

Requires a motor generator set with a capacity which is as follows;

Input ------------------ 1.25 K.W.

Floor Space ------------- 45 X 18 inches

Generator capacity ------ 160 volt max. - 1.00 K.W.

Dimensions of Motor Generator.

Input ------------------ -1.25 K.W.

Input to motor at ------- 220 volts - approx. 7

R. P. M. --------------- 1500

Length of set ----------- 39 inches.

Width of set ------------ 21 inches.

Heigth ------------------ 20-3/8 inches.