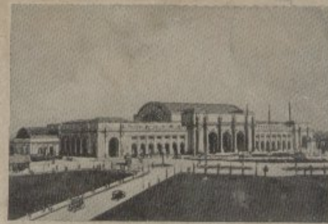
Pennsylvania Station, New York



Washington Union Station

ELECTRO-PNEUMATIC ·INTERLOCKING·

The Union Switch & Signal Co. Swissvale, Pa.

Boston South Station

Pennsylvania Station, Pittsburgh

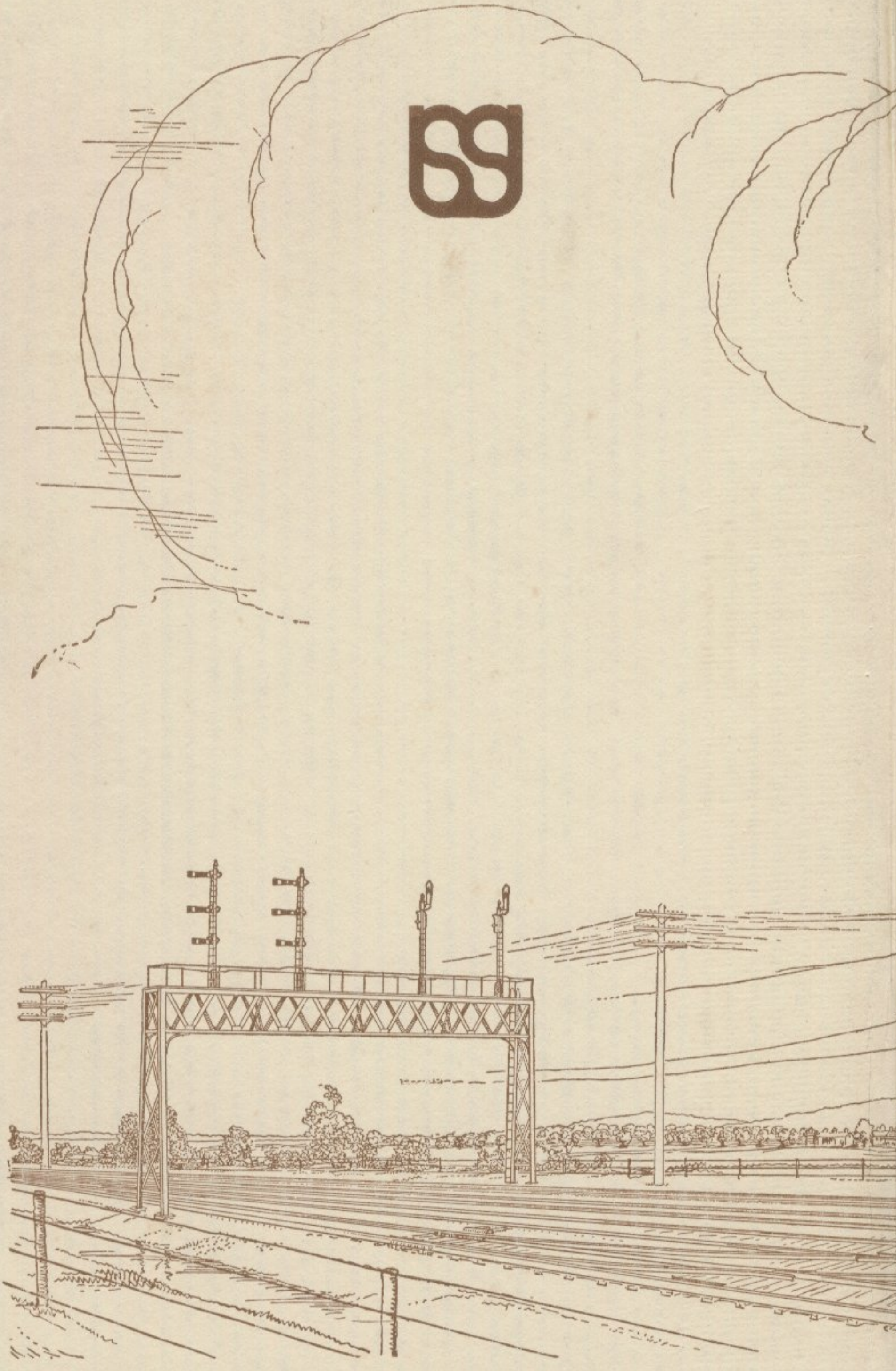
Kansas City Terminal

Union Station, Nashville

Hoboken Terminal

Reading Terminal, Philadelphia

BULLETIN No 75



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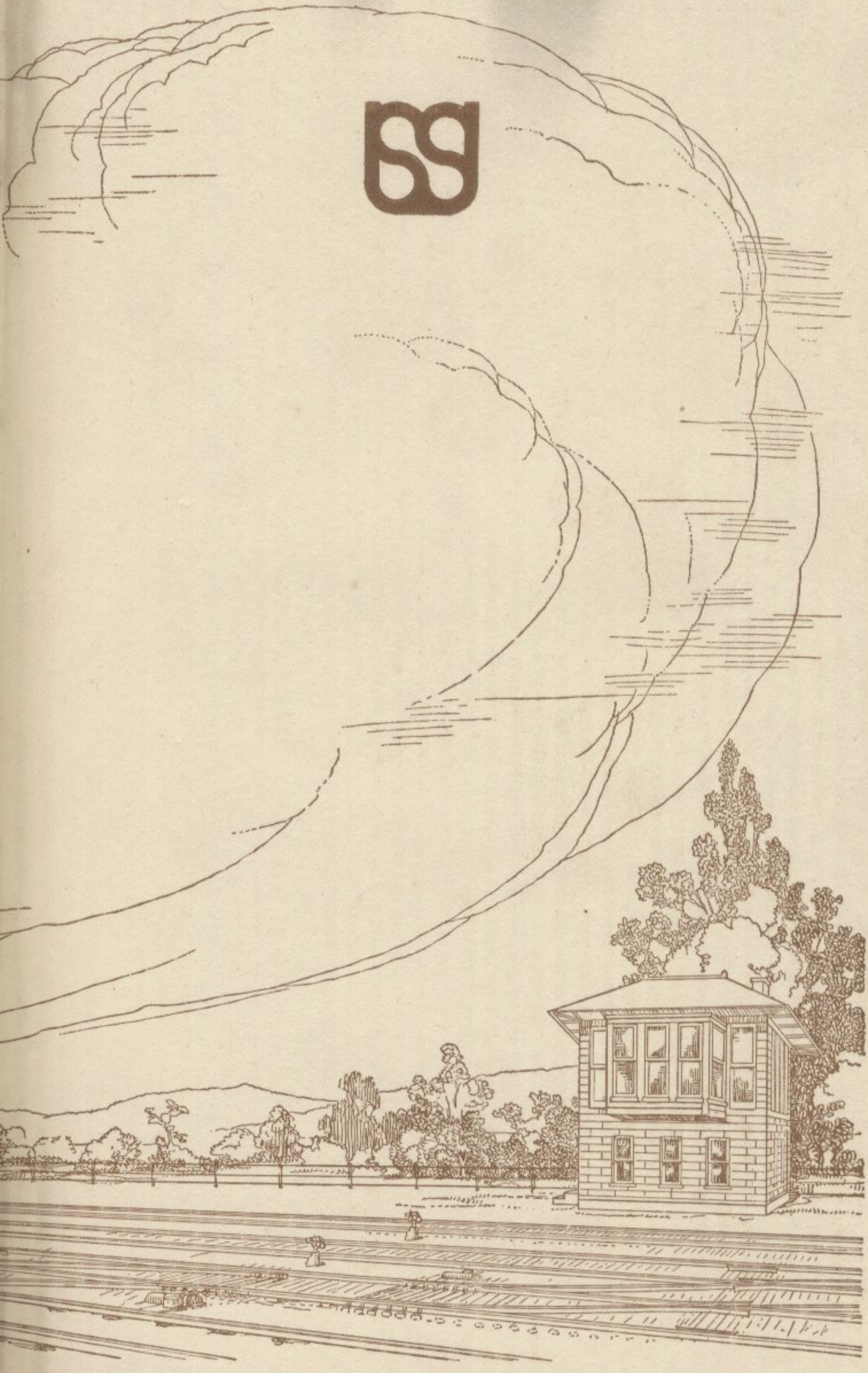


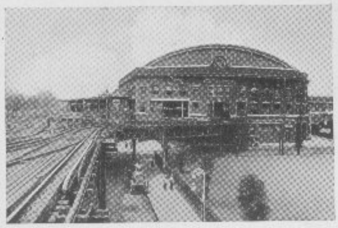
The Union Switch & Signal Company's
Publicity Department,
Swissvale, Pa.

November, 1914
Reprinted
August, 1928

The Union Switch & Signal Company

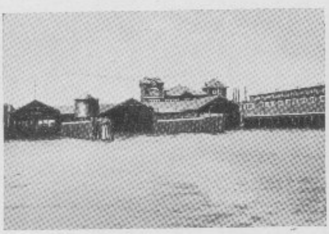
St. Louis Union Station

Flatbush Ave. Terminal, L.I.R.R.

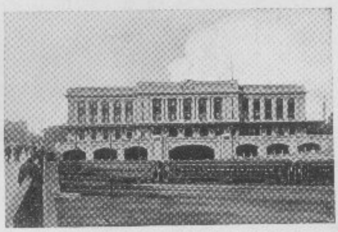


Sullivan Square Terminal, Boston

Brooklyn Bridge Station, N.Y. Subway



Jersey City Terminal, Erie R.R.



Baltimore Union Station

Scranton Station, D.L.&W.R.R.

Wheeling Terminal

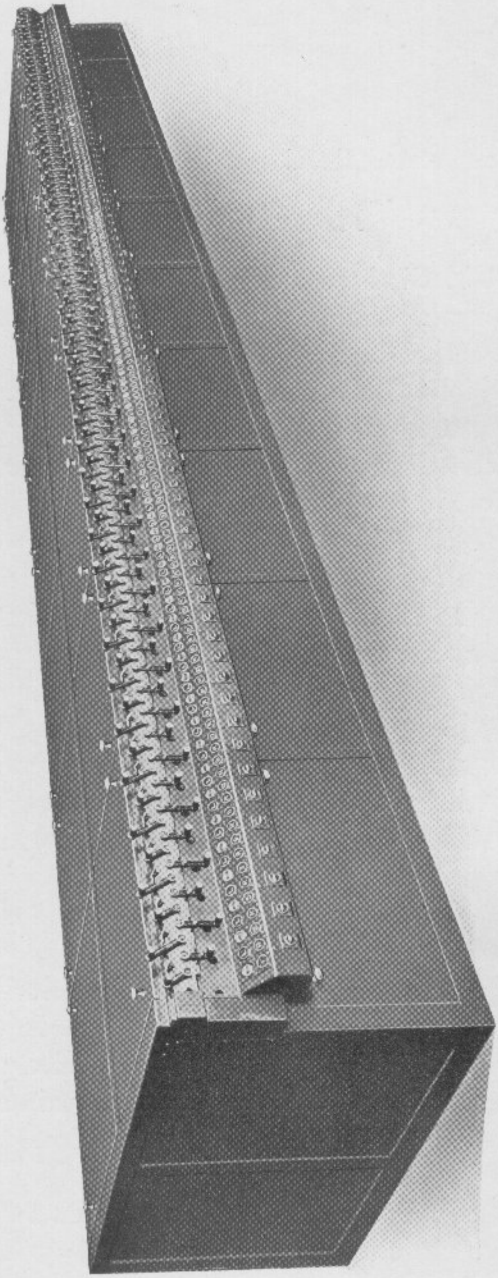
Electro-Pneumatic Interlocking

Introduction

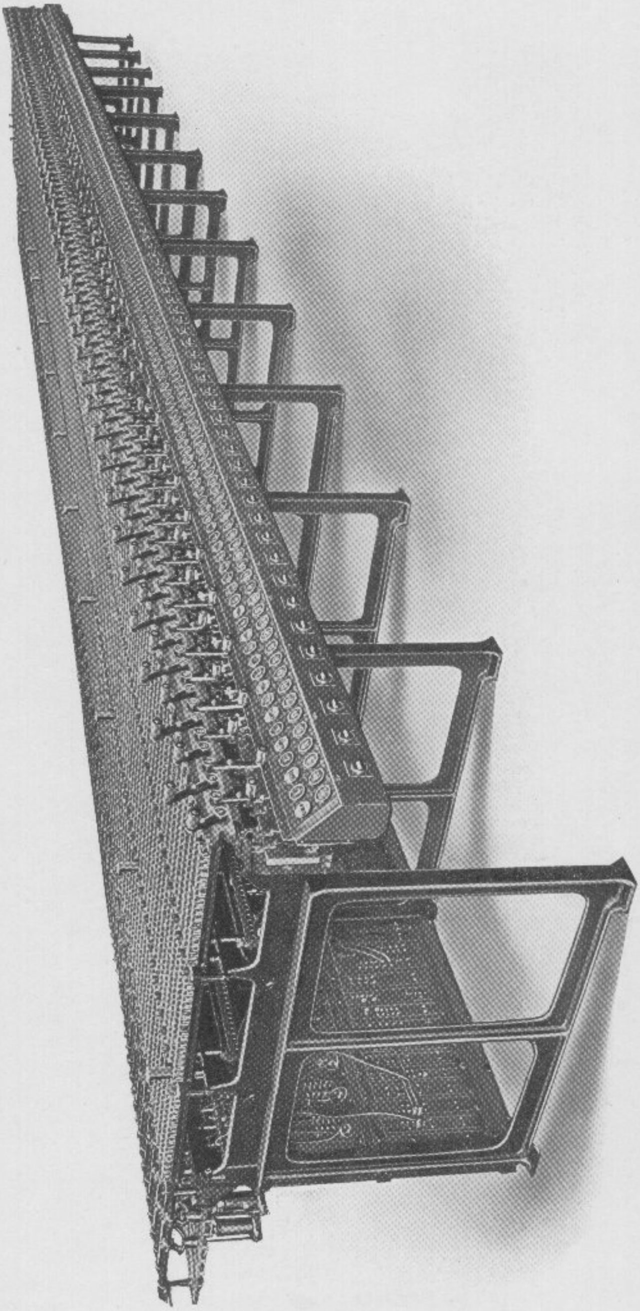
FOUR distinct systems of interlocking have long been known and are in wide use. These are the Electro-Pneumatic, Electric, Electro-Mechanical, and the Mechanical. To all railroad officers these names are so familiar that it is unnecessary to define or explain them. Everybody knows what they mean.

Each of these systems is more suitable than any of the others for use in some places and under some conditions. It is often the case, that, the decision which to use, is obvious; but it is also often the case that the decision is close and calls for much study and for sound judgment. But judgment presupposes accurate knowledge of many facts. It is the purpose of this bulletin to treat only of the Electro-Pneumatic System and to set forth certain facts that will help the engineer and the buyer to decide which of the four systems will best meet the conditions which he has before him.

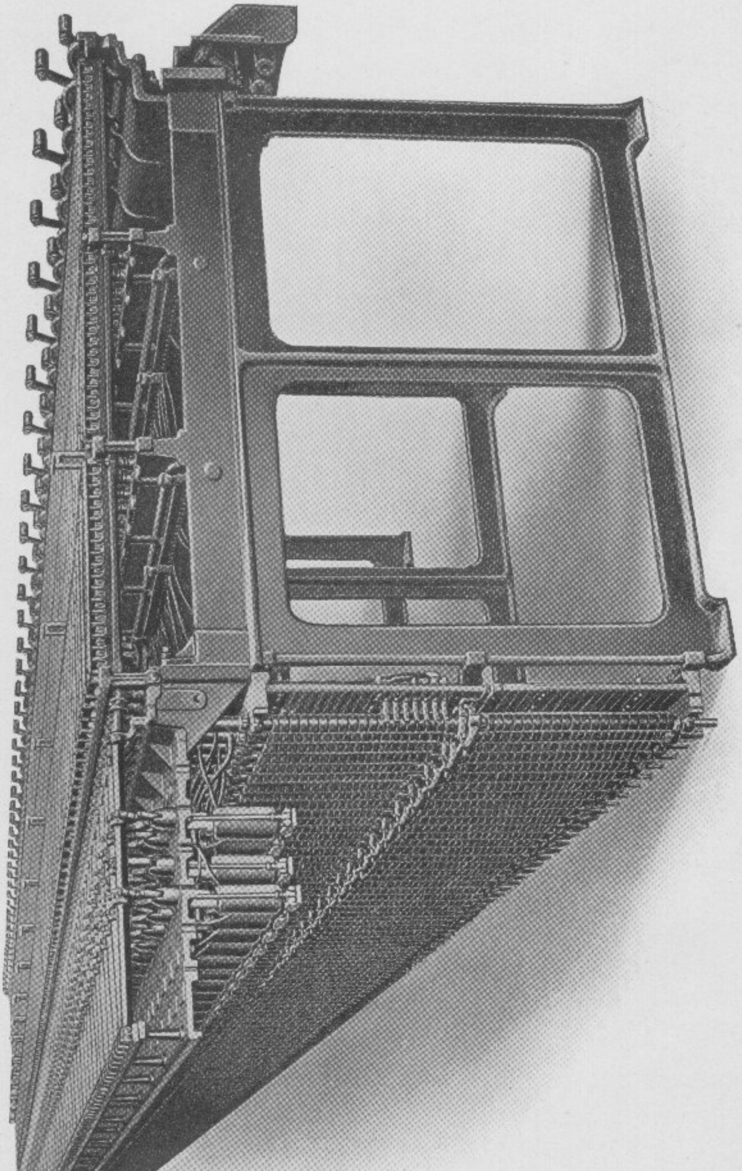
In the study of power interlocking, it is best to begin with Electro-Pneumatic, because it embodies the fundamentals of the art, and especially because the best system of electric interlocking now in existence, the system which expresses the highest state of the art, namely, the Type "F" System of The Union Switch & Signal Company, is the lineal descendant of the Electro-Pneumatic and has a close analogy to it in its fundamental principles.



Electro-Pneumatic Interlocking Machine, Complete with Metal Case.



Electro-Pneumatic Interlocking Machine, Complete without Case.



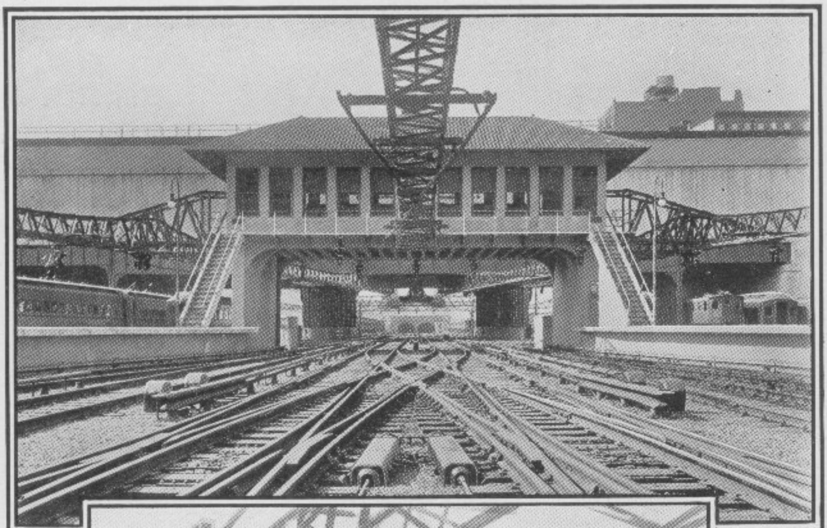
Electro-Pneumatic Interlocking Machine, Complete without Case, Rear View.

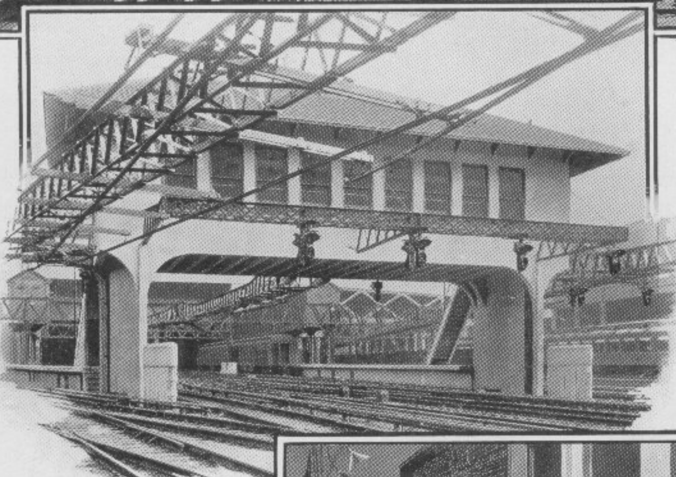
Power interlocking, like power signaling, had its origin and its engineering and commercial development in the United States. We are speaking now of the art as actually applied on a large scale to practical use, and shall not try to fix the credit of having first thought of handling interlocked switches and signals by power or of having worked out more or less practicable schemes for doing this. There were European inventors early in the field, but their inventions were not of real importance until long after the Electro-Pneumatic interlocking had become in the United States a well known and highly developed means of safety and economy.

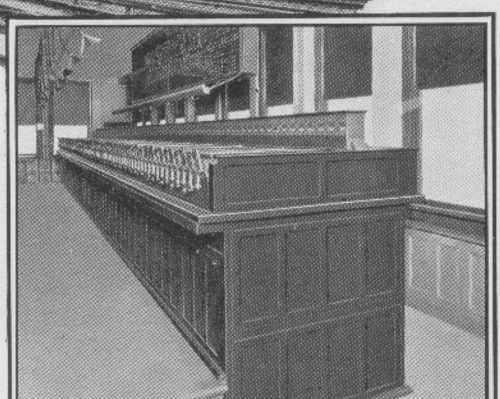
It is the old story of using machinery in place of man power. We, in this country, have usually been quicker to do this than other people, principally because of scarce labor and high wages. Other circumstances of our social conditions have, doubtless, made us inventive and enterprising, but probably labor and wages have been the most important elements in the introduction of machinery.

So, having begun sooner than other people to use power interlocking, it was inevitable that its use should spread as traffic increased and as the railroads grew in the capacity to pay for labor-saving devices; but for many years the progress in the introduction of any interlocking, either mechanical or power, was very slow, and it took a good deal of courage, as well as money, to keep a signal company in the field. Finally, the value of power interlocking having been proved, traffic having become dense, and the earnings per mile of railroad having become important, the use of power interlocking proceeded fast.

In 1882 The Union Switch & Signal Company designed and installed, at East St. Louis, an interlocking system of considerable magnitude, in which







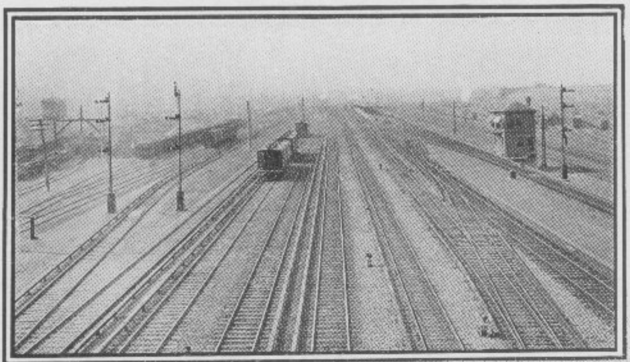
The Pennsylvania Terminal,
New York City.
Electro-Pneumatic Interlocking
at Cabin A.

the switches and signals were operated by hydrostatic pressure controlled by compressed air. This was the first power interlocking in this country. Some years later an interlocking system, using compressed air as the operating power and electricity to some extent in its control, was devised and installed by this Company. A number of this type of interlocking were installed in various parts of the country subsequent to 1890.

In 1890 the Electro-Pneumatic System, so successfully employed today in all but two of the great American Railway Terminals in which power-operated switches and signals are used, was first applied to exacting service at the Pennsylvania Railroad Terminal in Jersey City. On the Boston Elevated Railway System in 1902 it was first applied to an electric railway, and there it was first adapted to the control and operation of automatic train stops. Its extensive application to every known demand of safe railway transportation is in constant evidence at many places today, but nowhere is this more evident than in the congested subway and terminal systems in and adjacent to New York City where the passenger and freight traffic daily handled is of enormous volume.

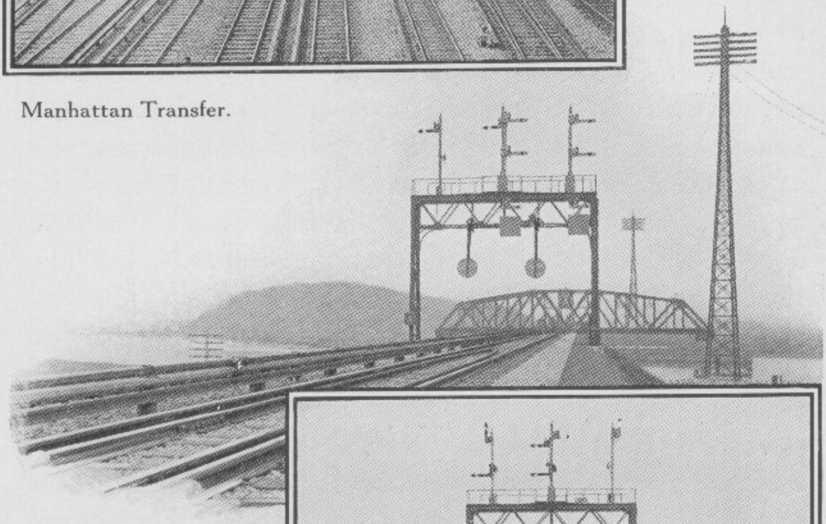
Since the beginning of Electro-Pneumatic Interlocking, it has been steadily improved by those changes which more than a quarter of a century of experience in the general field of power interlocking have suggested. Advantage has also been taken of the progress made in the art of signaling generally, and the system has been adapted in every way to all of the requirements of modern traffic. As installed today, it represents the highest development of power interlocking systems.

As to the safety and reliability of the Electro-Pneumatic system and as to its actual installation at

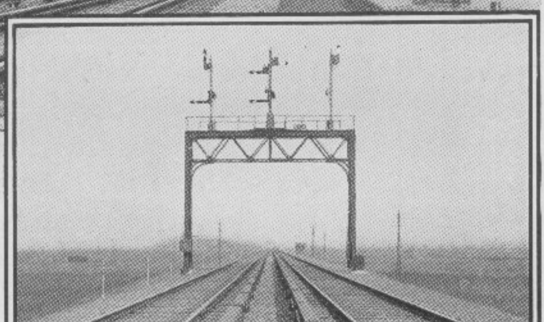


Electro-Pneumatic Interlocking in the Vicinity of New York on the Pennsylvania.

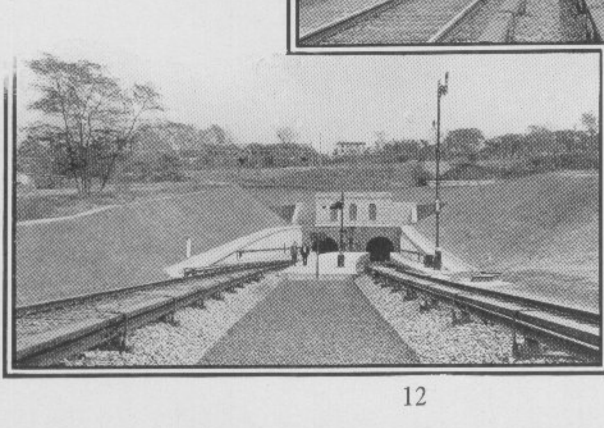
Manhattan Transfer.



Hackensack Drawbridge.



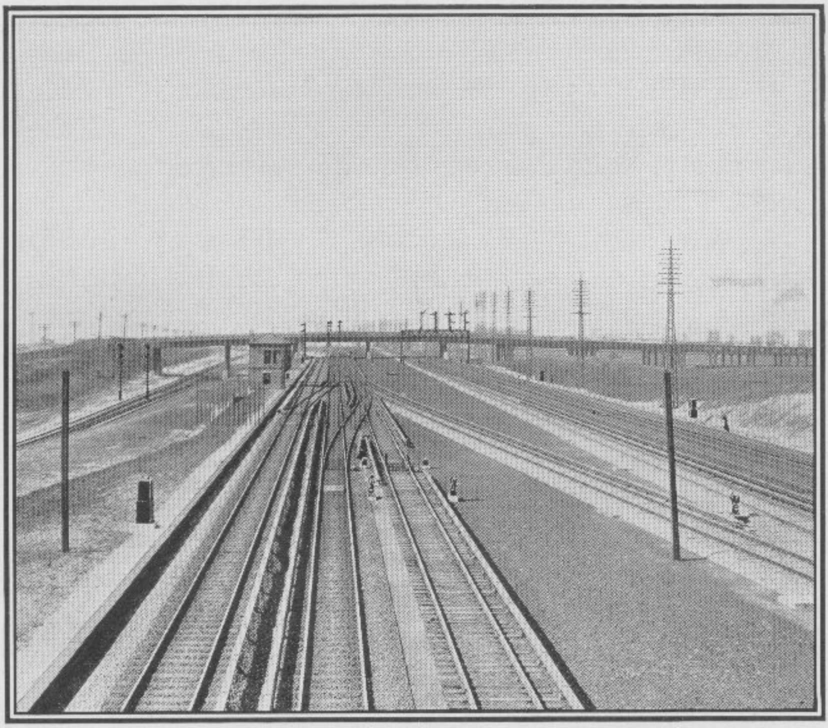
Signal Bridge on Meadows.



Hackensack Portal, Hudson River Tubes.

the greatest traffic centers in the world, these are set forth under the proper headings in this bulletin.

It is a matter of proper interest, although of little or no practical importance, to try to compare the amount of Electro-Pneumatic and of Electric Interlocking in actual use, and the obvious thing is, to compare the number of levers. Such a comparison is fallacious and misleading. A great part of the Electro-Pneumatic interlocking in use is at points where dense traffic and intricate track arrangements exist, where semi-automatic control of signals by trains, automatic announcement and route locking are demanded, and often where electric traction is to be contended with. A comparison on a lever basis gives no adequate idea of the service that each system is rendering either to the traveling public or to the railroads. Because of certain characteristics of Electro-Pneumatic levers, they have capacities for work beyond the capacity of the levers of the Electric interlocking system, and comparison by levers does not compare the *functional* duties. Since comparison by levers is worthless, we present on page 82, a list, not complete, of the Electro-Pneumatic interlocking plants in service today, where failure would be as inconvenient to the traveling public as it would be embarrassing to the railroads serving it, and on page 75, we give some figures to show the amazing reliability of the system.



Cabin H, Sunnyside Yard, Long Island.
Pennsylvania Railroad.
Electro-Pneumatic Interlocking

Electro-Pneumatic Interlocking

Part I. General Description

THIS bulletin is to set forth, in a general way, the main features of the Electro-Pneumatic System of Interlocking, and to outline those characteristics which it possesses and the principles upon which it is founded that have given it first place in American interlocking practice where MAXIMUM Safety, Simplicity, Reliability, Flexibility, Capacity and Celerity are demanded in switch and signal operation, as exemplified in its application to over 90 per cent of the power operated terminal track systems in the country and to many other locations of lesser importance.

Character of System

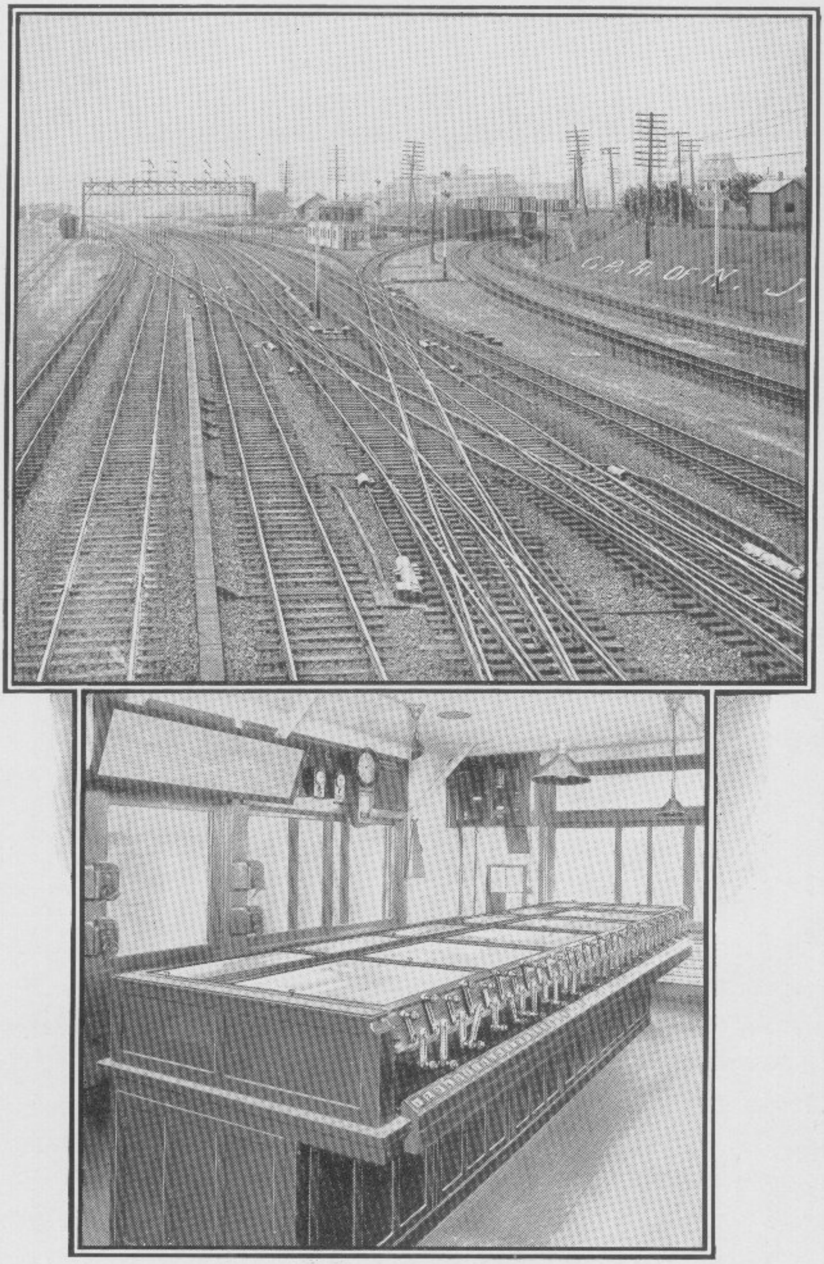
The Electro-Pneumatic System derives its name from the fact that compressed air is employed to *perform* the work—the shifting of the switches and signals, and electricity is used to *control* or *direct* the performance of the work—the admission and discharge of pressure to and from the cylinders by which the work is performed.

Elements of System

The system is comprised of the following elements:

First—A source of compressed air supply of approximately 75 pounds per square inch.

Second—A source of current supply of approximately 12 volts.



Electro-Pneumatic Interlocking. Communipaw, N. J.

The Central Railroad of New Jersey.

Third—An interlocking machine for controlling the operation of switches and signals.

Fourth—Switch operating mechanisms with their controlling and indicating circuits.

Fifth—Signal operating mechanisms with their controlling and indicating circuits.

Auxiliary devices, of optional character, for performing special functions, such as track circuits, detector locking, route locking, indicators, annunciators, etc., can be installed as desired. These elements are treated more fully below under corresponding headings.

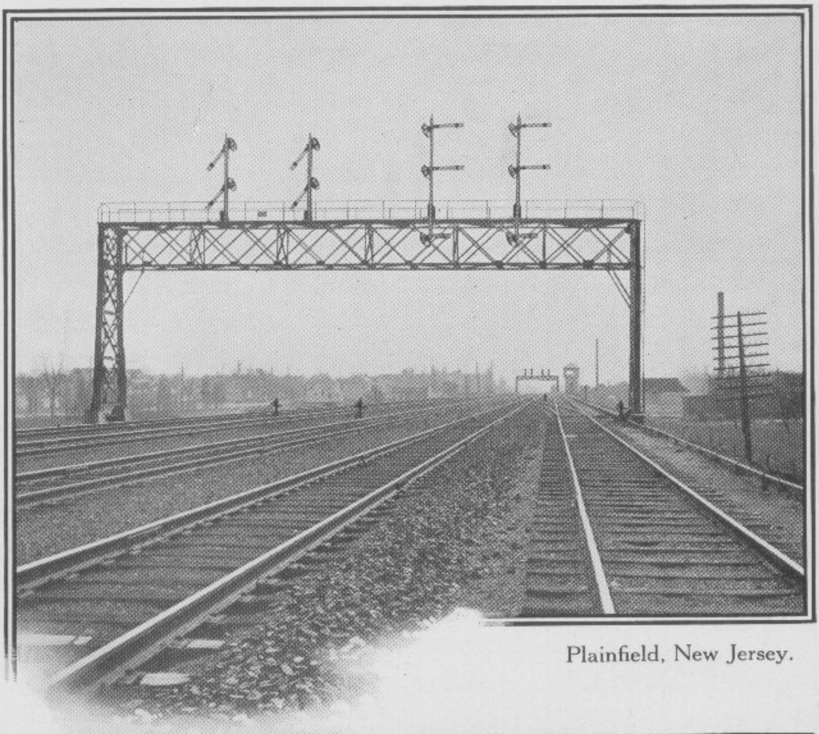
Compressed Air

This embraces, preferably, two compressors—one as a relay to the other—which may be driven by electric, steam or other available power, as local conditions may justify.

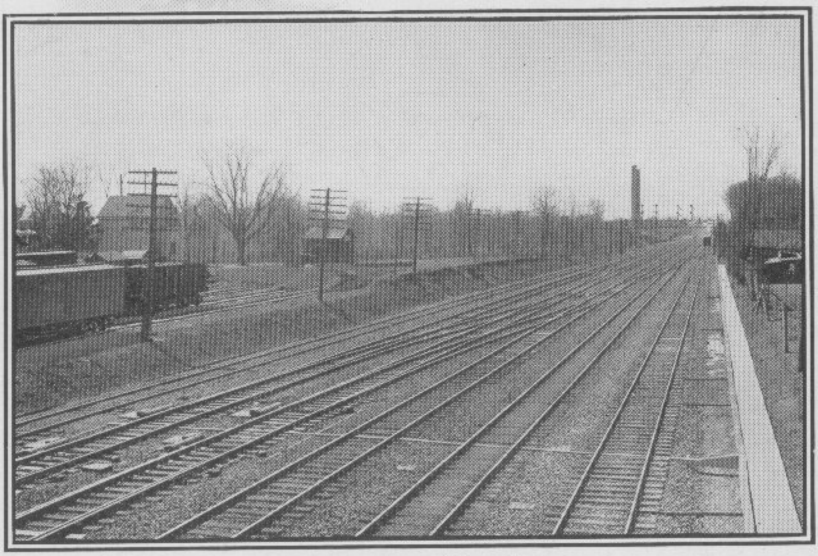
Frequently, especially at terminals, a source of compressed air supply exists, or is required, for other purposes—such as cleaning of cars, operation of tools, etc. This same supply may be used for the interlocking system, with no appreciable reduction in the volume of air available for the purposes it was originally provided for, since the interlocking system requires but a comparatively small amount.

At interlocking sites where no supply of compressed air exists for other than interlocking purposes, there is usually available a source of direct or alternating current which may be utilized for the operation of air compressors. In such cases, an automatic governor is provided as a part of the compressor equipment, which is so regulated that when the pressure in the main air pipe reaches the maximum desired the compressor is automatically stopped and when the air pressure reaches the minimum desired is automatically started. This makes a very satisfactory

Compressor



Plainfield, New Jersey.



Cranford Junction, New Jersey.

Electro-Pneumatic Interlocking on the Central Railroad of New Jersey.

and economical arrangement, since the compressors are operating on an average of but one-third of the time.

Motor driven compressors of the type employed for the air brake system of electrically propelled cars are frequently found ample in capacity and ideal in their self-regulating properties for interlocking duty. See Fig. 3, Part 2.

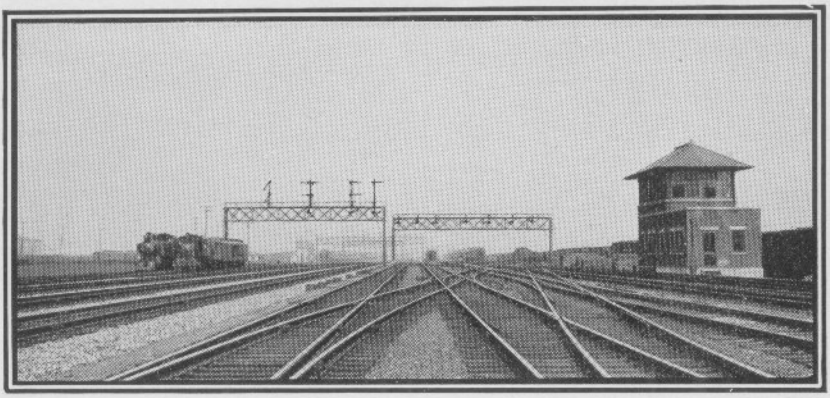
A two-inch air main extending throughout the interlocked territory is ample for distribution of the pressure to the various cylinders of the system with no appreciable loss due to drop therein. Branch pipes from the main air pipe are usually of ¾″ diameter, reducing at the switches and signals to a diameter of ½″.

Electricity

Electricity for the control of the various appliances of the Electro-Pneumatic system may be taken from any reliable source. Such a source is generally already available. The usual custom is to employ *direct* current for all purposes through the medium of a storage battery having an e. m. f. of 12 volts.

In a number of installations, however, (notably the equipment of the subways of the Hudson & Manhattan Railroad between New York City, Jersey City and Hoboken, etc., installed about six years ago), all of the electrical functions of the many Electro-Pneumatic interlockings in that vitally important artery of transportation are performed by *alternating current exclusively*. Alternating current is also used to control many of the functions involved in similar service elsewhere with highly satisfactory service results.

The work performed by *electricity* in the *control* of the Electro-Pneumatic system is of an insignificant amount, and, hence, both the pressure and the volume



The Central Railroad of New Jersey.
Electro-Pneumatic Interlocking,
Jersey City, N. J.

of the current used are remarkably low as compared with the energy employed for like duty in any other type of power interlocking. All of what may be classified broadly as "work" is performed by compressed air, the function of the electricity being simply the control of the various air valves by electro-magnets, and the control and operation of the electric locks, relays, indicators and similar appliances.

Interlocking Machine

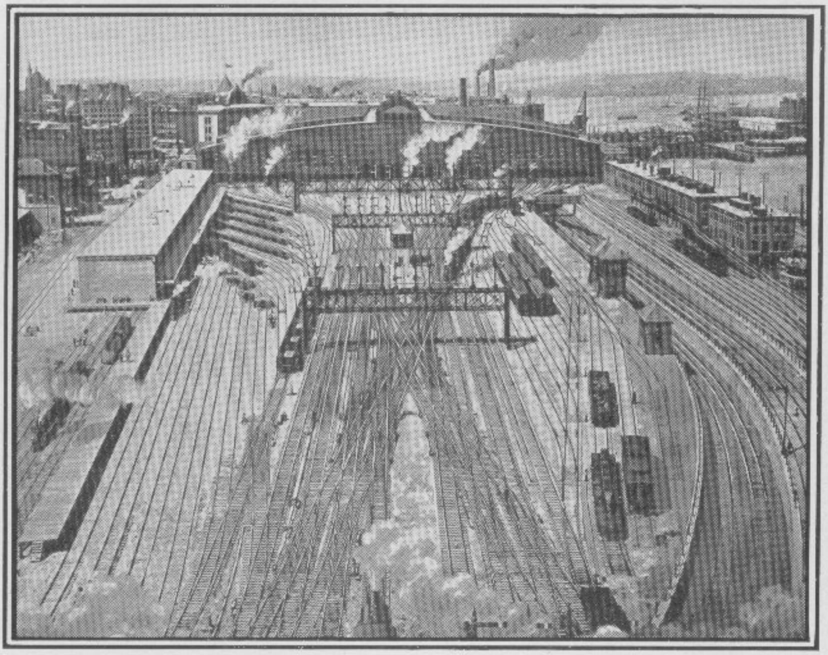
The Electro-Pneumatic Interlocking Machine is such in name only, since there is no compressed air used for any purpose within it. The machine consists of miniature levers conveniently arranged in a common frame and adapted to the operation of a bank of mechanical locking similar in character to that employed in mechanical interlocking machines, but of diminutive design. Each lever in the machine also operates a plurality of electric contacts, and attached to each lever is one or more electric locks.

Functions of Parts

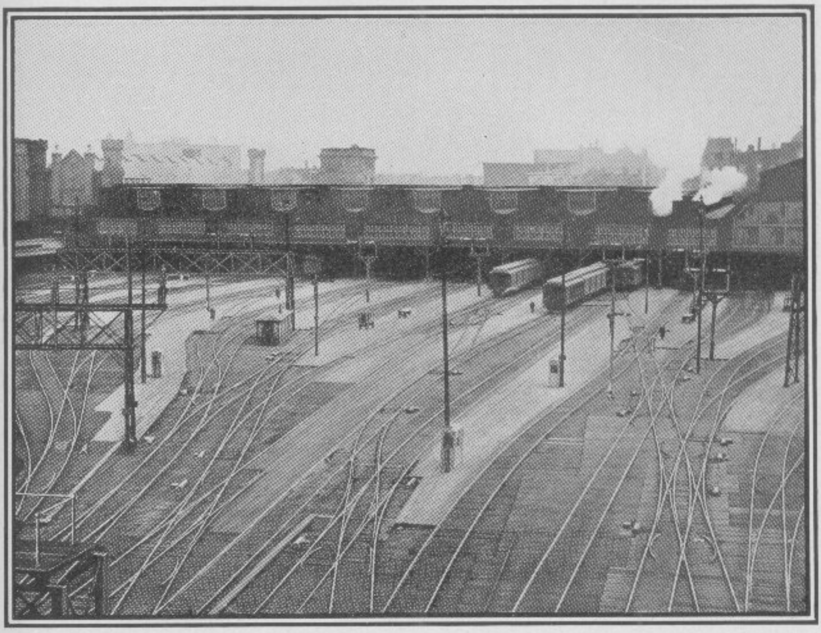
The *mechanical locking* is provided for preventing the operation of levers which, if moved, would conflict in function with one or more levers.

The *contacts* control electric currents by which switches and signals are operated by the levers, and are also used for opening and closing different circuits as required by the many combinations of lever positions.

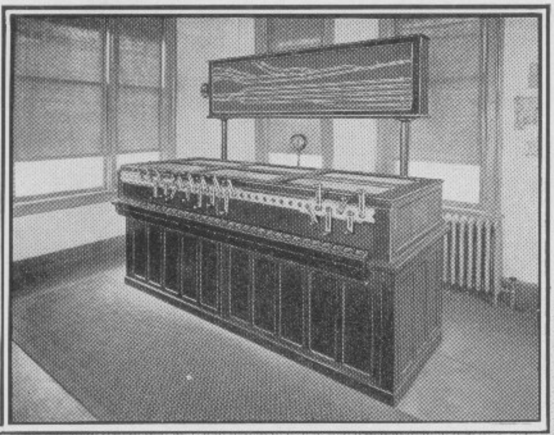
The *electric locks* are provided for restraining lever operation according to conditions remote from the machine when these are adverse to their safe operation, such as preventing final movement of levers until the operated unit has responded to the initial lever movement and preventing the initial movement



The Boston Southern Station.
The New York, New Haven & Hartford and the Boston & Albany.
Electro-Pneumatic Interlocking.

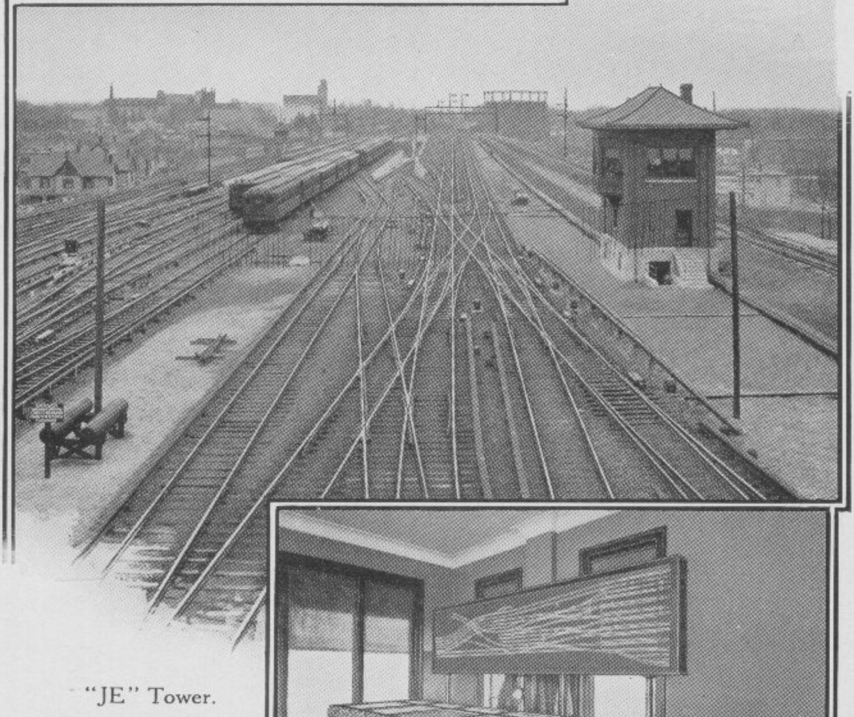


The North Station, Boston.
The Boston & Maine and the Maine Central.
Electro-Pneumatic Interlocking.

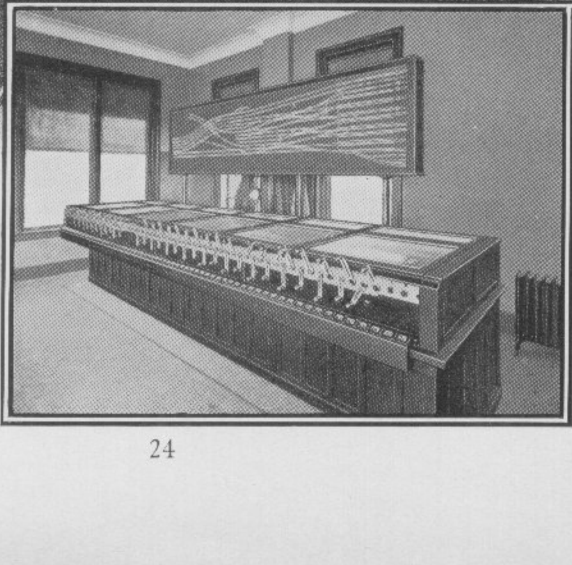


Interlocking Machine at "MP" Tower.

Electro-Pneumatic Interlocking at Jamaica, N Y., on the Long Island Railroad.



"JE" Tower.



Interlocking Machine at "JE" Tower.

of switch levers by train action where detector track circuits are used in lieu of mechanical detector bars.

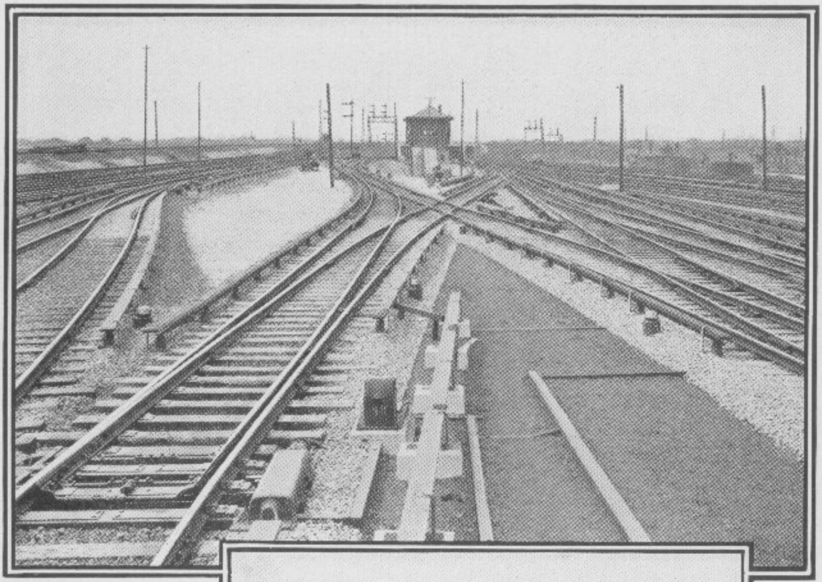
It is the custom in the Electro-Pneumatic system to operate from a single switch lever all of the switches upon the ground that it is permissible so to operate without restricting simultaneous traffic movements, and irrespective of the loads thus produced upon any lever. In the case of signal levers, it is the custom to operate all signals that under all circumstances govern routes conflicting with each other; thus many signals leading from individual tracks to a common point and diverging from the common point are handled from the same lever.

Levers

The form of the lever used and the manner of its operation were adopted years ago to obtain, effectively, the concentration of many levers within the smallest space practicable. This form was adopted to insure that the operation of many switches and signals from a central point might be effected without frequent shifting of position by levermen during lever manipulation and without extravagance in the dimensions of the structure containing the machine.

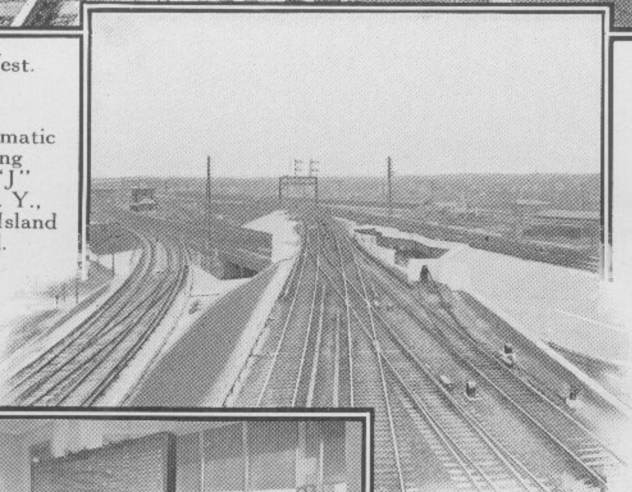
Due to this form of lever construction a large machine may often be operated by a single leverman without fatigue, while its location, conveniently within the track system, involves no serious encroachment upon space usually much needed for track purposes. The device is self-contained and suitably encased in a wood or metal case that is provided with detachable panels, each provided with means for locking the machine against access by other than authorized persons.

Few, if any, devices in existence today that were designed for the safe and reliable control of a multiplicity of contacts embrace that degree of concentra-

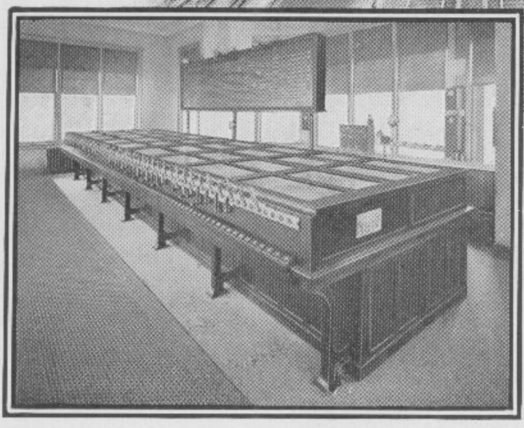


Looking West.

Electro-Pneumatic Interlocking at Tower "J" Jamaica, N. Y., on the Long Island Railroad.



Looking East.



Interlocking Machine.

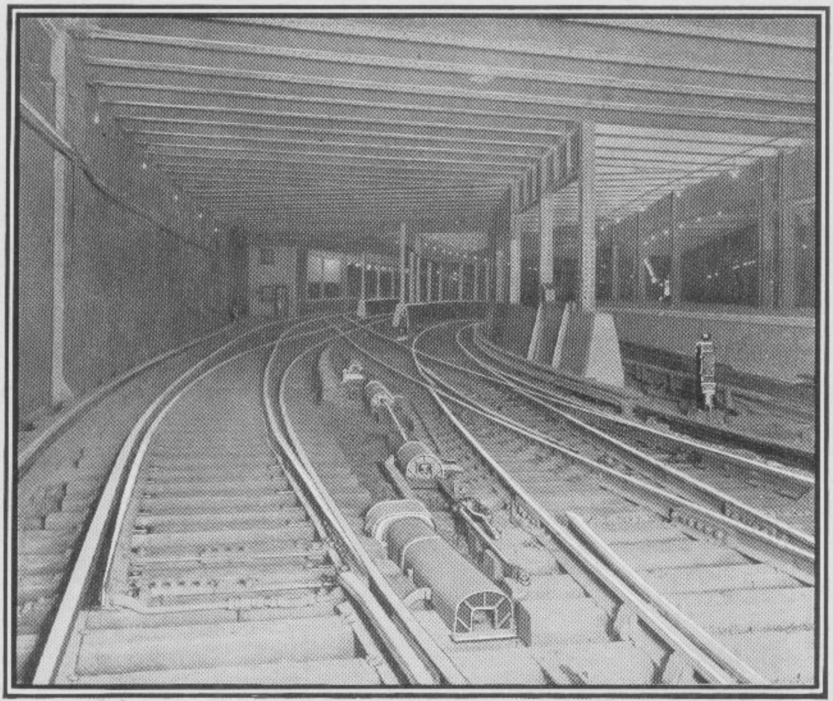
tion, security of construction, current carrying capacity, insulation and electrical separation of current carrying parts with that degree of accessibility and ease of inspection that are conspicuous features of the electrical equipment of the Electro-Pneumatic machine. Thirty years of development have not only permitted the embodiment within this machine of these characteristics, but have also made possible the machine's application to the operation of track layouts of extreme magnitude, and the direction of traffic of the most congested nature, without the slightest modifications of its structure or resort to substitute appliances for meeting the intricacies of special control and operation that such applications frequently have to provide for.

In the following pages, switch and signal operation from the machine and the intercontrol between machine, switches, signals, and track detector circuits are dealt with in such a way that the requirements of the interlocking machine for meeting the needs of the many functions involved will be better understood.

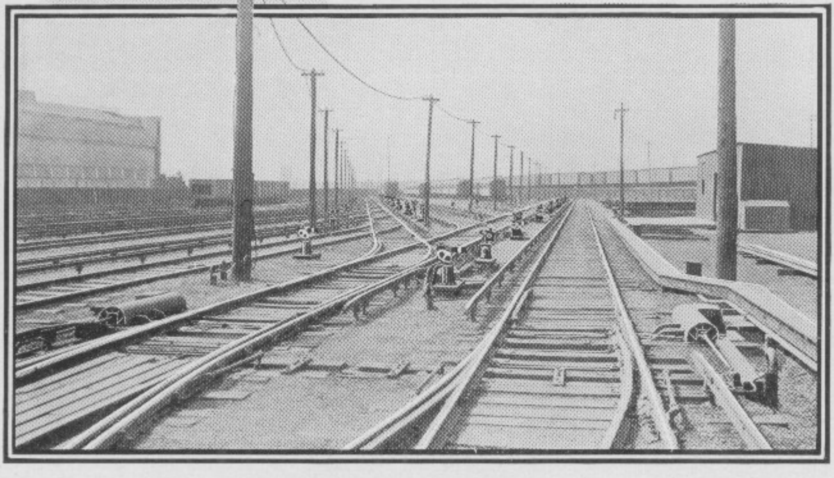
Switch Operation and Control

Each set of switch and frog points embraced in the track system is operated by what is commonly known as a switch and lock movement—a purely mechanical device designed first to unlock the switch, then shift it and relock it in its new position. The switch and lock movement is operated by direct action of the piston of a double acting cylinder, of which the admission and exhaust are controlled by a slide valve of simple design usually mounted upon the cylinder. The operation of the slide valve is effected by three electro-magnets, mounted on the valve, which are connected to the lever contacts of the machine by three individual wires.

Switch and Lock Movement



Flatbush Avenue Terminal,
Long Island Railroad.
Electro-Pneumatic Interlocking.



South Side Elevated, Chicago.
Electro-Pneumatic Interlocking, 63rd Street Lower Yard.

These three wires are the "control" wires. No additional wires are required when more than one switch movement is operated by a lever, the same three wires being extended to the other movements, with the valves connected in multiple.

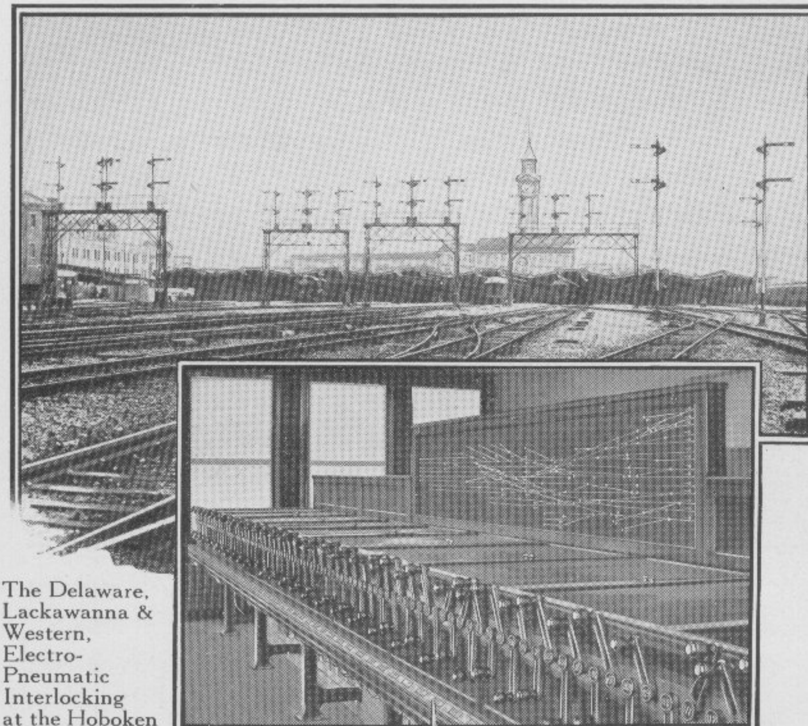
The switches in the Electro-Pneumatic system may be operated any distance desired from the interlocking machine. They may also be operated as slowly or as rapidly as conditions render advisable. Any number of switches that the peculiarities of the track layout render possible without restricting movements on adjacent tracks may be operated by a single lever.

Failures of switches to respond to their levers are detected with certainty and in a safe manner. Inadvertent or malicious operations of switch levers, or both, are likewise detected and ill effects resulting therefrom prevented. All switches are securely locked, not alone by the levers of signals governing train movements over them but also, where electric detector circuits are used, by the action of the trains themselves at such times. Interruptions to either the air supply or to the electric energy involved in switch operation are wholly without dangerous results.

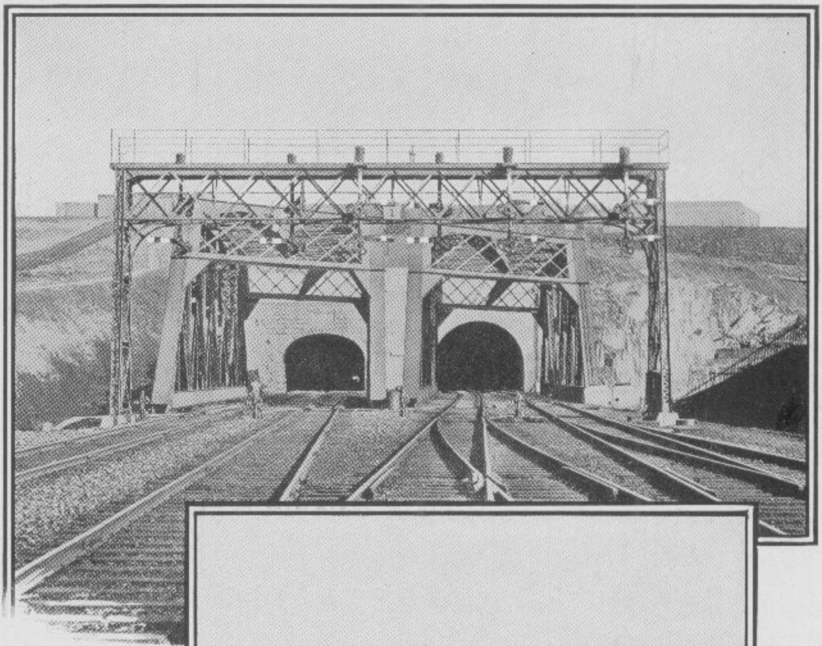
Safety Factors

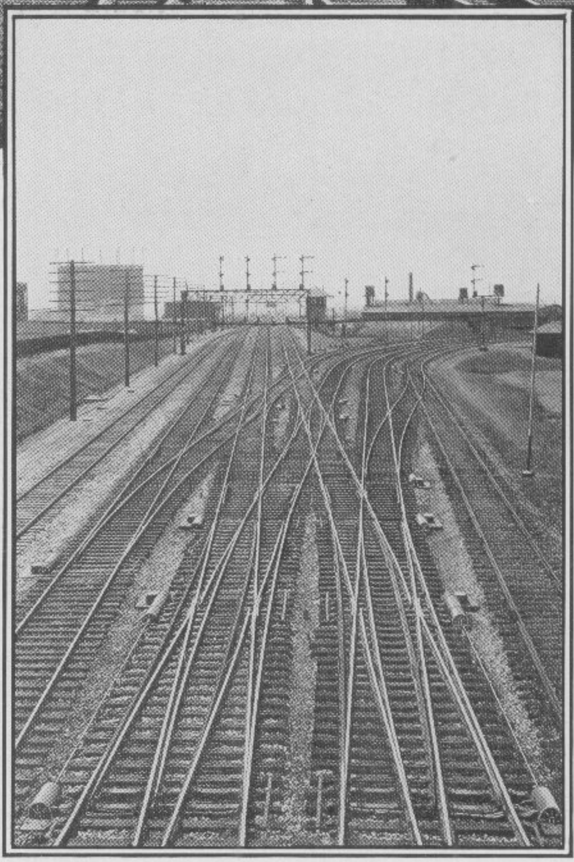
Simplicity of design, ease of application and maintenance, and remarkable durability are effectively combined in the switch operating mechanism, while the degree of reliability in operation obtained is not approached by any other known device for a like purpose.

Failure of switches fully to respond to lever movements would be serious if the switch exercised no influence over the operation of signals. To obtain this influence, means, described in the next paragraph, are provided for preventing the operation of signal levers until responding switches (by automatically permitting

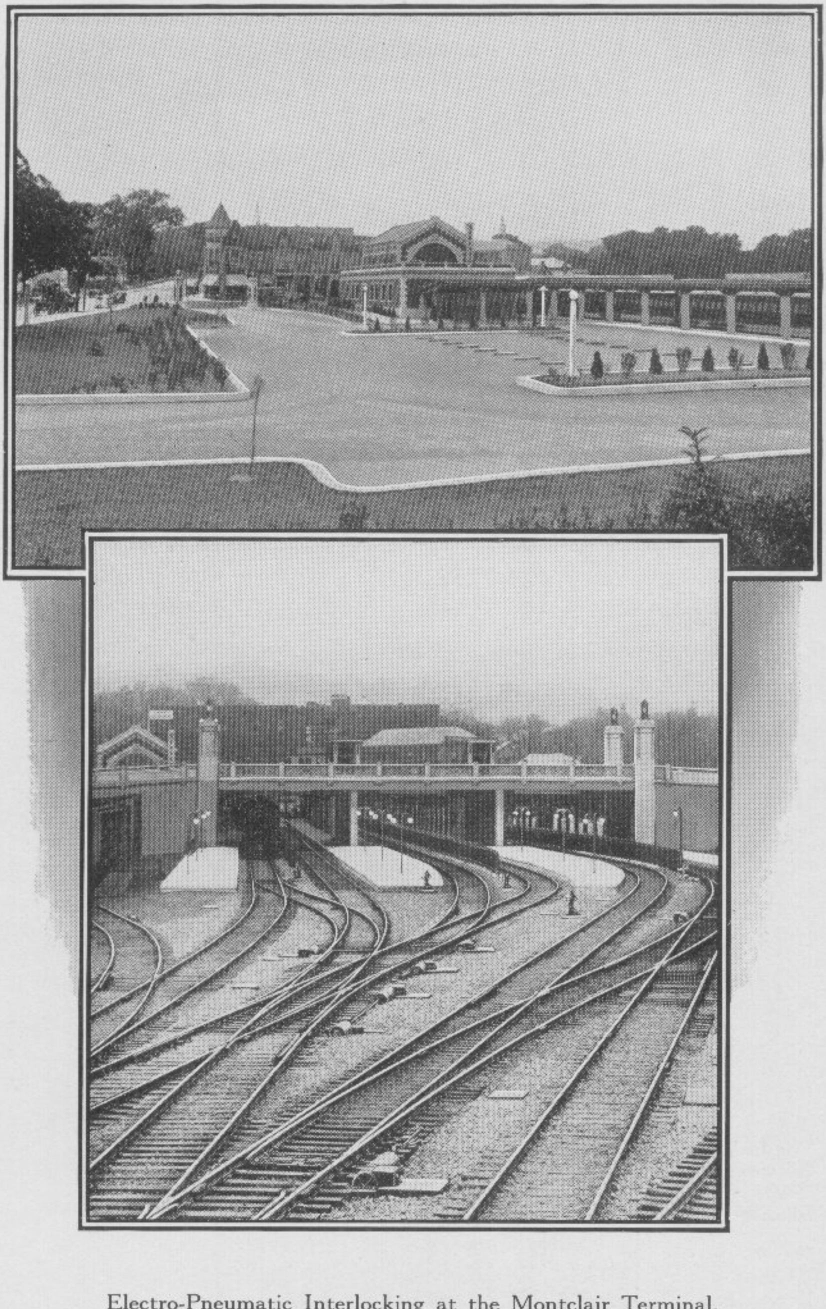


The Delaware, Lackawanna & Western, Electro-Pneumatic Interlocking at the Hoboken Terminal.





The Delaware, Lackawanna & Western, Electro-Pneumatic Interlocking West of Bergen Hill Tunnel.

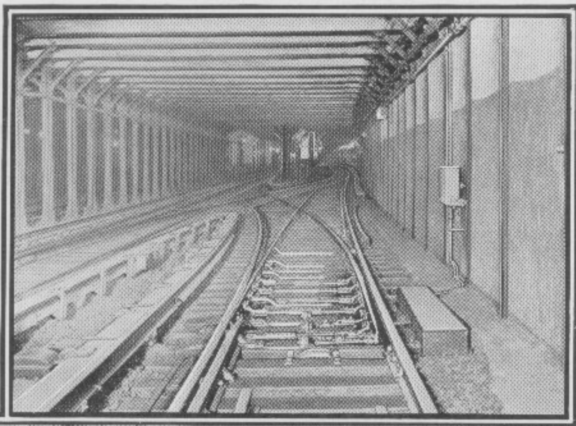


Electro-Pneumatic Interlocking at the Montclair Terminal,
Delaware, Lackawanna & Western.

final movement of their own levers) make signal operation safe. This feature is termed the "Switch Indicating" system. Attached to the switch and lock movement operating the switch points is a contacting device known as the "indication circuit controller." Two wires between this controller and the electric lock on the corresponding switch serve for indicating purposes. These wires are separate and distinct from the control wires, thus completely isolating the indication system from the control system. These two wires energize a polarized relay at the machine in the tower and constitute the complete indication circuit without connection with the common return wire, so that crosses or grounds have no serious effect. This arrangement eliminates the necessity of providing complicated apparatus for preserving the integrity of the control and indication circuits, which additional apparatus as employed in other systems is itself subject to derangement and consequent failure to perform the vital function for which it was intended.

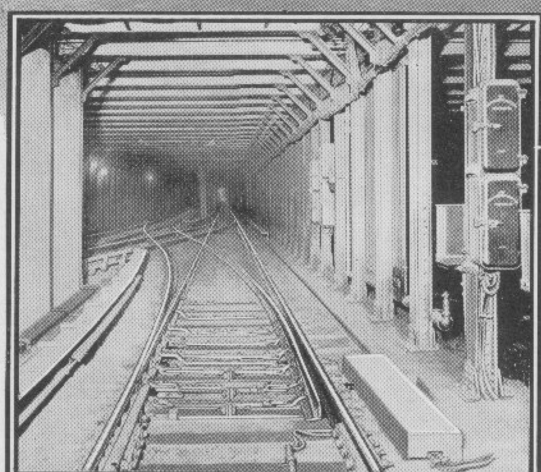
While inadvertent operation of switches under trains is prevented by the mechanical locking between switch and signal levers in the interlocking machine, so long as signals and their levers are in position granting trains permission to move over switches, the restoration of signals to their normal position removes this protection before trains have necessarily passed fully over the switches. Provision is, therefore, made for preventing the accidental operation of switches under trains either by means of detector bars operated by the switch and lock movement or by detector track circuits through which trains themselves are made automatically to lock switch levers electrically while passing over or standing on switches.

The Electro-Pneumatic System is amply protected from serious results due to crosses, which in



Ninety-sixth Street
Interlocking,
Electro-Pneumatic.

Brooklyn Bridge
Station.



Ninety-sixth Street
Interlocking,
Electro-Pneumatic.

The Interboro
Rapid Transit Co.

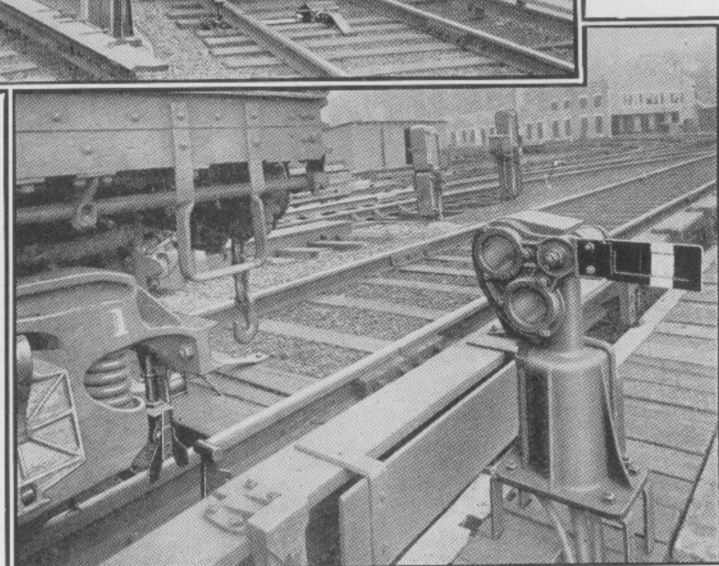
other indicating systems may cause false indications or false operations. In other systems the protection sought is dependent upon action of a magnetic device influenced by a current resulting from the cross. This device may fail to operate even though properly energized. Furthermore, this protective current to be active must flow through contacts which at the time *must necessarily be closed.* The proper closure of these contacts cannot be insured, since under the condition in which the protection is required, the contacts are not used for any other purpose, and, hence, if defective, will completely nullify the protection they are designed to give.

Indication and Cross Protection

In the Electro-Pneumatic System protection against crosses is obtained without recourse to any auxiliary instruments or conductors. Two indication wires and a polarized indication relay (without use of a common return wire) form a complete circuit from positive battery through a contact of the indication pole changing circuit controller on the switch and lock movement, through one indication wire to, and thence through, the coils of the indication relay back over the second indication wire to another contact of the indication circuit controller and thence to the negative side of the battery.

Thus each switch lever embraces the use of a polarized relay that can respond to a current of one polarity only for one indication, and which requires a reversal of that current for another indication; the use of two conductors electrically separated from other wires of the system, which include in circuit the polarized relay; and a pole changing circuit controller on each switch movement that not only separates both conductors of the indicating system from the source of electrical energy during transit of the switch but which

Van Cortland Park.



Dwarf Signal and Automatic Train Stop.

238th Street Yard.

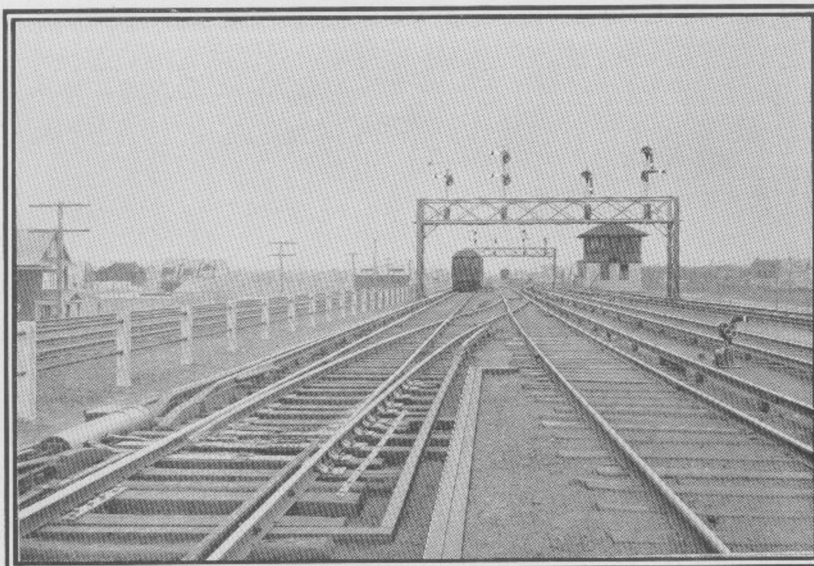
The Interboro Rapid Transit Co.
Electro-Pneumatic Interlocking.

also, at the same time, establishes a shunt or short circuit between the indicating conductors. These constitute three important features of the indicating system, each constituting in itself an important element of protection.

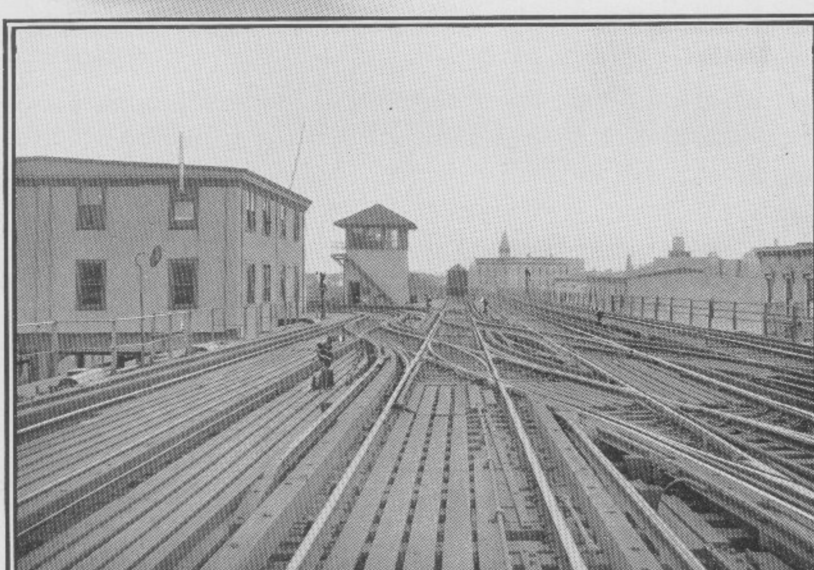
Signal Operation and Control

Each signal of the system is operated by a single acting cylinder, the admission of air to which is under the control of a pin valve and electro-magnet of similar construction to those employed on the valves used for switch operation. Since gravity is employed to return signals to their stop position, double acting cylinders are not required in signal service. The pin valve magnet is connected by wire with its operating lever in the interlocking machine and is energized only when the lever assumes one of its extreme reverse positions. When so energized air is admitted to the cylinder and the signal moved to the proceed position. This movement of the signal opens a contact in a second circuit including an electric lock engaging the signal lever, thereby applying the lock to prevent complete return of the lever to its normal position. Its partial return, however, is permitted, a movement which causes the interruption of the signal circuit, and hence a return of the signal to the stop position. Upon reaching the stop position the circuit including the lever lock is again established and the lock re-energized. This results in the release of the lever so that it may again be placed in its normal position.

Electro-Pneumatic signals may be operated in either two or three positions, upper or lower quadrant, and giving right or left hand indications as desired. They may also be operated without change by lever only, by track circuit only, or by combination of the two.



Kings Highway.



East New York.

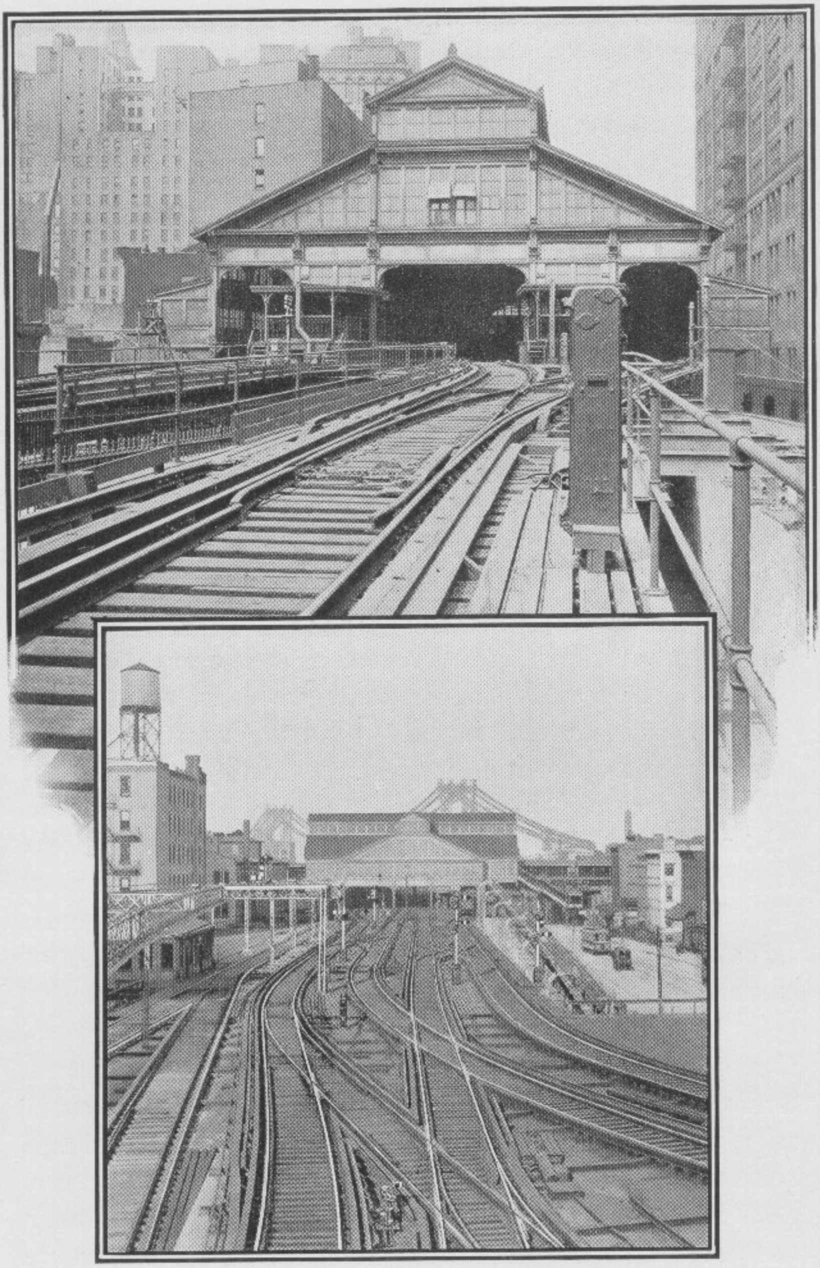
The Transit Development Co.
Electro-Pneumatic Interlocking.

The signals of the Electro-Pneumatic system, like the switches, are operable at any distance from the machine. The speed of their operation, furthermore, is entirely optional. Any number of signals may be operated from a single lever that the peculiarities of the track layout and of the signal arrangement adopted at any place may render permissible from a traffic operating standpoint.

Another protective feature of considerable merit found in the Electro-Pneumatic system, and used only by The Union Switch & Signal Company, is the continuous control of signals by all switches in their route (both facing and trailing points). This insures that after switches have properly responded to their levers, and after signal levers have thus been released for granting train movements over the switches, no malicious, accidental or other unauthorized change can take place in either the switch or its operating lever, or in both, without causing the signals involved to assume the stop position and retain it until the trouble is removed. Signal operation, without this precaution, would be wholly dependent upon the proper action of the indication system that takes place *prior to signal operation* as is the case in other power interlocking systems, and, since such indication systems are not *active* elements of control *except at the instant of completion of switch operation* this added feature of control *insures the continuity of signal control by switch positions at all times.* This protection is accomplished by carrying the current supply to all signals governing over the switch through contact points of the polarized switch indication relays.

Continuous Control of Signals by Position of Switches

This adds no equipment to the system as originally designed and employs for this important detective function *no parts that are active elements* (at other periods of time) *in the indicating system.* It, therefore,



Brooklyn and New York Ends of the Brooklyn Bridge.
The Transit Development Co.
Electro-Pneumatic Interlocking.

constitutes an added *function* of the indicating system, without added complication, rather than an added *system* within itself. This function is popularly known as the "*S. S. control.*" These various features are elsewhere treated more in detail and their operative relations made evident by suitable diagrams and illustrations.

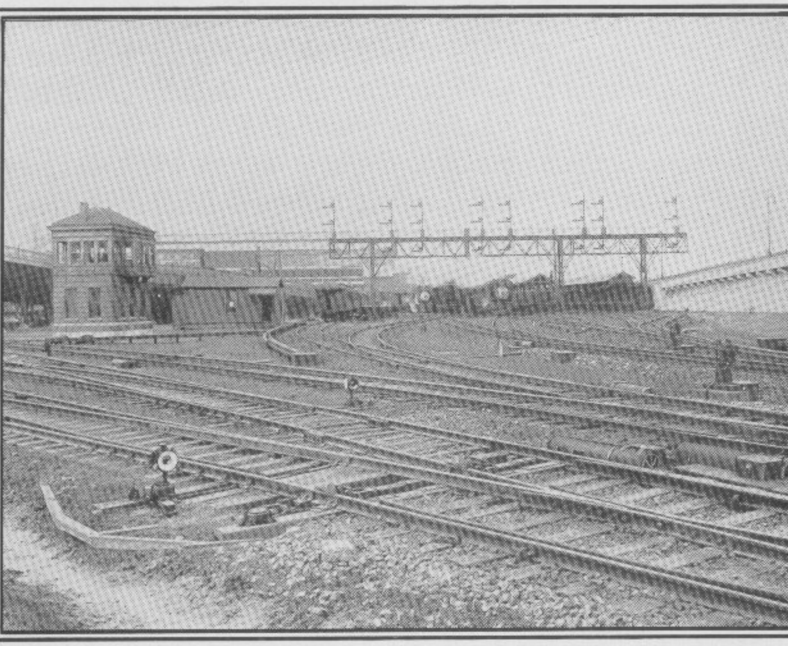
Auxiliary Features

Those elements already described are what may be termed *essentials* of the system. Additional special features are frequently desired or required by the peculiarities of the local conditions under which the system is to operate; the most important of these features may be summarized as follows:

First: The control of signals by trains through the medium of track circuits. This feature of interlocking practice is called "semi-automatic control."

Semi-Automatic Control

It frequently happens, especially when interlockings are located in territory where the blocking of trains is performed by automatic signals, that it is desirable so to control the interlocked signals that trains will act to put them to the stop position on passing them, as in automatic signaling, and this without necessary operation of their controlling levers. When interlocked signals are so semi-automatically controlled they will again clear when the train has passed out of the territory over which the signals control. The clearing of the signal in this manner after the passage of the train may be undesirable, in that, should the leverman fail to restore the controlling lever to normal before the signal had cleared, a following train might accept the signal when it was desired to hold the train. To prevent this, signals are usually controlled as stick "semi-automatic," in which case one of the track circuit controlled relays is wired as a "stick" relay, which after being opened by



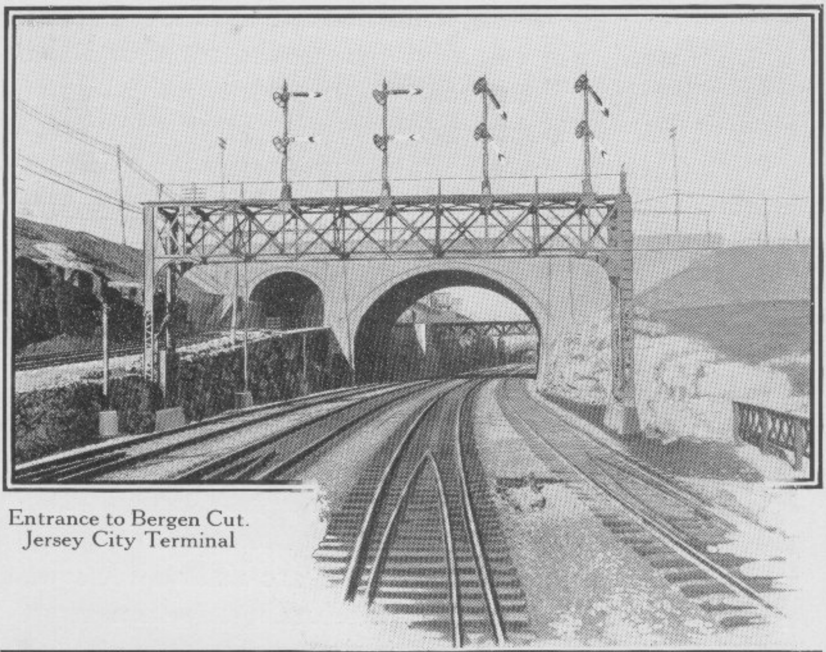
St. George Terminal, Staten Island, N. Y.
The Staten Island Rapid Transit Co.
Electro-Pneumatic Interlocking.

action of a train on the track circuit would not again pick up until the train had cleared the route and the controlling lever been restored to its normal position also. Under this arrangement, the leverman is required to operate the controlling lever every time a signal is cleared. The elements embraced in the semi-automatic control of signals are well illustrated on page 151, where its application to a three-position signal is shown. In the electro-Pneumatic system no additional apparatus is required to secure this control nor is a special design of signal or other apparatus required over and above the usual standard equipment.

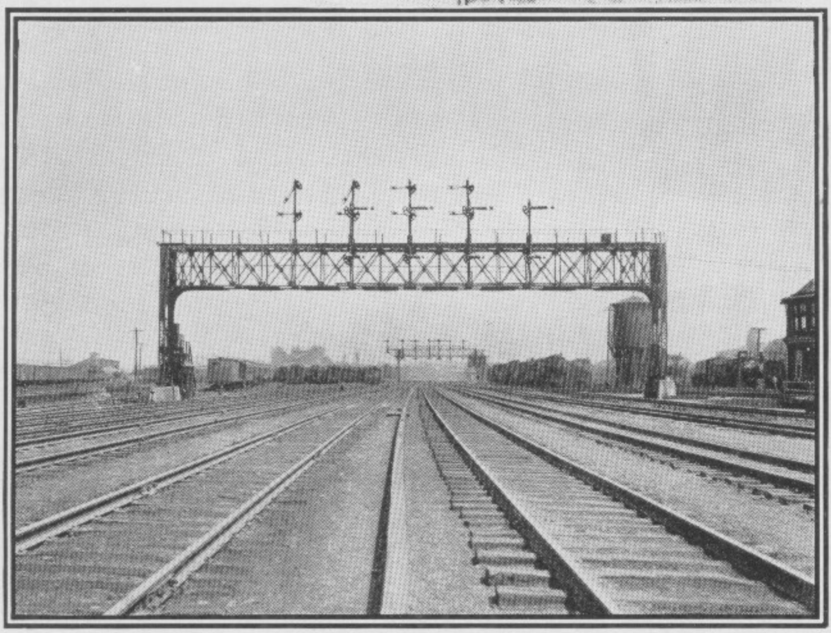
This semi-automatic control of interlocking signals is designed to make impossible the operation of such signals to permit train movements into tracks already occupied by other trains. There are times, however, and especially at terminal interlockings, where strict adherence to this custom is impracticable from an operating standpoint, as when a shifting engine is depended upon to withdraw a coach or draft from a station track or when a road engine is to be backed in against coaches to permit of these coaches being taken out under the regular schedule.

Calling-on Arms

To permit of such movements being made with safety, calling-on arms are frequently employed in conjunction with the signals governing the usual movements of trains. The calling-on arm generally used is of the usual type giving the indication of "proceed at low speed," and is operable from the machine only when the usual signal governing high speed movements is in the stop position, its lever reversed, and an auxiliary device actuated by either the leverman or the directing despatcher in the tower. This auxiliary device in the Electro-Pneumatic System is in the form of a self-latching push button which, when once depressed to clear the signal, retains it in this position until the



Entrance to Bergen Cut.
Jersey City Terminal



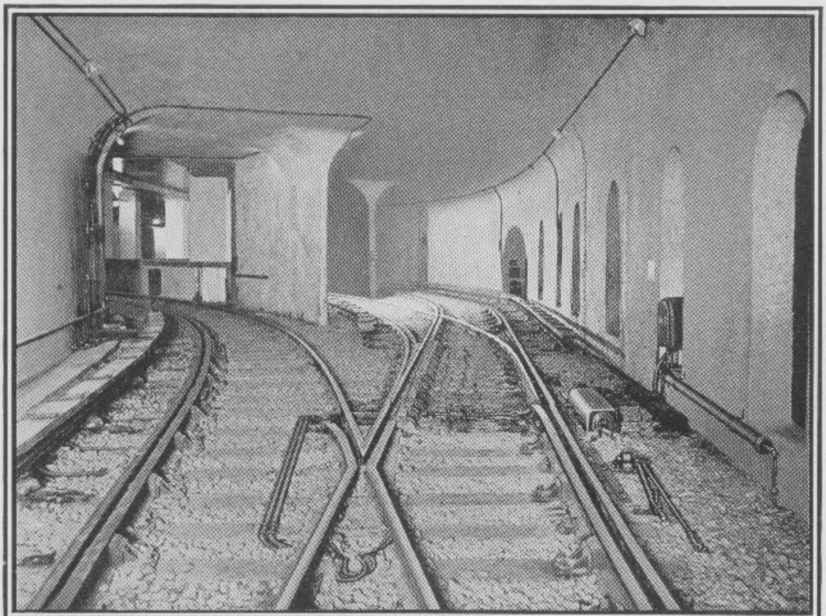
Jersey City Terminal. Electro-Pneumatic Interlocking.
The Erie Railroad.

signal lever, in being moved to restore the signal to the stop position unlatches the push button. Subsequent operations of the lever produce operations of the usual high speed signal only provided external conditions permit of its operation. If they do not, the calling-on arm may be again employed by joint action of the lever and the push button as before.

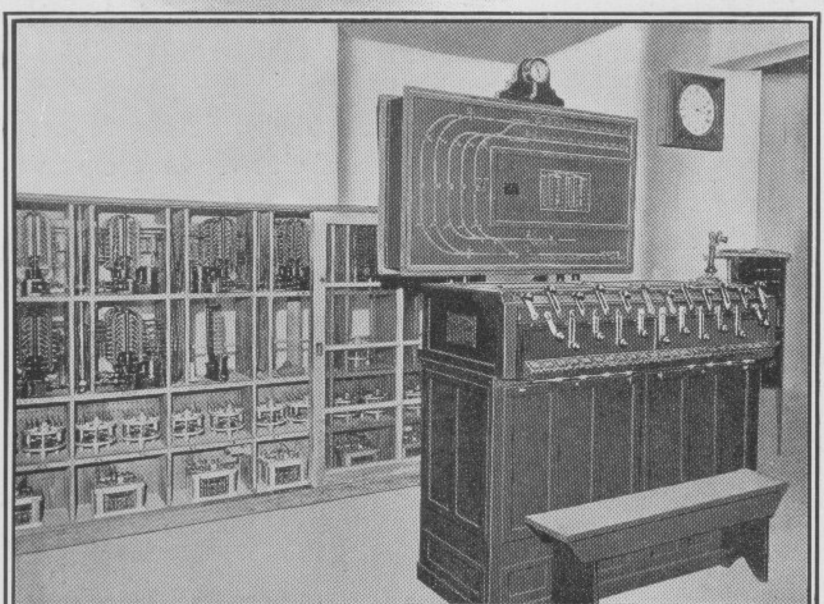
If, after the calling-on arm is cleared in this manner, the condition preventing the clearing of the usual high speed signal is no longer active, the indication displayed by the calling-on arm is nevertheless continued. This is done rather than incur the automatic changing of the indication in the face of a train.

Second: The automatic and simultaneous locking, electrically, of all switch levers involved in a route governed by a signal by action of trains in accepting such signals; and the automatic, individual release of each switch thereafter upon passage of the complete train over it and beyond the fouling limits of the track leads. This feature is designated as "sectional route locking." It consists of an arrangement of circuits, relays and circuit controllers in conjunction with the standard electric lock equipment on the levers of the controlling machine which are jointly acted upon by levers and trains to place all of the switches within a route governed by a signal wholly beyond the operator's power to move them from the time a train has accepted a signal giving permission to move over that route until each switch is successively released by the entire train passing completely over it and entirely clear of the fouling points embraced in its track leads, whereupon the restoration of the signal lever to normal permits the release of each switch in sequence.

Section Locking

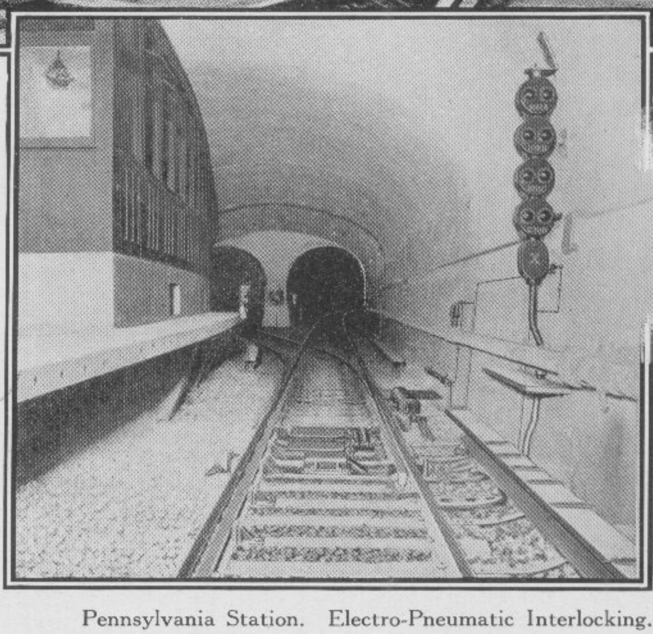


Courtlandt St. Approach.
Church St. Terminal.



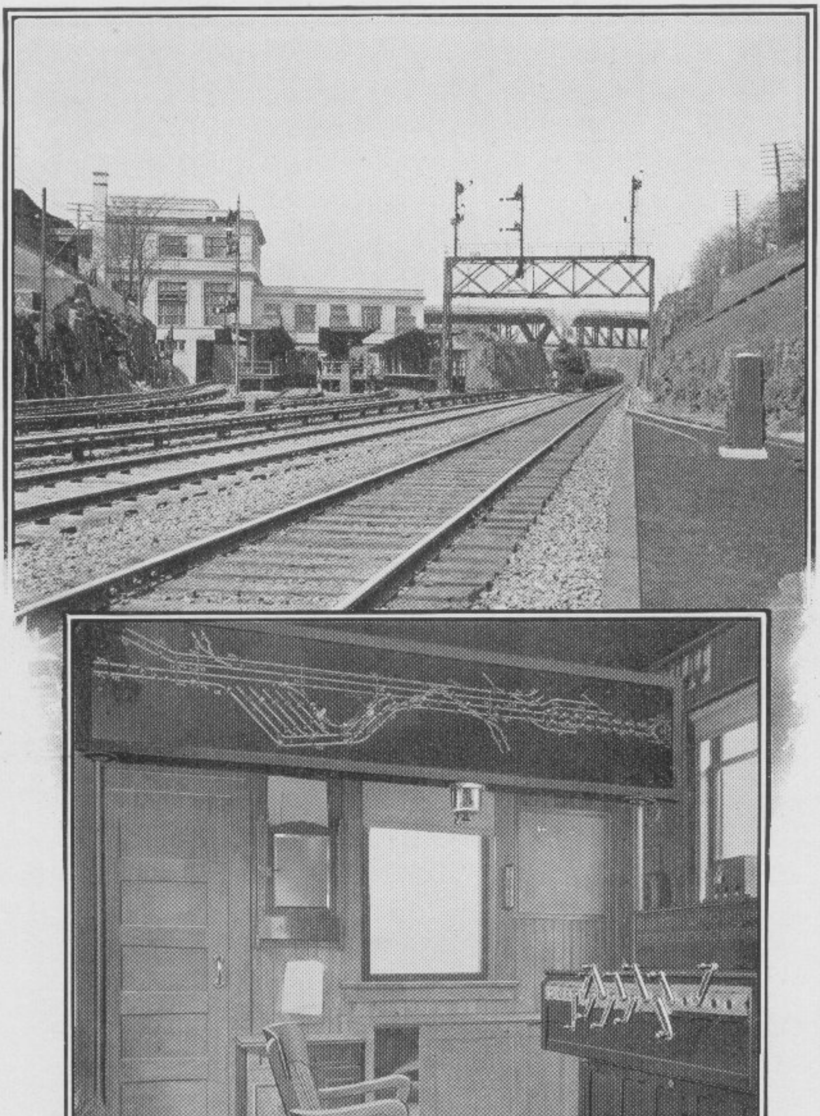
The Hudson & Manhattan.
Electro-Pneumatic Interlocking.

Henderson St. Coach Yard.



Pennsylvania Station. Electro-Pneumatic Interlocking.

Hudson & Manhattan.



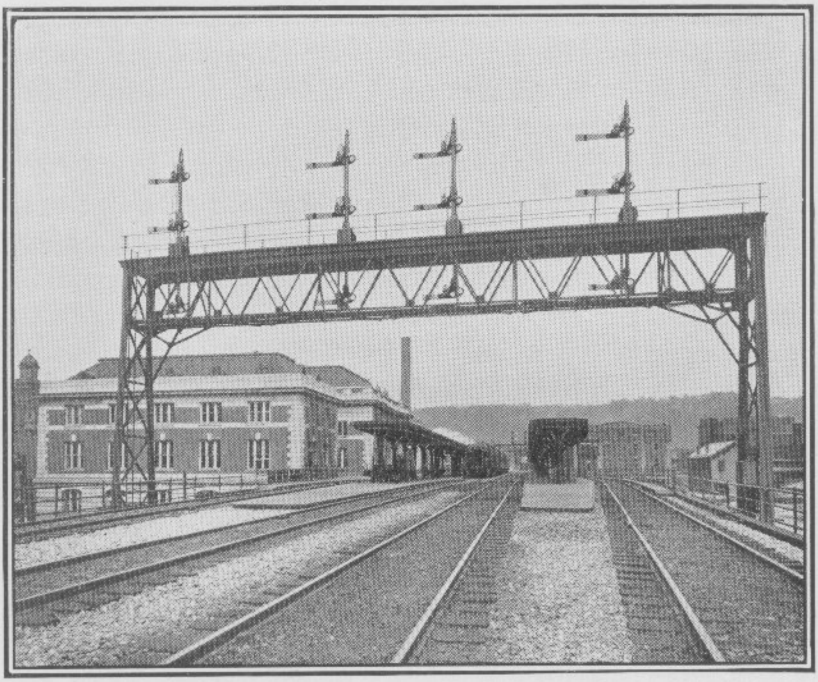
Summit Avenue Station Interlocking. Hudson & Manhattan.

Third: The locking of routes, usually through the medium of the signal lever, by the action of trains approaching an interlocking, is termed "approach locking." It is usually accomplished by opening the circuit of the electric lock of the signal lever by the track relays between the home and distant signal and also by a track circuit in the rear of the distant signal. This prevents the movement of the signal lever to the extreme normal position and, therefore, through the mechanical locking, locks the entire route governed by the signal. This locking is usually automatically released by action of a train passing the home signal, at which time the "sectional route locking" becomes effective.

Approach Locking

It is obvious that this provision may result in delay or inconvenience should it become necessary to change a route because of error in setting it up or from need, during emergencies, of changing the destination of a train after it has accepted a clear distant signal. After the withdrawal of the proceed home signal in such cases, the release of the controlling home signal lever to its normal position must be accomplished by some auxiliary means before the train may be advanced to its proper destination. This is accomplished through the medium of an emergency device known as a "time release." Its operation to release the lock of the signal lever, and through action of that lever the levers operating switches within the route, is effective immediately to restore the home signal to the stop position regardless of the position of its controlling lever, but its action to release the electric lock is not instantaneous, requiring a period of one to three minutes, as desired. Obviously, as the restoration of a signal lever to the full normal position can be accomplished in this way only when one

Time Release



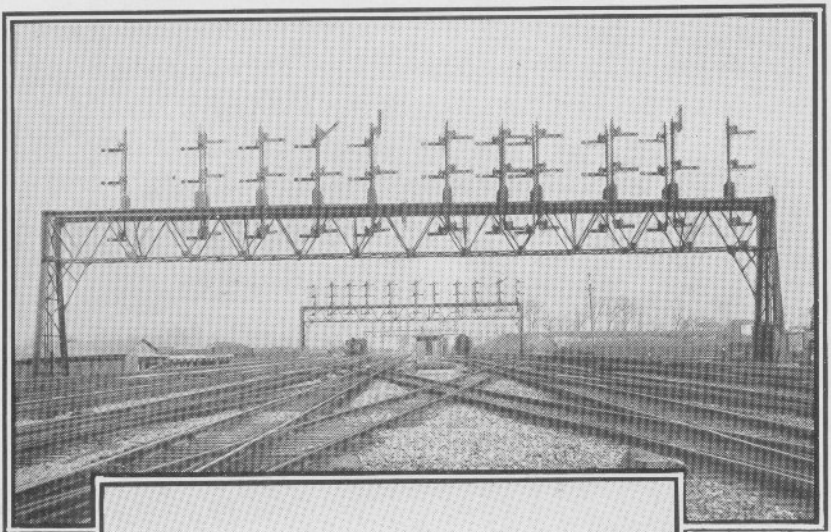
Baltimore & Ohio Railroad.
Electro-Pneumatic Interlocking at the Wheeling Terminal.

minute or more has elapsed after the proceed signal has been withdrawn from a train, the change in position of a signal would either have been observed in sufficient time to come to a stop or to have passed safely through the interlocking. Thus the "time release" is a recognized element in "approach locking." At interlocking plants where "approach locking" is installed, it is the usual practice to provide in the interlocking towers visual or audible annunciators, or both, to give the lever operators advance information as to the approach of trains in either direction. These annunciators are easily and simply controlled by the same device which effects the approach locking of signal levers.

Fourth: The intercontrol of signals of an interlocking with those of another interlocking when such signals govern opposing train movements over tracks common to both. This feature is commonly known as "locking between towers" or "check locking."

Check Locking

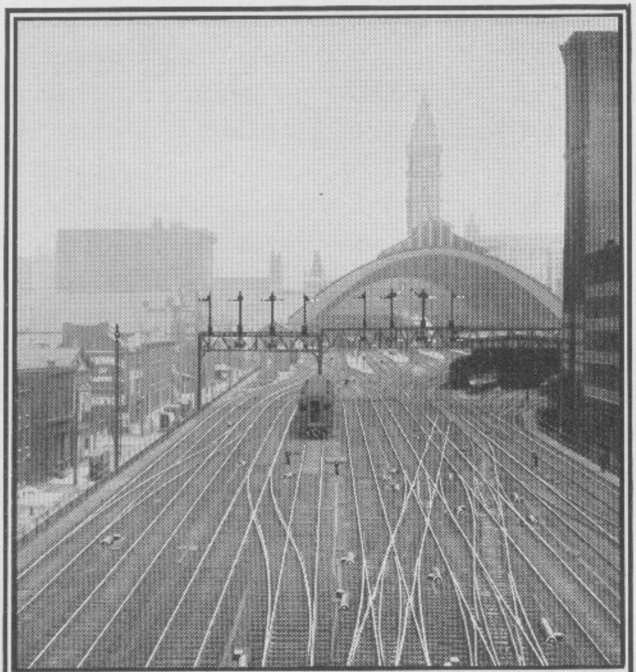
It not infrequently occurs that the tracks uniting two interlocking plants cease to be ample for the needs of traffic between them when the use of each track is restricted to train movements in one direction only. To provide additional tracks for the relief sought is often difficult and always expensive. When such tracks pass through tunnels, city streets and over bridges and viaducts, this remedy is often prohibitive. Certainly, these expedients are not to be thought of, until the full capacity of the existing tracks is utilized and found inadequate. The first step taken to determine the full capacities of such tracks is to operate traffic over them in *both* directions. Naturally, material relief from this method cannot accrue save where the forced operation of traffic over each in a *single* direction involves a considerable period of time during which one or more of them lies idle for want of traffic of the direction to which it is assigned. When such is the



Electro-Pneumatic Interlocking
at the Washington Terminal.

case, the idle track can, under reverse operation, be employed for the relief of other tracks that at the time are overburdened with traffic. The approach tracks of most of the large terminals operating under the Electro-Pneumatic System are thus employed to great advantage, not only during the morning and evening hours when traffic moves largely in one direction, but also at other times during emergencies, as when under repair, etc. Tracks so operated call for unusual care in the equipment provided for such traffic movements over them. The usual method is to utilize the interlocking signals provided for regular directions of traffic and to control them to the opposing signal of the other interlocking involved. In some cases a separate set of signals for reverse movement at each interlocking plant may be required, depending, of course, upon traffic and track conditions. Means are also provided in both interlocking machines for compelling the co-operation of the leverman at each plant before a change in the direction of traffic over any track can be effected. It is furthermore essential before changing traffic direction that all signals governing the track concerned shall at both interlockings be in the stop position, and also that the track throughout its entire length shall be unobstructed by trains upon it or upon the leads to adjacent tracks within the fouling points of such leads. Tracks so operated are necessarily equipped with track circuits throughout their entire lengths, for it is by this means alone that each train admitted to the track from either direction can both retain the track for its own direction of operation (while within its limits) and protect itself by the automatic operation to stop of the signal admitting it to the track, against following trains.

Broadly considered, this provision embraces the control of the conflicting signals of two separate inter-



Electro-Pneumatic Interlocking at the Broad Street Station, Penna. R. R. Philadelphia.

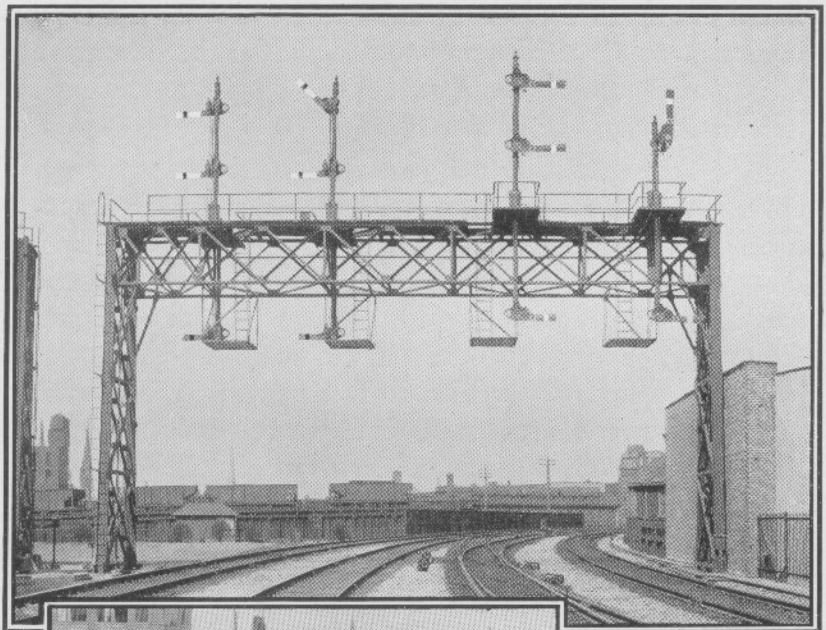
The Pennsylvania Railroad, Philadelphia.

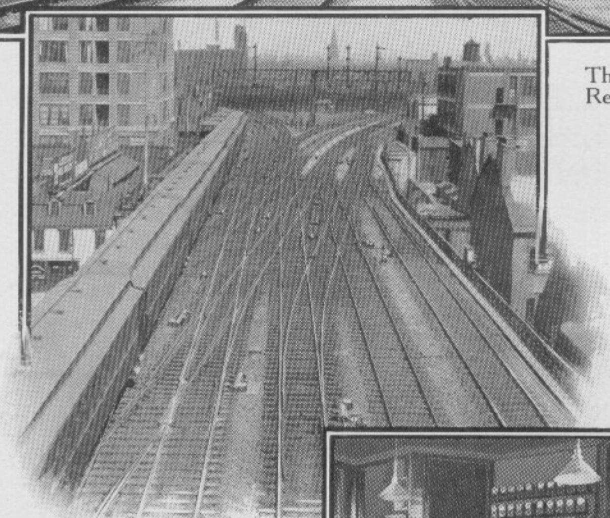
lockings governing the same track, by electrical means in lieu of mechanical means, as would be the case were all of the signals involved operated from a single machine instead of from two.

Fifth: A further provision that has been made a conspicuous feature of both Electro-Pneumatic Interlocking and Automatic Block Signaling Systems, installed on subway and elevated divisions of electric rapid transit railways by The Union Switch & Signal Company, has been the "Automatic Stopping of Trains." Electro-Pneumatic train stops were first extensively installed upon the Boston Elevated Railway in 1900. Four years later they were installed throughout the New York Subways of the Interborough Rapid Transit Company, followed by installations on the subway and elevated lines of the Philadelphia Rapid Transit Company, the subway system of the Hudson & Manhattan Railroad in New York and New Jersey, the tunnels of the Pennsylvania Railroad entering New York City, and the Centre Street Loop, New York City, operated by the Brooklyn Rapid Transit Company.

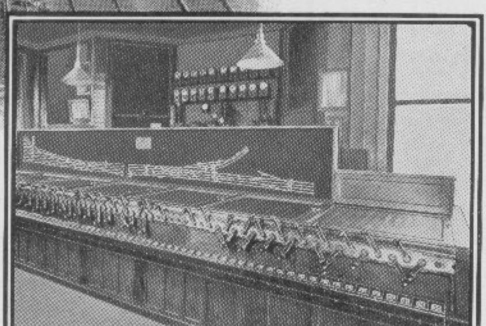
Automatic Train Stops

The stopping of trains automatically by brake action embraces in the brake system a valve responsive to influences transmitted to it from an external source. This response is obtained usually by physical contact between a brake-setting member on the vehicle and a device on the track influenced in its movements relative to the vehicle by conditions considerably in advance of its location. This device, for convenience, may be termed the "tripper" arm of the automatic stop. A tripper arm thus located must bear some definite relation to the fixed signals by which train movements are permitted or prohibited, to serve efficiently its pur-





The Philadelphia & Reading Railway.



Electro-Pneumatic Interlocking at the Reading Terminal, Philadelphia.

pose of stopping trains when engine drivers fail to observe signals properly. This definite relation is determined by the following considerations:

It is customary in both block signal and interlocking practice to regard a stop signal as *a point of danger;* actually the danger may be there or anywhere between that signal and the next one. It is manifestly important, therefore, that *automatic stop devices upon the roadway should be placed "braking distance" away from stop signals*, if trains influenced by them are to be automatically prevented from entering the danger zone. Braking distance depends largely upon the class of train involved, its speed, the grade encountered, and the characteristics of the braking system itself. Generally, it will equal the maximum distance permissible between signals as employed in block and interlocking service. Accepting this, then, as a general fact, the tripper arm of the automatic stop is necessarily placed at or close to the signal preceding the one that governs the zone of actual danger. Obviously, then, the signal adjacent to the tripper arm must also be operated to stop by the same influences within the danger zone that caused the tripper arm and the other signal so to act, for, if this was not done, the tripper arm would set the brakes of a train passing over it under permission granted it to do so by a proceed signal—a conflict of authority not to be tolerated and, hence, a situation to be avoided. By extending the limits of control of each signal so as to include the track governed by the next succeeding signal (a method commonly described as "*overlap*" control) this conflict is avoided completely, and two stop signals are therefore always maintained between a train and the one following it.

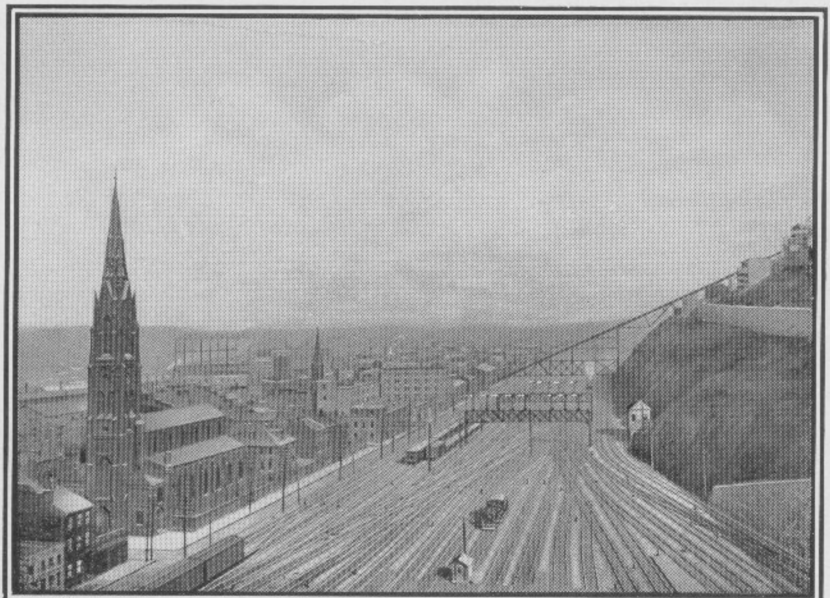
In addition to the *Auxiliary Features* above described, there exist others of more or less importance that pertain to *convenience* of operation rather than to

Electro-Pneumatic Interlocking
on the
Philadelphia Rapid Transit Lines.

safety of operation. A brief summary of the most noteworthy of these follows:

What may be termed for convenience a "working diagram" of the track system is usually placed vertically over the interlocking machine. Two methods are in common use for the construction of this device; one in which the tracks are formed of metal strips that shift positions mechanically with lever movements to correspond with like movements of the switches on the ground; the other employing a sheet of metal in which are cut slots corresponding to the tracks and illuminated from the rear by miniature electric lights that are under train control. The *mechanical* model has been largely superseded by the *electric* model because, whereas the former serves only to render clearer to levermen the positions of the switches at any time, information fairly discernible to skilled levermen from *lever* position alone, the latter serves a distinctly different and much more useful function. This function is to indicate visibly to levermen the condition of the electric locking as affected by trains moving through the track system. As already stated, in connection with *detector circuit and sectional route locking*, the electric locking is applied automatically by the trains physically to restrain lever action under conditions that would render such action dangerous. The information given by the electric track model is therefore solely in the interest of rapid and comprehensive lever manipulation—a means for avoiding useless effort on the part of levermen and of showing the progress of trains through the interlocking when trains themselves are not clearly discernible to levermen—the latter a not infrequent condition to be provided for in modern interlocking installations. While the track model thus serves as a guide to levermen, the service it renders is of a somewhat *general*

Truck Model and Indicators



The Union Station Yard,
Pittsburgh, Pa.

The Jersey City
Terminal Yard.

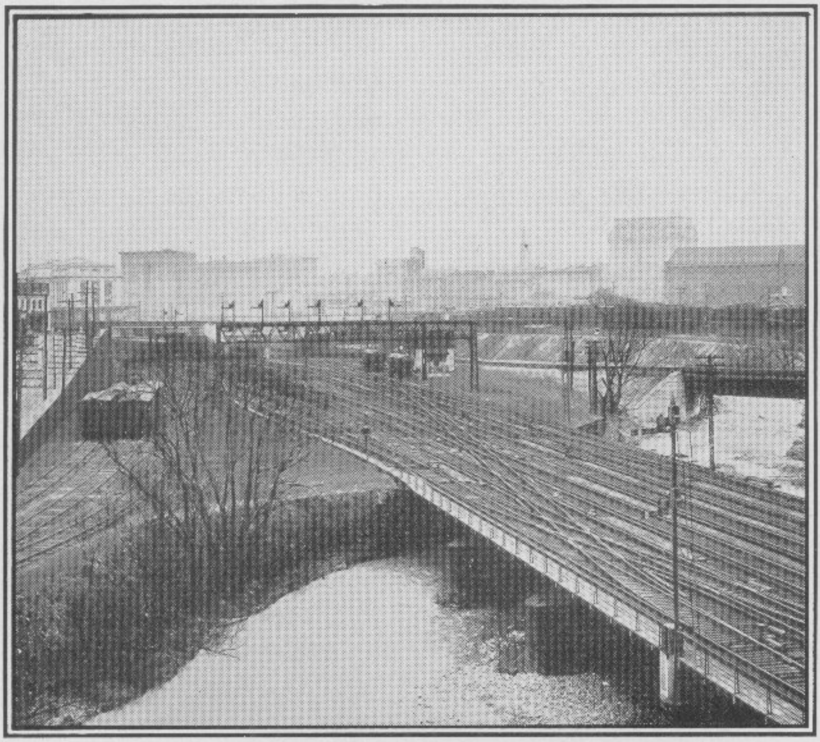
Electro-Pneumatic Interlocking
on the Pennsylvania.

character; involving, usually, more in each indication displayed than is peculiar to the function of any single lever. To reduce to a minimum the mental effort required of levermen in applying the information they thus obtain to the operation of individual levers, a second system of visual indicators may be employed immediately in front of each lever that automatically co-acts with the illuminated track model and conveys, by miniature lamp signals, the information essential at each lever for avoiding attempts to operate them save when their operation is wholly possible and entirely proper.

A compressed air whistle is usually made a feature of Electro-Pneumatic interlockings for use as an alarm when emergencies arise, such as from a derailment or from the over-running of signals by enginemen; the sounding of the whistle in such cases being interpreted as an order for all traffic to stop and stay stopped until again ordered to proceed.

The foregoing represents the more important auxiliary features usually encountered in interlocking work, but the Electro-Pneumatic system admirably lends itself to the inclusion of any or all additional features that local conditions may make desirable; such as, for instance, the operation of drawbridges, crossing gates, etc.

The incorporation of the features hereinbefore mentioned requires, in the Electro-Pneumatic system, no departure from structural apparatus in the interlocking machine or switch and signal mechanisms; standard apparatus being wholly suited regardless of the auxiliary features desired, since these features are accomplished solely through the medium of the circuits. This is one of the many advantages present in the system. In no other system of power interlocking can



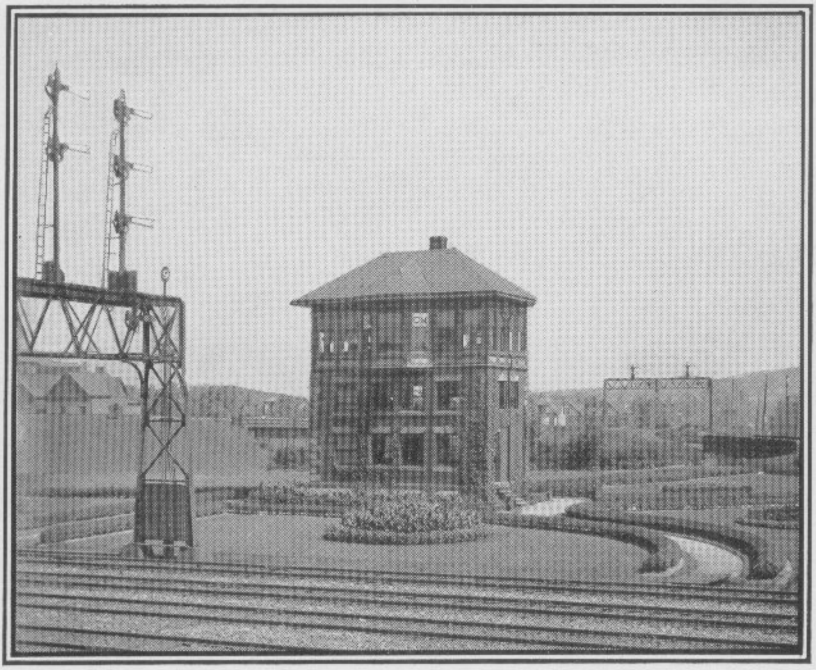
Baltimore Terminal Yard.
Pennsylvania Railroad
Electro-Pneumatic Interlocking.

auxiliary control be introduced with the same simplicity and safety, as in the Electro-Pneumatic system.

Why Use Compressed Air?

The combination of compressed air as a working force and electricity as a controlling medium found original expression in the Electro-Pneumatic interlocking system fully thirty years ago. It has since been employed in other fields with marked success. Noteworthy among these is the operation of train brakes by air pressure electro-magnetically controlled, as in the quick-acting brake system now performing such wonderful service in the field of train control.

The use of two kinds of power, as employed in the Electro-Pneumatic Interlocking System, must be supported by a more substantial reason than mere novelty or commercial expediency. It must possess a value based upon the especial fitness of each power used for the separate duties assigned it. Until this fact is made evident, the practical mind must naturally raise the questions: Why employ compressed air at all? Why, since electricity is an absolutely essential element of the system, and is relied upon so completely for most of the duties of the system, is not its use extended to include, also, those functions that are assigned to compressed air? The users of Electro-Pneumatic interlocking need no answer to these questions; the difference between performing the *operation* of switches and signals by compressed air and its performance electrically, *in the same period of time,* is obvious to them. To those unfamiliar with the subject, we commend for consideration the facts, that electric brakes are practically unknown in railway transportation, and that the highest development of the art embraces the control of air brakes by electro-magnets in precisely the same



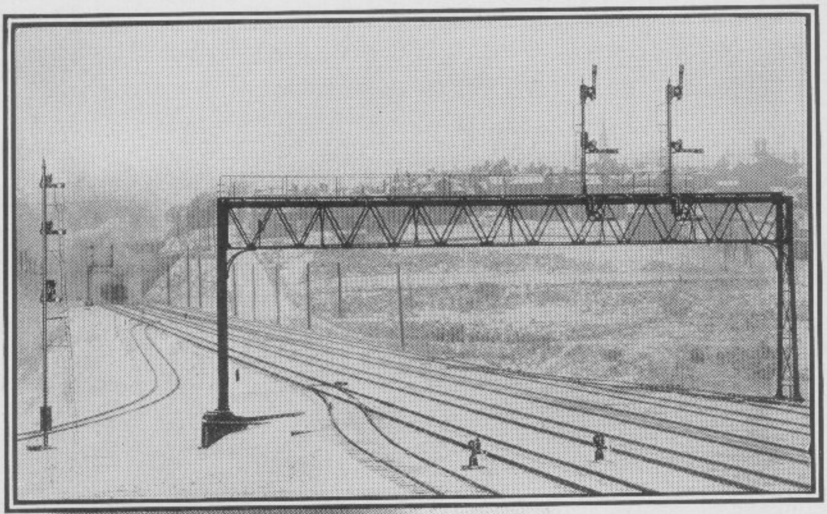
Electro-Pneumatic Interlocking,
"CM" Cabin, East Liberty,
Pennsylvania Railroad.

manner as in the Electro-Pneumatic system, the operating cylinders of switches and signals are controlled.

The use in the Electro-Pneumatic System of simple cylinders for switch and signal operation as against the use of electric motors for like duty in purely electric systems gives to the Electro-Pneumatic System one of its chief advantages—the advantage of extreme simplicity, accessibility and durability in their design and application—characteristics in keeping with those of the other elements of the roadbed with which they are associated. Second only to this important advantage is that arising from the ready control, in a simple and effective way, of the energy (the compressed air) which they employ without destructive influences either upon the devices controlling it or upon the appliances utilizing it.

What these advantages mean will be fully apparent to those familiar with the application of electric motors and solenoids in other fields to the performance of much work within short periods of time. The destructive arcs and the overloaded condition of conductors that develop during periods of abnormal resistances to the operation of motors and solenoids are totally absent in the Electro-Pneumatic system.

Such work in the Electro-Pneumatic system is performed electrically by the electro-magnets in their control of the operation of both the cylinders and the levers of the system is small indeed by comparison, and is furthermore of a very *constant* character, i. e., it is unaffected by either the *amount of work* normally performed by any cylinder or by an *increase or decrease* in the amount which may arise in service from many causes, such as from sleet storms, variations in switch adjustments, etc. In the operation of the valves of the system, some variations in the load thus placed upon these magnets does occur, but these variations are so



Electro-Pneumatic Interlocking
at Southwest Junction on the Pennsylvania.

slight, even within the range of the considerable pressure variations that are permissible, that they are distinctly negligible factors in both the reliability and in the energy economy of the controlling system.

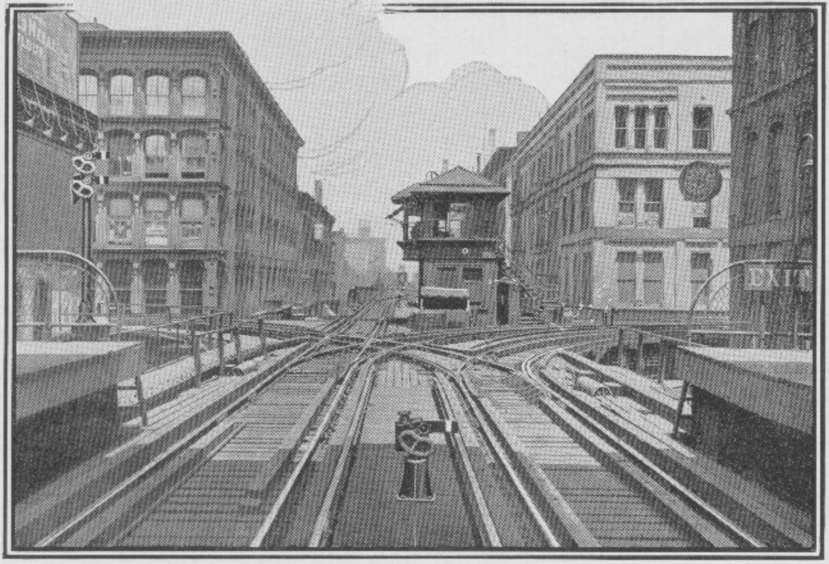
Because of the constancy of the loads thus encountered, the electro-magnets of the system are operable by currents of comparatively uniform volume, while their requirements in the way of energy, for the light duty assigned to each, permit the use of relatively high resistances in them for all purposes without resorting to an e. m. f. exceeding 12 volts. Highly efficient magnets are thus operated effectively for all duties, both upon the machine and at points remotely distant therefrom, through conductors of small and uniform cross-section, and with but insignificant losses of energy in the controlling circuits. Not only does this use of magnets of relatively high resistances insure a minimizing of the losses in the conductors external to them, especially where long distances are involved in their control, but batteries of relatively small capacities are made practicable for the operation of all the magnets of even the most extensive applications of the system without exceeding an initial e. m. f. of 12 volts in the current supply for all. Contacts, furthermore, are never called upon to carry or to interrupt currents of injurious volume or of destructive potential.

Uniform Power Consumption

Comparison Concerning Cost

Comparisons based upon questions of power consumption, of first cost of apparatus, and of maintenance charges derived from some selected plant where all of the conditions are favorable to low cost, long life, and comparative freedom from derangements because of light traffic are usually not difficult to make but are rarely fairly made with the records of installations

Wabash Avenue and Van Buren Street



Lake Street and Fifth Avenue.

The Chicago Union Loop. Electro-Pneumatic Interlocking.

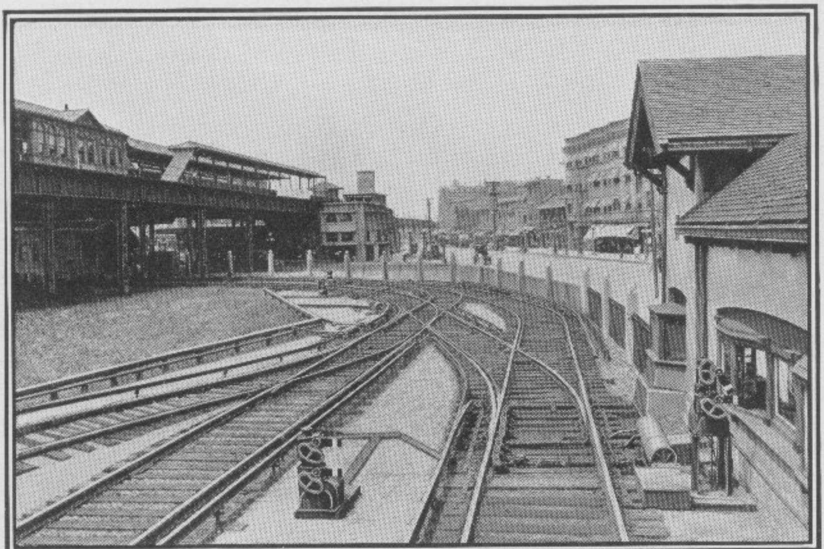
operating under average conditions. These facts, therefore, caused us to omit from this bulletin all such comparisons and to stand for support of the Electro-Pneumatic system upon the broad principles which are embodied in it, that declare *safety* to be *first; reliability* second; *flexibility* third; *durability* fourth, and *cost* last. Nor do we mean by this that the costs of Electro-Penumatic interlockings or of their operation and maintenance would necessarily exceed like costs of other systems of power interlocking applied to the same conditions; each may be greater or less according to prevailing conditions and according to the extent to which the auxiliary protection features herein cited are made a part of it; therefore, no statement affecting costs is undertaken because, without applying to specific conditions, none is truthfully possible.

A few of the Advantages of the Electro-Pneumatic System

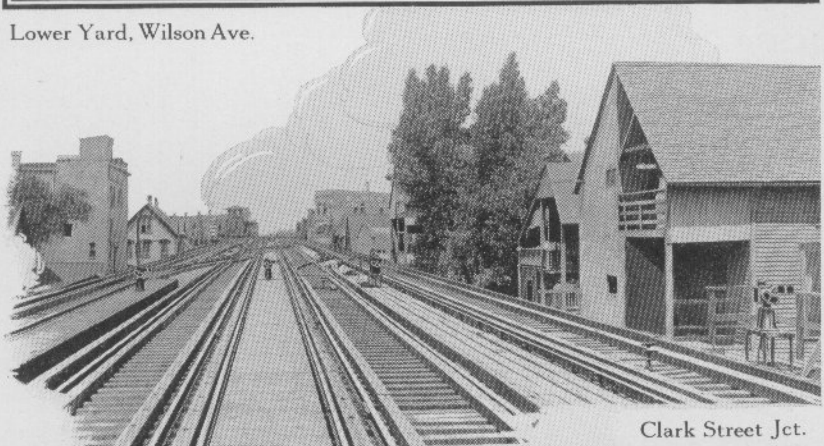
First: The extremely high degree of safety and simplicity in the *indication* system it employs, a system representing the highest development in the art.

Second: The extreme ease with which a large volume of work can be performed in a brief interval of time by a simple cylinder, piston and valve, unaffected by distance, and the control of these devices by simple electro-magnets which use currents of extremely low voltage and volume—an energy readily handled by relatively small contacts. The latter feature is of especial advantage in interlocking machines where the forced concentration of many contacts into a restricted space renders them at best ill suited to the interruptions of currents of great volume and high e. m. f.

Third: From the nature of the appliances used great simplicity, accessibility and durability are obtained.



Lower Yard, Wilson Ave.



Clark Street Jct.

Montrose Boulevard.
Electro-Pneumatic Interlocking on the Northwestern Elevated, Chicago.

Fourth: Because of the very small electrical energy employed by the valve magnets, the smallest operating wires that mechanical considerations render practicable are more than of ample conductivity for avoiding any material drop below the initial e. m. f. of the generator at magnet terminals in the most extensive applications of the system. Wires of No. 16 gauge B. & S., in cable form, are recommended for all purposes excepting for the two main feed wires, which are usually of No. 9 B. & S. gauge.

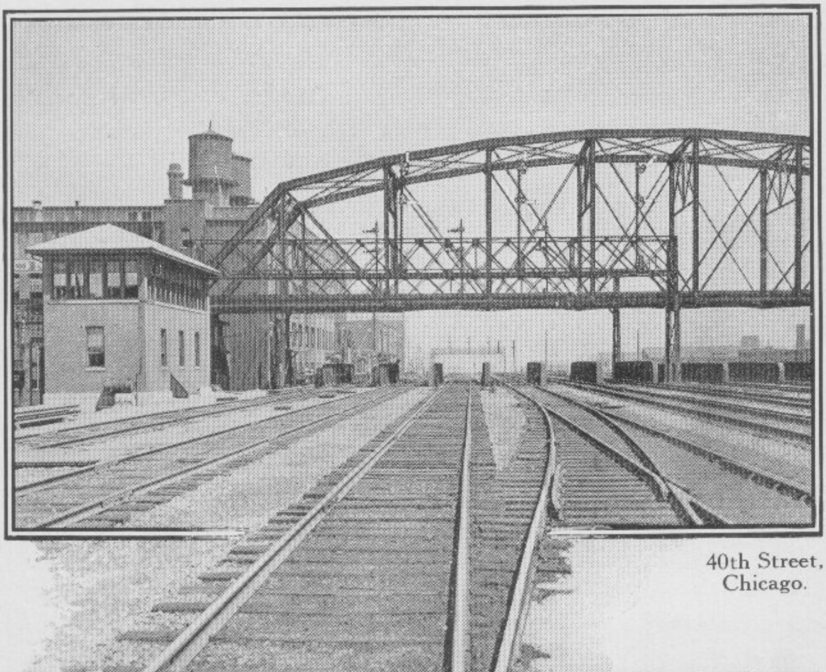
Fifth: The operation of switches and signals by pneumatic cylinders insures long life to the apparatus by reason of their shock absorbing qualities.

Sixth: The method by which the operation of the switches and signals is controlled by the Electro-Pneumatic machine permits the operation therefrom of more switches and signals by a given number of levers than is practicable in any other type. This insures not only economy in the size of the building housing the machine, but also of the ground upon which it stands—frequently a matter of great importance.

Seventh: Rapid handling of traffic is still further augmented through the fact that the operator of this machine may handle more levers without shifting his position than is possible in other types—a fact resulting from the peculiar characteristics of the form of lever employed.

Safety

A decided advantage resides in the very fact that the energy provided for doing the *work* of the system is, notwithstanding its great potential energy (its high pressure and great volume) incapable of adversely disturbing the more delicate features of the system, as



40th Street,
Chicago.

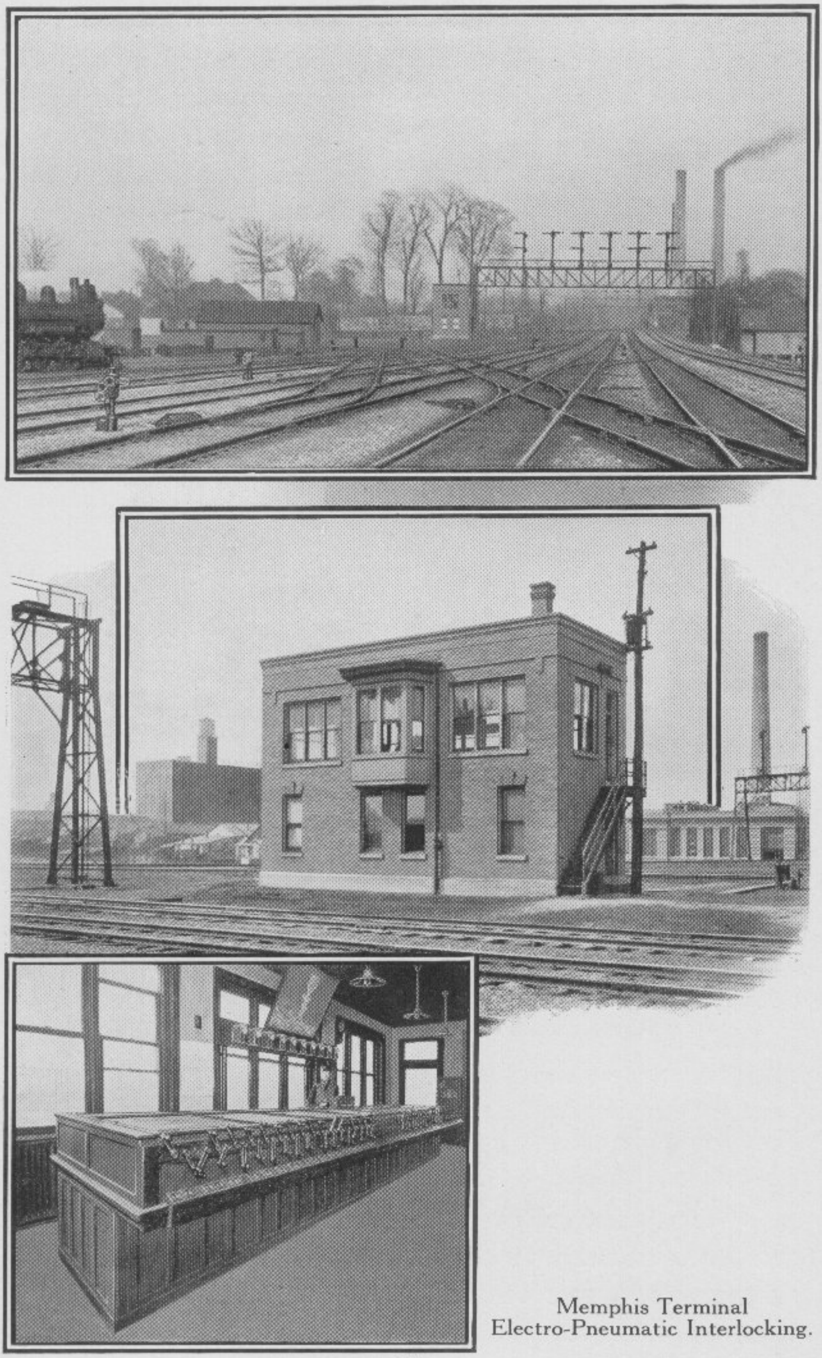
The Chicago & Western Indiana Railroad.
Electro-Pneumatic Interlocking.

these are embodied in its electric control by currents of low e. m. f. and small volume, because that energy is of a wholly different character—one employing conductors and other appliances of a non-electric character. Because of the low e. m. f. employed, grounds, crosses and like disturbances that occasionally develop in all applications of electricity to roadbed equipment are less liable to affect adversely either the insulations and contacts of the system or the proper functional operations of the appliances it embraces. Fuses, cutouts and similar safeguards have never been used in the system to counteract the effects of grounds and crosses, because it has been demonstrated, during 25 years of service at many points, that such provisions are alike unnecessary to its safe operation and to the durability of its insulations and contacts.

The extensive and very successful application of the Electro-Pneumatic system to both interlocking and block signal service where electric traction prevails exclusively, as upon the Boston Elevated Railroad for twelve years, the New York Rapid Transit Railroad for ten years, the Philadelphia Rapid Transit Railroad for a similar period, the Hudson & Manhattan Tunnels and the Pennsylvania Railroad, New York Terminal Station and approaches for approximately five years, affords all the proof that may be reasonably demanded concerning the *safety* of the system and its adaptability to the most adverse conditions under which electrically operated and controlled devices are called upon to perform in railroad service.

Reliability

What better evidence can be presented than reference to the fact that of the many great American railway terminals to which power interlockings have been applied, *over 90 percent of the total number use*



Memphis Terminal
Electro-Pneumatic Interlocking.

the Electro-Pneumatic system exclusively. Most of these embrace such large areas as to involve from two to ten separate but interconnected interlocking plants, each of considerable magnitude, while some also embrace many miles of Electro-Pneumatic automatic block signaling upon their main line approaches.

Actual performances in service fully substantiate our claims, as is evidenced by the following service records of several large and important installations of the Electro-Pneumatic System.

Interboro Rapid Transit

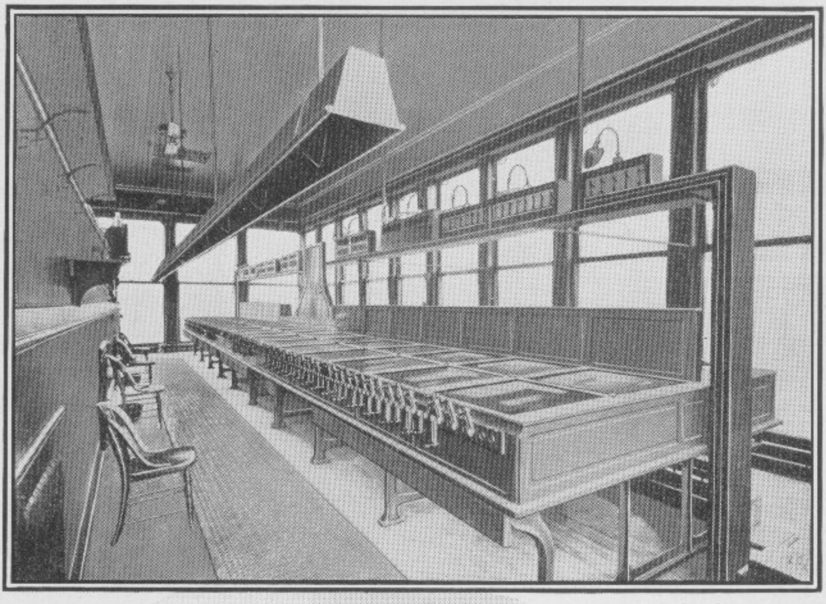
The Subway System of the Interborough Rapid Transit Company has 2072 signaling units and handles an average of 2088 scheduled trains and 1,000,000 passengers every 24 hours. In the year 1913 the number of switch, signal and automatic stop operations was 220,075,253, with but 381 imperfect operations, or one to every 577,625.

Hudson & Manhattan

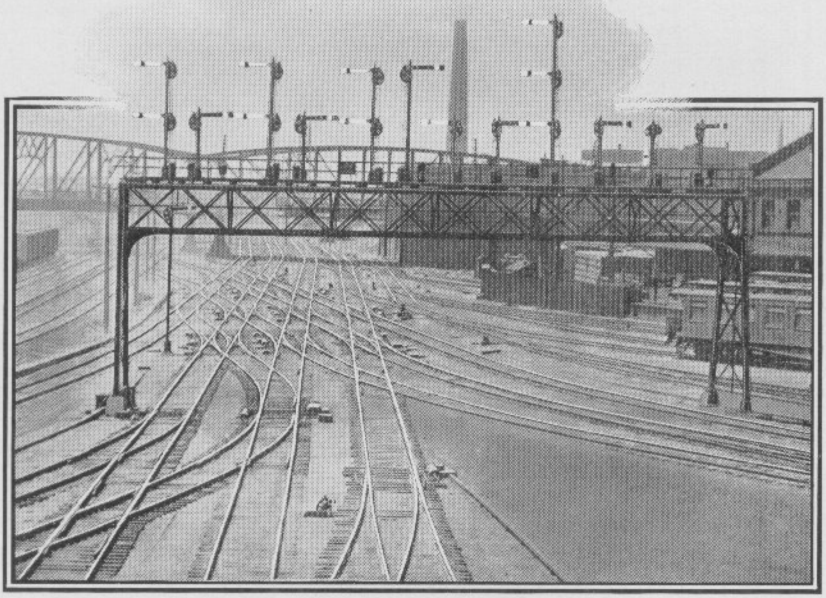
In the subways of the Hudson & Manhattan Railroad (Hudson Tunnels), having 516 signaling units and handling an average of 1761 trains and 180,000 passengers every 24 hours, the number of switch, signal and automatic stop operations totalled 39,580,231 in the year of 1913, with but 52 imperfect operations, or one to every 761,158.

Long Island

Flatbush Avenue Terminal, Brooklyn, N. Y., on the Long Island Railroad, has 85 signaling units handling an average of 352 scheduled trains and 65,000 passengers every 24 hours. In 1913 the number of switch and signal operations were 4,407,375, with 7 imperfect operations, or one to 629,625.



St. Louis
Union Station.



The Terminal Railroad Association of St. Louis.
Electro-Pneumatic Interlocking.

Hoboken Terminal of the Delaware, Lackawanna and Western Railroad, comprising three interlockings controlling 627 signaling units, from April, 1913, to April, 1914, had 28,721,750 switch and signal operations of which but 36 were imperfect, or one to 797,837.

D. L. & W.

The Subway and Elevated Lines of the Philadelphia Rapid Transit Company are protected by eight Electro-Pneumatic interlocking plants and 131 Electro-Pneumatic automatic block signals. From May 1, 1912, to April 30, 1913, the number of trains operated were 133,800. There were 21,617,497 automatic signal operations with 52 imperfect operations, or one to 415,336. In the interlocking plants there were, during this period, 4,466,458 lever operations, with but six failures, or one to 744,409.

Philadelphia Rapid Transit

The Electro-Pneumatic System thus handles the busiest, densest and most exacting traffic in the world.

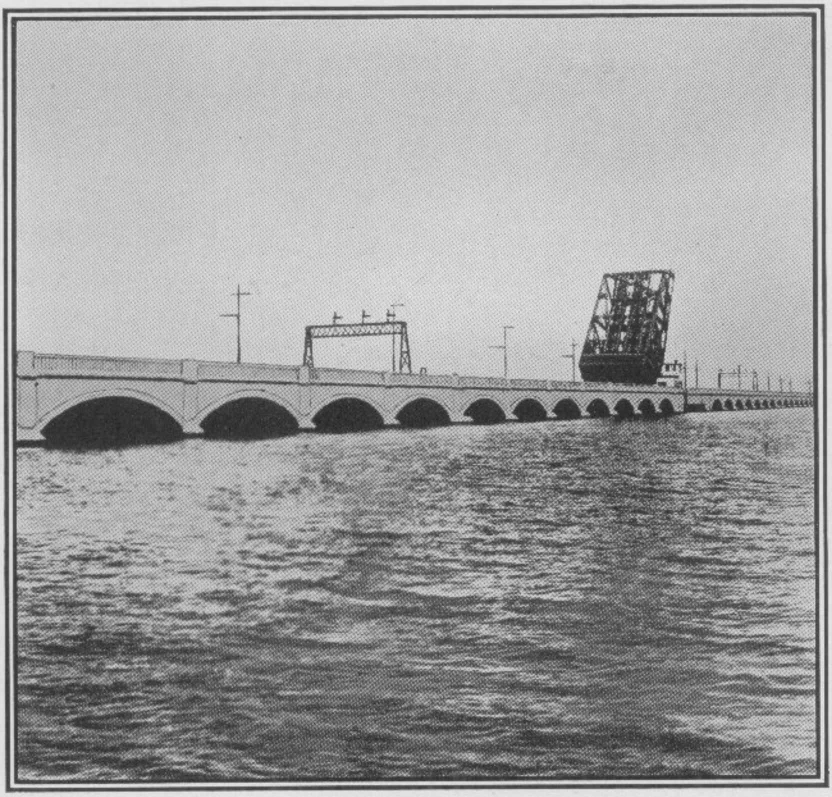
Flexibility

In the matter of *flexibility* the system surpasses every other form of interlocking known, and if it has one dominating characteristic that comparisons with other systems under varying conditions cannot dwarf, this is that one. Speed of operation is optional, and is unrestricted by either the lengths or the sizes of the conductors controlling switch and signal operations; hence, uniform conductors are employed for all functions.

Speed

The capacities of the cylinders used are so proportioned as to meet the different loads that signals, single switches, slip switches and movable frogs impose upon them, thus making a uniform air pressure practicable for all loads, and permitting complete uniformity of equipment in the opera-

Uniformity



The Gulf, Colorado & Santa Fe Railway.
Electro-Pneumatic Interlocking on the Galveston Causeway

ting and controlling elements of the system—an equipment completely interchangeable in its application.

Emergencies

Exigencies affecting the loads represented by switches and signals during winter storms may be promptly met by simply increasing the air pressure of the system until the crisis is over.

Auxiliary Devices

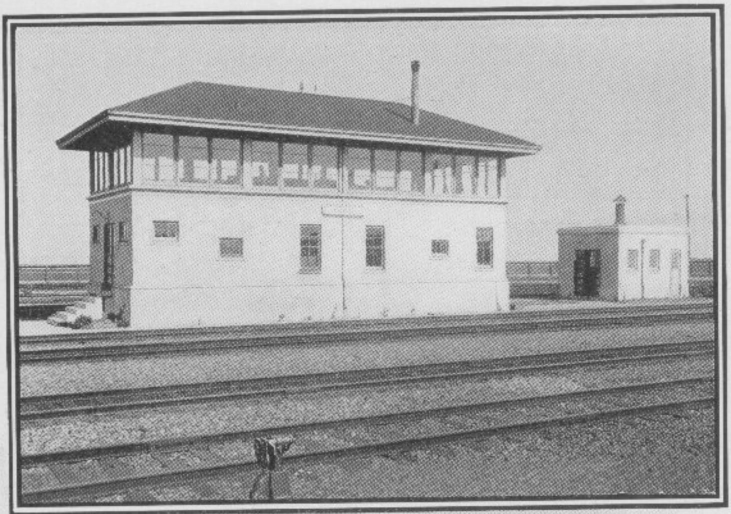
The operation of switches and signals by their cylinders being affected wholly by action of simple magnets of high resistances and employing extremely small currents, control of their operation is readily extended to devices other than the interlocking machine without inconvenience when desired, and the intercontrol of one device by another is unrestricted by conditions involving either distance or the element of time involved.

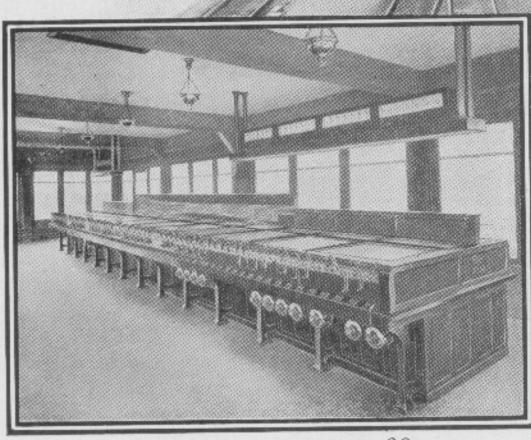
Use Outside Railway Field

So flexible, indeed, is this system that fifteen years ago its several elements were adapted to the operation of the flushing gates of the Moon Island reservoir, that control the sewage of the city of Boston, with excellent satisfaction. A few years later the bells of the blast furnaces of the enormous plant of the Lackawanna Steel Company in Buffalo were also equipped for operation by the standard elements of control of the system with wholly gratifying results.

With Electric Traction

The compactness of the switch and signal operating mechanisms is of especial value where electric traction prevails, because of the ample clearances that are thus obtained with reference to the contacting members of the propulsion system. While it is customary to mount the electromagnetic valves of the system upon the switch and signal cylinders, these may be separately mounted if desired—a feature of value in switch operation where third rails and contact shoes encroach upon the space





Oakland Pier Terminal.
The Southern Pacific Co.
Electro-Pneumatic
Interlocking.

ordinarily used for the valves, and it is also of advantage where signals are not convenient of access or where the valve controlling the signals' movements also controls those of automatic stops and like devices upon the ground.

Durability

This attribute is abundantly manifested by the long service, without material renewals, of many Electro-Pneumatic interlockings installed during the last 30 years. Only a few years ago, a revision of the system installed over 30 years ago at Oakland Pier, Cal. (Southern Pacific R. R.) was made, not because of excessive wear of its appliances, but because of a complete revision and a material extension of the track facilities there. At the congested Union Station of Kansas City, Mo., last year, a new machine was substituted for the one originally installed in 1890; Electro-Pneumatic switch valves being substituted for the type originally employed, not because of any appreciable wear of the latter, but in order that the modern methods of controlling switch operation that the new machine embraced could be fully incorporated—the machine and switch valves originally installed employing hydrostatic pressure for switch valve control. The original switch movements and their cylinders were retained where re-arrangement of tracks was not embraced in the general overhauling, and the original signal movements were also again employed. The air pipe reservoirs and like parts of the pneumatic equipment were also found in a good state of preservation.

Some of the large Installations of the Electro-Pneumatic Interlocking System

Place	Company	No. of Plants	No. of Levers*
Jersey City Terminal and approaches......	Central R. R. of New Jersey..............	17	739
New York Terminal and approaches.	Pennsylvania R. R....	11	733
Phildelphia Terminal and approaches.	Philadelphia & Reading Ry................	11	434
New York Subways....	Interboro Rapid Transit Co................	47	581
Oakland Pier Terminal and approaches.	Southern Pacific Co....	9	463
St. Louis Terminal and approaches.	Terminal R. R. Association of St. Louis.....	7	453
Washington Terminal and approaches.	Wash. Terminal Co. Pennsylvania R. R. Balto. & Ohio R. R. Richmond, Fredericksburg & Potomac R. R..............	7	395
Boston North Station..	Boston & Maine.......	2	214
Boston South Station..	Boston Terminal Co...	3	165
Boston Elevated and Subway Lines.	Boston Elevated Ry...	11	173
Hudson Tunnels (New York—New Jersey).	Hudson & Manhattan..	9	219
Hoboken Terminal and approaches.	Delaware, Lackawanna & Western....	3	237
Kansas City Terminal....	Kansas City Terminal Co................	3	309
Chicago Elevated Lines	Metropolitan West Side Elevated. North Western Elevated. South Side Elevated. Union Consolidated Elevated..........	23	392

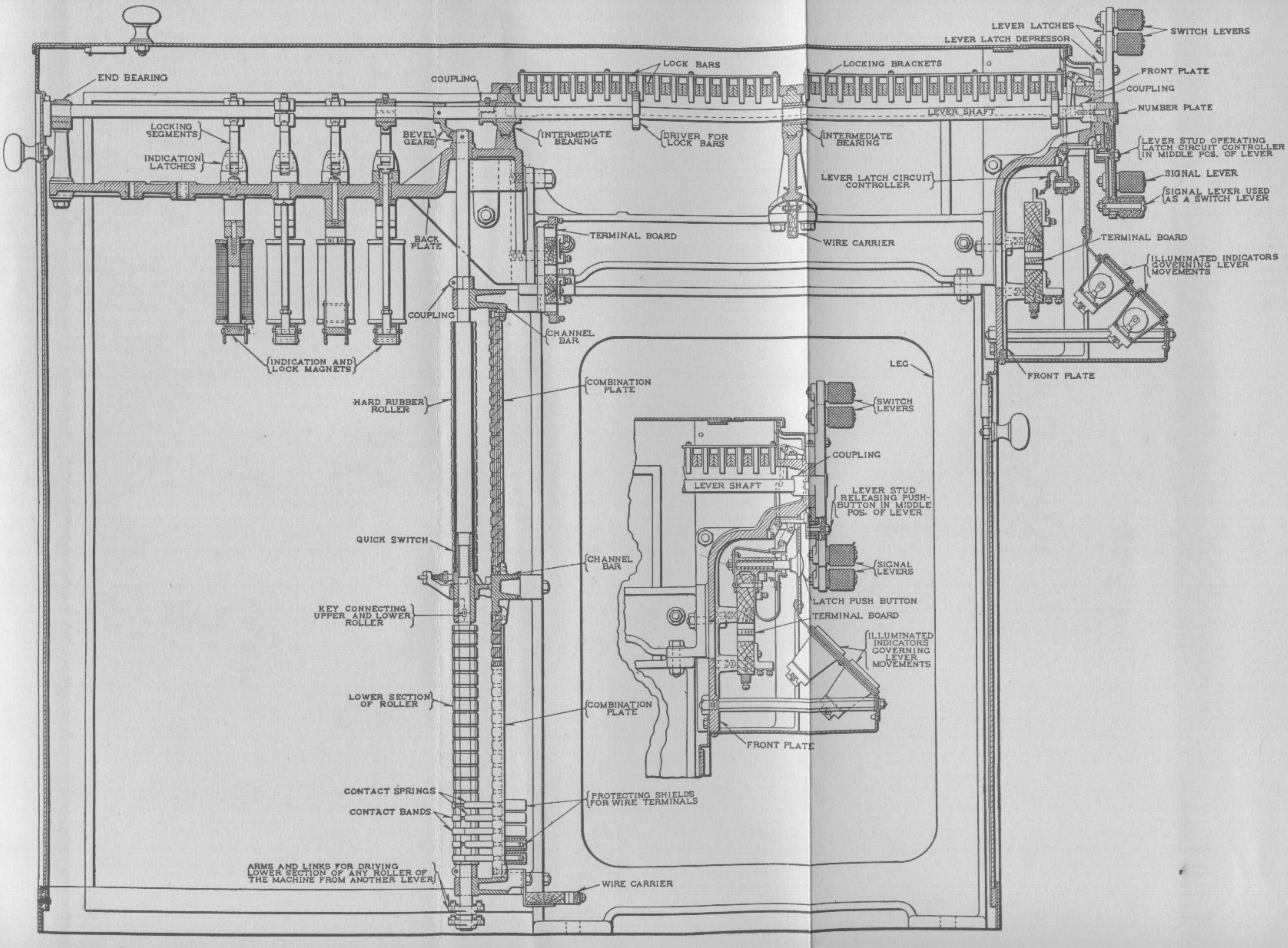
Place	Company	No. of Plants	No. of Levers*
Pittsburgh Terminal and approaches.	Pennsylvania R. R.....	7	401
Jamaica Terminal.....	Long Island R. R......	4	236
Philadelphia (Broad St.) Terminal and approaches.	Pennsylvania R. R.....	1	71
Jersey City Terminal and approaches.	Pennsylvania R. R.....	1	59
Memphis Terminal....	Memphis Union Station Co.................	1	107
Albany Union Station..	New York Central & Hudson River R. R..	3	105
Jersey City Terminal and approaches.	Erie Railroad.........	3	171
Scranton, Pa..........	Delaware, Lackawanna & Western..........	3	121
Brooklyn Elevated Lines.	Brooklyn Rapid Transit Company........	14	153
Phila. Subway & Elevated Lines.	Philadelphia Rapid Transit Co..........	9	70
Baltimore Terminal and approaches.	Pennsylvania R. R.....	4	254
Long Island City Terminal.	Long Island R. R......	2	184
Wheeling Terminal and Junction.	Balto. & Ohio R. R....	2	76
Flatbush Ave. Terminal, Brooklyn.	Long Island R. R......	4	68
St. George Terminal, Staten Island.	Staten Island Rapid Transit. Balto. & Ohio R. R....	2	58
Argo, Washington.....	Oregon-Washington R. R. & Navigation Co................	1	41
Texarkana, Texas.....	Texas & Pacific—St. Louis—S. Western...	1	47
Third & Townsend Sts., San Francisco, Cal.	Southern Pacific Co....	1	107

Place	Company	No. of Plants	No. of Levers*
Grafton, W. Va.	Balto. & Ohio R. R.	1	71
Altoona, Pa.	Pennsylvania R. R.	6	136
Grand Ave., St. Louis, Mo.	St. Louis & San Francisco R. R.	1	95
Nashville Terminal	Nashville, Chattanooga & St. Louis R. R.	1	35
Galveston Causeway	Gulf, Colorado & Santa Fe Ry.	3	93
River Station, Los Angeles, Cal.	Southern Pacific Co.	1	59
Montclair, N. J.	Delaware, Lackawanna & Western	1	41
East End Port Morris Yard.	Delaware, Lackawanna & Western	1	47
South West Penn Jct.	Pennsylvania R. R.	1	59
Baltimore, Md.	Balto. & Ohio R. R.	2	76
Green Spring, W. Va.	Balto. & Ohio R. R.	1	47

Note—The foregoing list of Electro-Pneumatic Interlocking installations does not represent, by any means, the total number of those today in service. There are many other installations on the railroads mentioned and also on many others. Space, however, does not permit of a detailed list of all.

*The ratio of operated units to number of levers in this type of machine is from 25% to 40% greater than in any other type of power interlocking machine.

Fig. 1. Electro-Pneumatic Interlocking Machine Complete.



LEVER LATCHES
SWITCH LEVERS
LEVER LATCH DEPRESSOR
LOCK BARS
LOCKING BRACKETS
FRONT PLATE
END BEARING
COUPLING
COUPLING
NUMBER PLATE
LEVER SHAFT
LOCKING SEGMENTS
BEVEL GEARS
INTERMEDIATE BEARING
DRIVER FOR LOCK BARS
INTERMEDIATE BEARING
LEVER STUD OPERATING LATCH CIRCUIT CONTROLLER IN MIDDLE POS. OF LEVER
INDICATION LATCHES
LEVER LATCH CIRCUIT CONTROLLER
SIGNAL LEVER
SIGNAL LEVER USED AS A SWITCH LEVER
BACK PLATE
TERMINAL BOARD
WIRE CARRIER
TERMINAL BOARD
ILLUMINATED INDICATORS GOVERNING LEVER MOVEMENTS
COUPLING
CHANNEL BAR
INDICATION AND LOCK MAGNETS
LEG
FRONT PLATE
COMBINATION PLATE
HARD RUBBER ROLLER
SWITCH LEVERS
COUPLING
LEVER SHAFT
LEVER STUD RELEASING PUSH-BUTTON IN MIDDLE POS. OF LEVER
QUICK SWITCH
CHANNEL BAR
SIGNAL LEVERS
LATCH PUSH BUTTON
KEY CONNECTING UPPER AND LOWER ROLLER
TERMINAL BOARD
ILLUMINATED INDICATORS GOVERNING LEVER MOVEMENTS
LOWER SECTION OF ROLLER
COMBINATION PLATE
FRONT PLATE
CONTACT SPRINGS
PROTECTING SHIELDS FOR WIRE TERMINALS
CONTACT BANDS
ARMS AND LINKS FOR DRIVING LOWER SECTION OF ANY ROLLER OF THE MACHINE FROM ANOTHER LEVER
WIRE CARRIER

Electro-Pneumatic Interlocking

Part II. Detail Description

Air Compressors, Condensers and Distribution.

FIGURE 2, shows diagrammatically the appliances used for the compression, cooling and distribution of air in large Electro-Pneumatic Interlockings. The compressor is preferably of the motor-driven variety, self-regulated by the pressure developed, and self-regulating in the control of its water-cooling circulation. Almost any of the well-known makes of compressors are obtainable with these features incorporated in the complete equip-

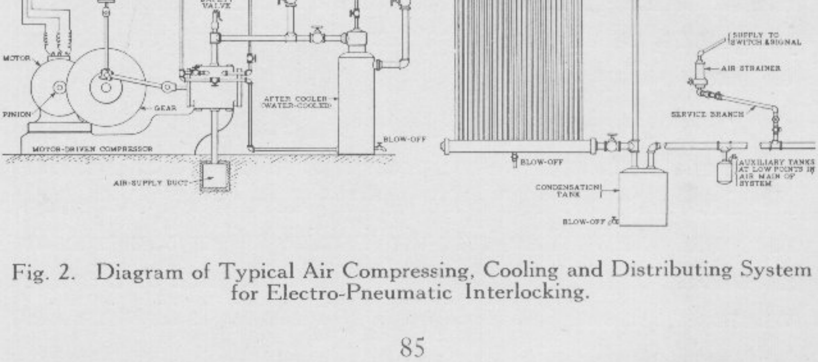


Fig. 2. Diagram of Typical Air Compressing, Cooling and Distributing System for Electro-Pneumatic Interlocking.

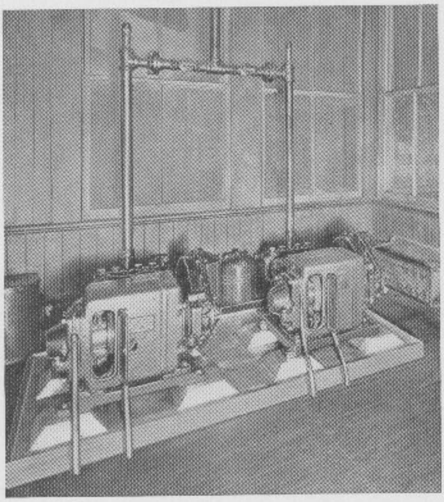


Fig. 3. Motor Driven Air Compressor Plant Using Air Brake Equipment. The Transit Development Co.

ment furnished with them. Capacity in cubic feet of free air per minute, and pressure in pounds per square inch are the governing factors in determining the energy required for compressor operation. In ordering electric-driven compressors it is necessary to specify this capacity, and also the e. m. f. of the energy that is to drive them, if of D. C. character; if A. C. energy is to be employed, the e. m. f. frequency and the number of phases involved are also necessary to the proper motor and control equipment of the compressor. Both the normal pressure that the machine is to maintain and the maximum pressure that it may at any time be called upon to develop, should be stated. Specifications should also state whether single or two-stage compression is desired, where a preference exists, although this may usually be left to the maker's judgment, when the character of the duty involved is understood by him.

Elements

Two stage compressors are, however, always the more efficient, and where pressures in excess of normal requirements are to be frequently demanded these are recommended. The free-air intake of a compressor should be connected, always, by liberal duct to a point where dry, clean and cool atmospheric air is obtainable.

After-coolers of the types customarily furnished with air compressors, as a part of an air compressing plant, employ water circulation through them for reducing the temperature of the air after compression. These vary in form and in capacities with different manufacturers. When after-coolers are ordered with compressors, these features are usually best left to the judgment of the compressor builders.

After-Coolers

After-coolers of the air-cooled type (termed Manifold Condensers), also a desirable element in the efficient cooling of compressed air for interlocking work, are of our own design embracing only standard pipe fittings in their make up. These, too, vary in capacities to meet the needs of the maximum volume of air delivered to the interlocking at any time, and vary in dimensions occasionally to meet peculiarities of their location.

By-passes are desirable around after-coolers of all types, as shown in the diagram to permit of repairs, etc., to these devices, when needed, without necessarily interrupting the compressed air supply to the interlocking system.

Condensation tanks are also essential to each type for collecting the water precipitated by the coolers, and to permit its expulsion to atmosphere by attendants.

A safety valve is located preferably as near the compressor as practicable, but without a valve intervening between it and the compressor.

Accessories

A pressure gauge, preferably connected with the service main where this joins the cooling system, is also essential; its connection thus gives not only an accurate reading of the pressure in the service pipes, but it also avoids the violent action of the index hand of the gauge that accompanies its location close to the compressing cylinders due to the pulsation of the compressors.

A water regulator for maintaining a definite relation between the volume of air compressed and that of the water employed for cooling it is a feature with water cooled compressors of importance where inconstant or intermittent demand for air prevails. This is a feature preferably called for in the specifications of the compressor selected; its design and arrangement being best left to the manufacturer of the compressor, as is also the switch-board equipment for the starting and regulation of the compressor, jointly by the pressure it develops.

The pipes employed throughout the system are preferably galvanized to insure internal cleanliness and maximum durability against the corrosive effects of moisture both within them and external to them. Unions of the flange type are used in the air main and brass screw-unions for the smaller branch pipes; brass valves and cocks are used in the air main and its branches. Contraction and expansion in the air main may be met by use of return bends or by slip expansion joints where compensation is needed.

Pipe and Fittings

Drainage of the pipes of an interlocking system is of importance notwithstanding the influence of after-coolers, since these cannot under all atmospheric changes, precipitate all of the moisture contained in the compressed air passing through them. Some moisture will, at times, be deposited within the air main but rarely, if ever, need this occur disadvantageously in branch pipes where due regard for drainage of the main has been observed in its application by the introduction of condensation tanks at low points therein. These tanks should be connected to the under side of the main. Branch pipes, furthermore, should be connected to the upper side of the main. By this method condensation within the main can never enter the branch lines (if condensation tanks are properly blown off periodically), and such condensation as may occur within branch pipes will be solely from that amount of air which is conveyed by them to the individual switch and signal operating mechanism. The air thus used is not only intermittent in its flow but the flow is of short duration and the volume small; the flow is also of relatively high velocity—especially is this true in switch operation. The small volume of air thus conveyed by a branch pipe every 24 hours not only contains but little moisture but its velocity, when flowing, tends to carry with it any moisture that it may have deposited during the period of no flow. To avoid an objectionable amount of condensation thus reaching the valves of the system and to arrest any particles of sediment that may be within the pipe and carried by the air, a combined sediment chamber and strainer is employed at the terminal of each branch pipe where it joins the operating mechanism. This device is provided with a blow-off cock for expelling the sediment and moisture as collected. The air supply to switch cylinders is through flexible connections, usually in the form of short lengths of armored hose, to prevent track vibrations from causing dangerous stresses within the air supply. A like provision is not required in the air supply to signal cylinders.

Drainage

Electric Generators and Equipment

Electric generators for charging storage batteries are preferably of the D. C. shunt wound type. The direct charging of storage batteries from alternating current generators is impracticable, though batteries may be charged from such generators indirectly by means of rectifiers or by D. C. generators driven by A. C. motors. Duplication of the equipment for charging storage batteries is not essential, although duplication of the batteries them-

Generator and Battery

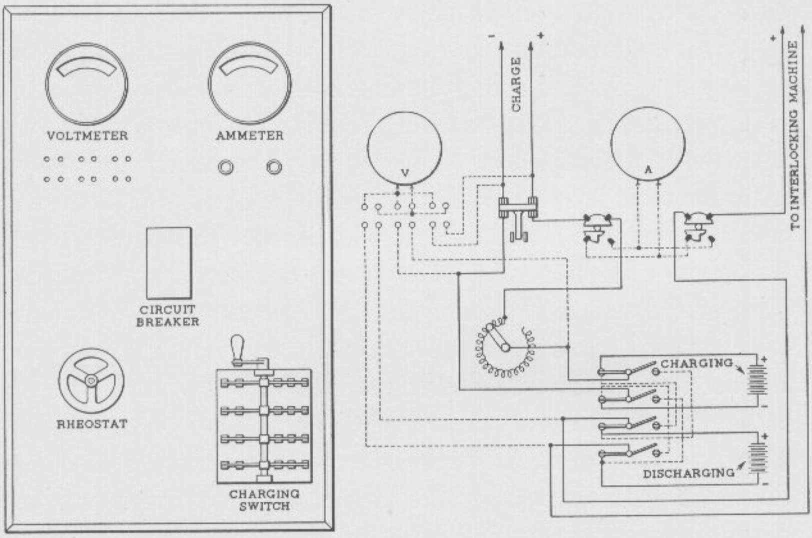


Fig. 4. Typical Switch Board Equipment and Circuits for Electro-Pneumatic Interlocking Charging Plant.

selves is always to be preferred—even though a single set be used that is equal in capacity to both sets of the duplicate arrangement. The most satisfactory equipment embraces not only separate sets of batteries for the circuits of the interlocking proper, but separate sets also for track circuit duty when storage batteries are used for track circuit work. Each set of main battery consists of but six or seven cells of lead or about 12 cells of Edison storage battery, and because of the small number and capacity required, duplication does not materially increase the first cost, while giving the added advantage that the interlocking is never subjected to a greatly increased voltage during charge, especially when the charging current is from a high voltage source. Continuity of service in the event of accident to or derangement of a battery is also assured and reliability enhanced.

The switch-board equipment and the electrical connections by which a duplicate set of storage cells are charged and discharged independently as service demands are shown in Fig. 4. A single ammeter and voltmeter are adapted to individual use in the various circuits by the attendant since conditions rarely call for the taking of simultaneous readings of the same character in this class of service. Automatic cutout switches are inserted to insure disengagement of the charging battery from the generator, should the e. m. f. of the latter fall below that of the former, or rise dangerously above it from any cause. Many other methods are practicable, each capable of modifications in many ways, and the method here shown is intended primarily as a suggestion since the arrangement best suited to any interlocking is a matter governed by many local conditions affecting power economy, such as cost of attendance, initial power cost and the emergency operation to be provided for.

Switch Board

Storage batteries are as a general rule used for the supply of current to power operated interlockings where direct current is employed for the circuits thereof. Primary batteries are applicable to this service, too, but the frequency and rather high cost of their renewals render them less advantageous than storage batteries where a considerable current discharge from them is called for.

Primary Battery

Because of the use in the Electro-Pneumatic System of electro-magnets exclusively, where in purely electric interlockings electric motors are used, there is never in the former an increase of more than 10% in the volume of current normally discharging from the battery; however many switches or signals may be operated simultaneously. In electric interlocking, because of that property inherent in electric motors which requires heavy initial currents through them to develop the torque essential to the performance of the work assigned to them in the time available, the operation of many switches simultaneously, or the failure of motors to rotate because of excessive loads, involve a demand for current that greatly exceeds the rated capacity of batteries that are wholly suited to the demands of the system when at rest. Batteries of extreme capacity are hence essential in such systems to avoid injury to them and curtailment of their life.

The external conductors employed in the Electro-Pneumatic system in all cases, exclusive of the two main feed wires which extend from one end to the other of the track system, are employed for the energization of electro-magnets exclusively. The ohmic resistances of these magnets being high, the currents are of very small volume and hence there is an inappreciable loss of energy in conductors. Because of the low e. m. f. used, the insulation of the conductors is furthermore subjected to neither high electric stresses by working currents, nor to high temperatures resulting from excessive currents due to short circuits that occasionally occur accidentally at terminals of magnets and like exposed conductors during repairs or inspection.

Magnet Resistance

Electro-magnets employed for the operation of the pin valves of switch and signal movements are wound to a resistance of 400 ohms each. Many of these remain upon closed circuit for long periods, one magnet for each switch always, and one for each signal during its display of proceed. Electro-magnets adapted to the control of lever movements at the machine are wound to 130 ohms each because of their heavier duty, but these are energized for very brief periods only so that the greater currents thus employed by them do not materially affect the total economy of current. The 400 ohm magnets of switches and signals may, obviously, be operated from the interlocking machine through conductors having a total of 40 ohms resistance with but 10% drop, an allowance usually permitted in the general transmission of electric energy. Assuming the switch or signal to be 1000 feet from the tower (an excessive average distance) its operation, with but 10% drop in its external circuit, would be possible with a copper conductor of No. 23, B. & S. gauge. Consideration of mechanical strength, however, prohibits the use of such a wire in this service, and larger wires are employed in practice which practically eliminate all losses in external circuits. This is in marked contrast with the losses that occur in the circuits of the motors of switches operated directly from the levers of electric interlocking machines, where during the very times when the full e. m. f. of the batteries is required to meet abnormal loads the losses in the conductors are from 25 to 40% frequently, notwithstanding that much larger conductors are employed for motor operation.

Size of Conductors

Conductors of No. 16 B. & S. gauge in cable form are well suited to all duties embraced by the Electro-Pneumatic System save those peculiar to the two battery mains. These mains are usually of ample conductivity when wire of No. 9 B. & S. gauge is used in the largest of installations.

The conductors of the system are protected against injury by their arrangement in suitable conduit usually constructed of wood, and placed above ground. Where this is not convenient the conduit may be placed underground.

The Electro-Pneumatic Pin Valve

In Fig. 7 is shown a cross section through the electro-magnet and the pin valve by which the control of pressure to and from the pneumatic cylinders of the system is accomplished. This device constitutes one of the most important as well as one of the most trustworthy elements of the system. In signal operation it controls directly the pressure to and from the operating

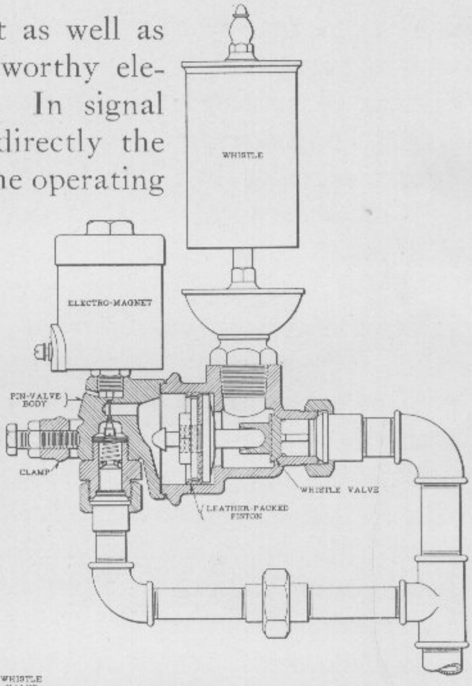


Fig. 5. Electro-Pneumatic Whistle. Magnet Normally Energized.

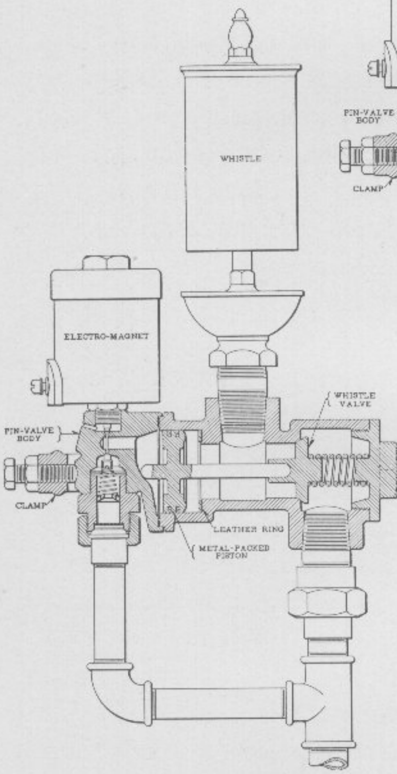


Fig. 6. Electro-Pneumatic Whistle. Magnet Normally De-energized.

cylinder; in switch operation it is not so well adapted to this direct control because of the greater volume of air required by switch cylinders and because, also, of the quicker action demanded of switches. Its modification to meet the demands of direct control in this service would involve the use of much larger pin valves and magnets and a very material increase in the electrical energy required for their operation. For these reasons it is made to control a D-valve, or slide valve, through the medium of two miniature cylinders

Pin-Valve and Magnet

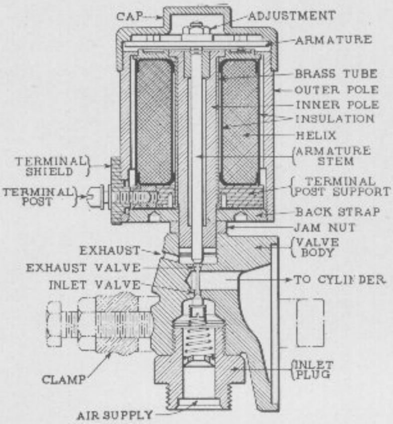


Fig. 7. Cross Section of Pin-Valve and Magnet.

—the D-valve directly controlling the pressure to and from the switch cylinder. It is in a like manner adapted to the blowing of air whistles of large calibre, as illustrated in Figs. 5 and 6.

The magnets employed are of what are designated as the iron-clad type, very efficient, substantial and simple, and operable in exposed places unprotected from the weather if desired. Fig. 8 diagrammatically illustrates the e. m. f. essential at the terminals of these magnets for pin valve operation when the magnets are

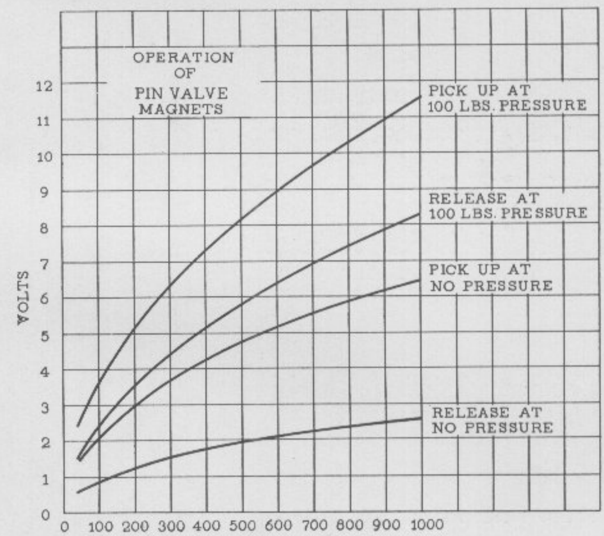


Fig. 8.

wound to any resistance that is practicable. The upper curves assume an air pressure of 100 lbs. per square inch to be acting upon the valve. These curves correspond to those which represent the "pick-up" and the "shunting" points as these

Magnet Operation

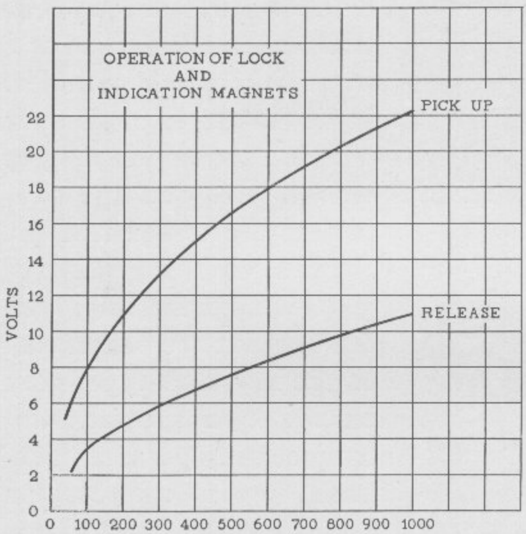


Fig. 9.

are commonly understood in the specifications of relays. Fig. 9 shows diagrammatically the characteristics of those magnets, Fig. 10, which are used for locking and indicating duty on the machine; these do not embrace the control of air pressure as is evident, and the curves are correct for armature strokes of 5/32″ only—a stroke customarily used for electric locks of Electro-Pneumatic interlocking machines.

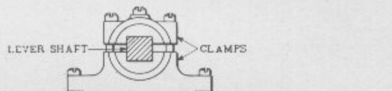


Fig. 10. Cross Section of Indication or Lock Magnet.

The Interlocking Machine

The purpose of the interlocking machine, its character and its functions being broadly understood, a detailed description of its construction and the relations of its elements to those appliances which are external to it and which, to some extent, control its manipulation, are next in order. Preceding this explanation, a brief recital of the acts performed during switch and signal operations by levermen as these are influenced by switch, signal and train movement will contribute toward a clearer understanding of the machine as a whole and of its functional parts.

The complete operation and locking of a switch (from either of its two positions) are effected in this system, as in all power interlocking systems, by a partial (preliminary) movement of its lever, the complete (final) movement of the lever being impossible until the proper response of the switch to the preliminary lever movement occurs. Two systems of circuits are employed for these purposes; one for effecting switch operation, and one for releasing the lever thereafter for its final movement; the latter being known as the indication system.

Switch and Signal Operation and Indication

The complete operation of a signal from stop to proceed is effected by a continuous, complete lever movement, but its operation from proceed to stop necessitates two movements of the lever; a preliminary movement for interrupting the power supply to the signal, and a final movement that can be made only when the signal, so deprived of power, returns fully to the stop position. The operation of switches and signals thus involves the opening and closing of electric contacts during lever movement and at definite points in the lever's throw. The control of lever movement by switch and signal position (which also embraces this contact control) necessitates the use of electric locks upon the machine which permit or prevent lever operations according to the energized or de-energized state of their magnets. Control of these locks is not restricted solely to switch and signal operation, train action being also at times a factor in it.

Fig. 11a, represents the several positions occupied by a switch lever at important times during the operation of a switch from normal to reverse and from reverse to normal. It also shows the formation of the quadrant secured to the front of the machine frame and that of the lever latch carried by the lever, as these, to some extent, are designed to restrict lever movements. It also illustrates means for forcing the lever-latch into engagement with the quadrant at midstroke; a means provided that this quadrant and not the segments of the electric locks will receive the impact of the lever's arrested movement, thus insuring entire freedom of action of the latches of the electric locks when these are to be elevated to release the segment for final lever movement after the indication is received. Incorporated, also, in this figure, but only in a vague way shown, is a stud or pin which co-acts with the latch to open and to maintain open a set of contacts under certain positions of the latch and the lever; this circuit controller and its operation jointly by the lever and the latch will be described in connection with the automatic locking of switch levers by train action through the medium of the electric locks, employed primarily for switch indications. Fig. 11b, represents one of the two segments and latches of a switch lever that are employed jointly for switch indication and detector circuit locking. Fig. 11c, shows diagrammatically the several positions occupied by a switch lever, as already referred to, and the angle of rotation that lever movements impart to the rubber rollers of the machine during lever operation. These rollers move at double the speed of the levers and, hence, their total angular movement is double that of the levers, or 120 degrees. Fig. 11d, shows a section of the hard rubber roller that, while mounted concentrically upon and operated by the roller shaft, is not continuously movable with the shaft, but is restrained from following it during preliminary lever movements by a

Switch Lever

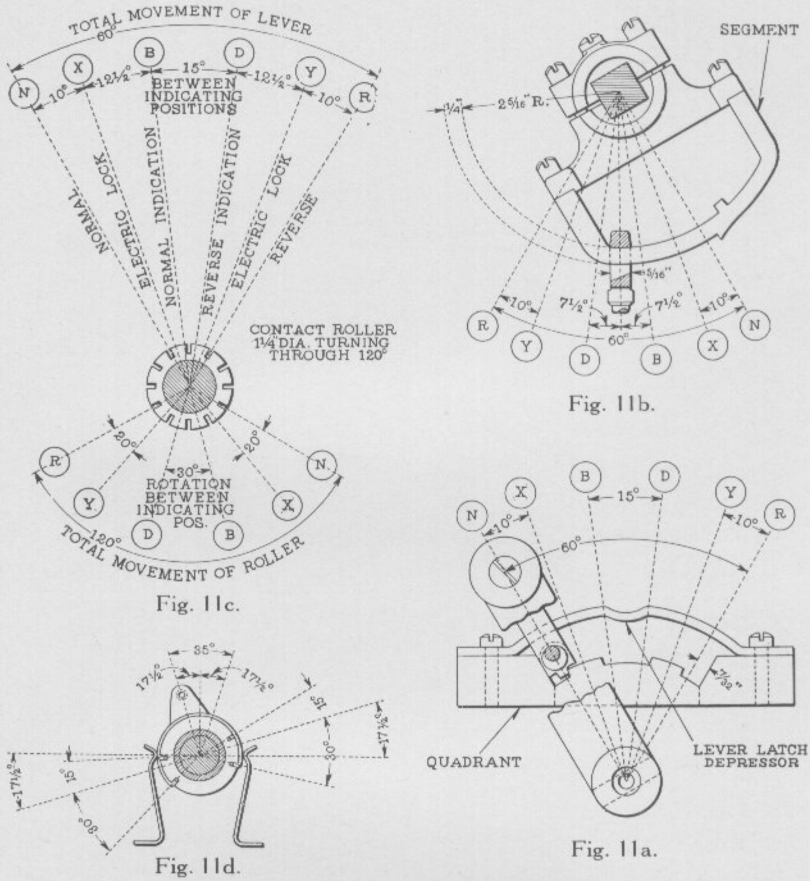


Fig. 11c. Fig. 11b. Fig. 11d. Fig. 11a.

Fig. 11. Diagram of Switch Lever and Operation.

spring actuated toggle and until the final movement of the lever occurs after the indication has been received. This device is embraced in the indicating system and is known as the "quick switch."

Fig. 12 shows like characteristics of the Electro-Pneumatic signal lever. Fig. 13 shows, in perspective, the actual design and relations of the various features of the switch lever, while Fig. 15 shows in like manner those of an Electro-Pneumatic signal lever. Fig. 14 shows a fragmental view of the insulated plate which

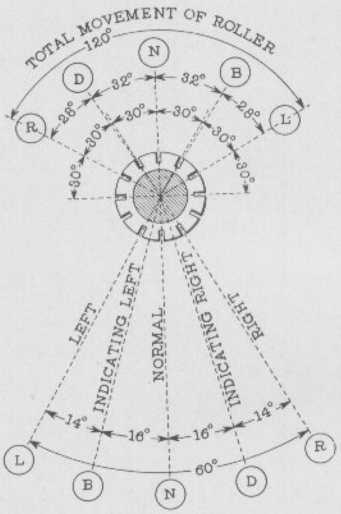
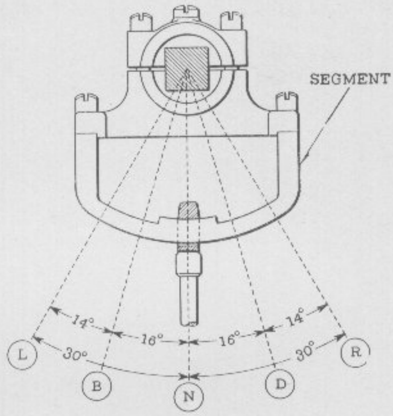
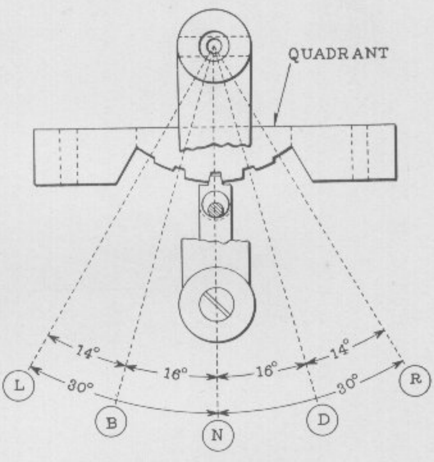


Fig. 12. Diagram of Signal Lever and Operation.





carries the contacting system of the machine. This drawing also illustrates certain features of construction peculiar to the rubber rollers, quick switches and contacting devices that will be referred to elsewhere.

Sectional elevations of the machine, giving a clear idea of its construction and the relations of its various parts, will be found in Fig. 1. The external appearance both with and without its encasing cabinet, may be observed on pages 6, 7 and 8 of Part I.

Figs. 16, 17, 18 and 19 are diagrams showing the circuits peculiar to switch operation and switch lever control in the system and the influence of these circuits as produced by lever, switch and train action upon the devices which they embrace. Figs. 20 and 21 are

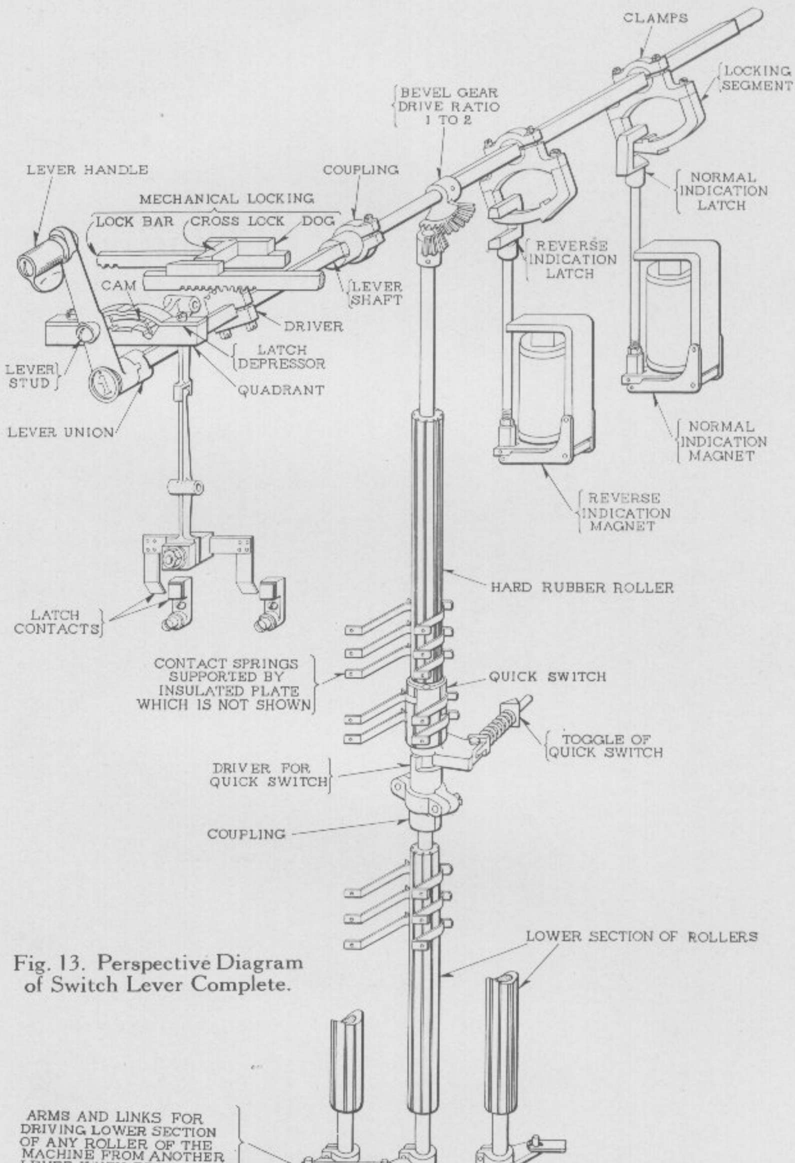


Fig. 13. Perspective Diagram of Switch Lever Complete.

similar diagrams showing the circuits peculiar to signal operation and to signal lever control by signal position only. The simple control of signals and lever locks by

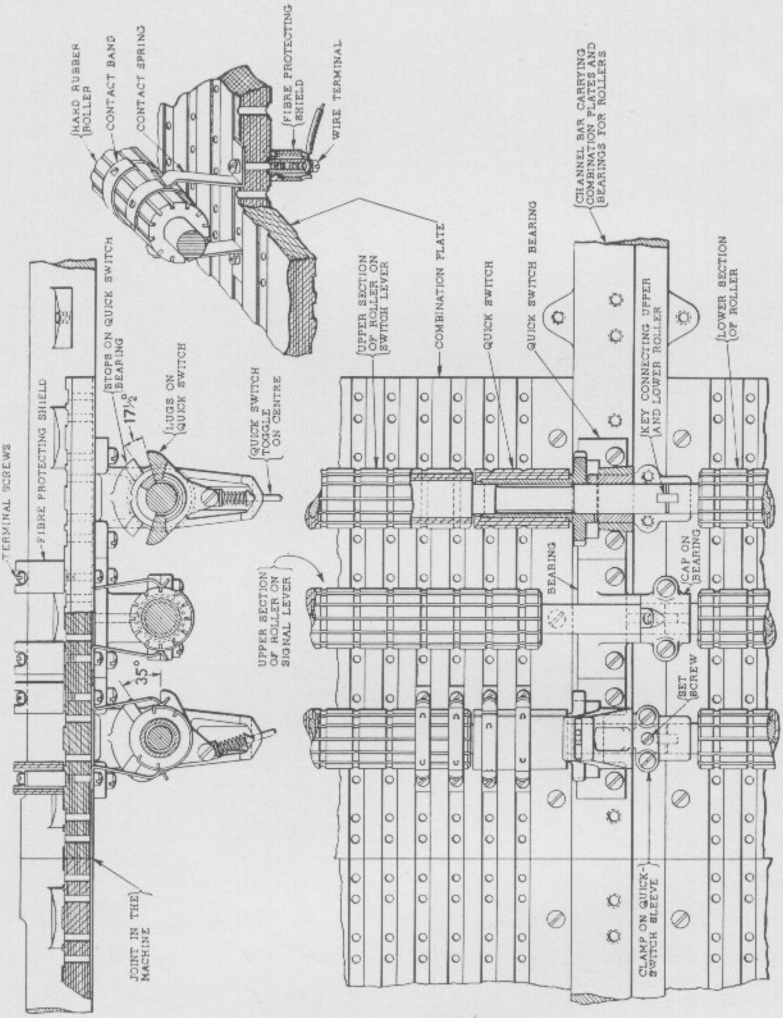


Fig. 14. Part of Combination Plate and Contact Rollers of Electro-Pneumatic Interlocking Machine.

train action and by various other means is so obviously possible from this diagram that such control is omitted in the interest of simplicity in both the diagram and in its explanation.

In describing the operation of the levers of the Electro-Pneumatic machine the effects of lever movements upon switch and signal position, and the effect of switch, signal and train operation upon lever manipulation, it is assumed that the function of the mechanical locking of the machine is fully understood to be: first, the release of one lever for operation only after another has been fully operated; and second, the locking of one lever against operation by movement of another lever before movements of the other have advanced sufficiently to affect those conditions which prevailed before an attempt to move it was made. No detailed description of this feature of the machine will be given, because the type of locking used is well understood and its efficiency and durability are well known to everyone at all familiar with mechanical interlocking practice—a practice in which we have employed the type of locking used in Electro-Pneumatic machines for a quarter of a century, most successfully. In the method of driving the bars of this locking from the levers in Electro-Pneumatic machines, a departure from the practice employed in mechanical interlocking machines was made, however; this embraced not only a much more direct and a simpler driving mechanism than that there used, but it involved the operation of the locking during lever movements and not preliminary to lever movements, as in its operation from the catch-rods of mechanical machines. This method was employed both because of its great simplicity and because in power interlocking practice, unlike in mechanical interlocking practice, levers are necessarily moved

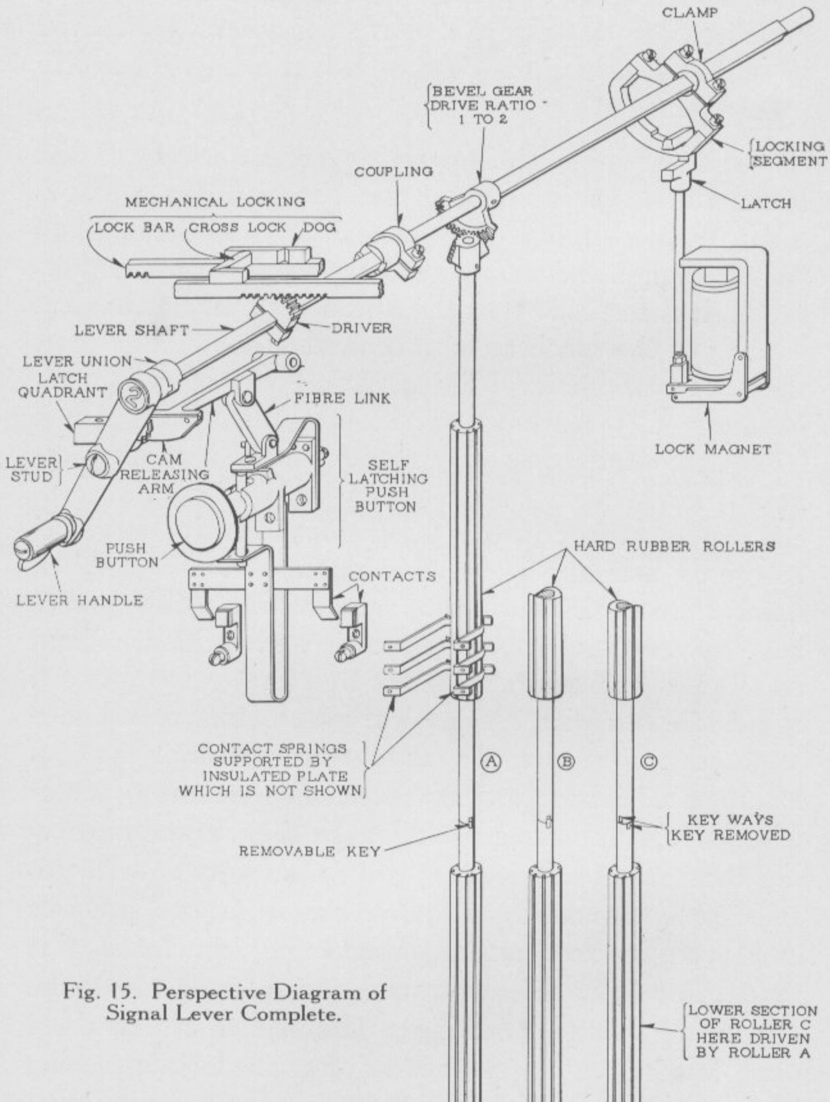
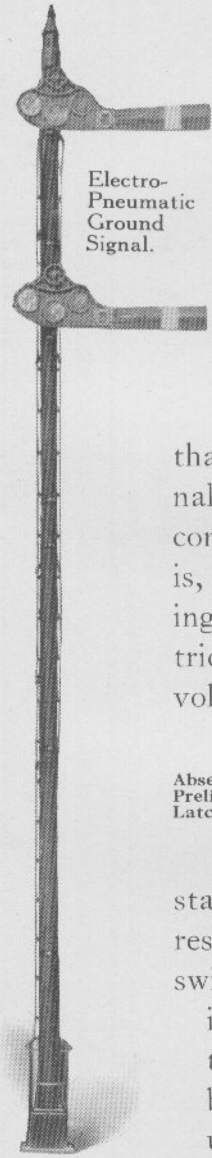


Fig. 15. Perspective Diagram of Signal Lever Complete.



Electro-Pneumatic Ground Signal.

through a considerable part of their stroke before their movement is influential in causing switch or signal action. This fact completely removes from all power interlocking machines that need for a preliminary operation of the mechanical locking that arose in mechanical interlocking through the fact that a change of switch and of signal position is there simultaneous and continuous with lever operation. There is, however, another feature embracing the locking of levers (both electrically and mechanically) that is involved in the concentration of this feature of the catch-rod's function within the lever itself, that should be made clear before the foregoing statement can be accepted as in all respects true. The movement of the switch lever, Fig. 11a, to position D is the first act necessary to operate the switch. This movement is possible only when the switch lever is unrestrained by both the mechanical and the electric locking of the machine. Ordinarily, the mechanical locking prevents any appreciable movement of the lever from position N when restraining the lever's movement when the mechanical locking of one lever by another, however,

Mechanical Locking

Absence of Preliminary Latch Locking

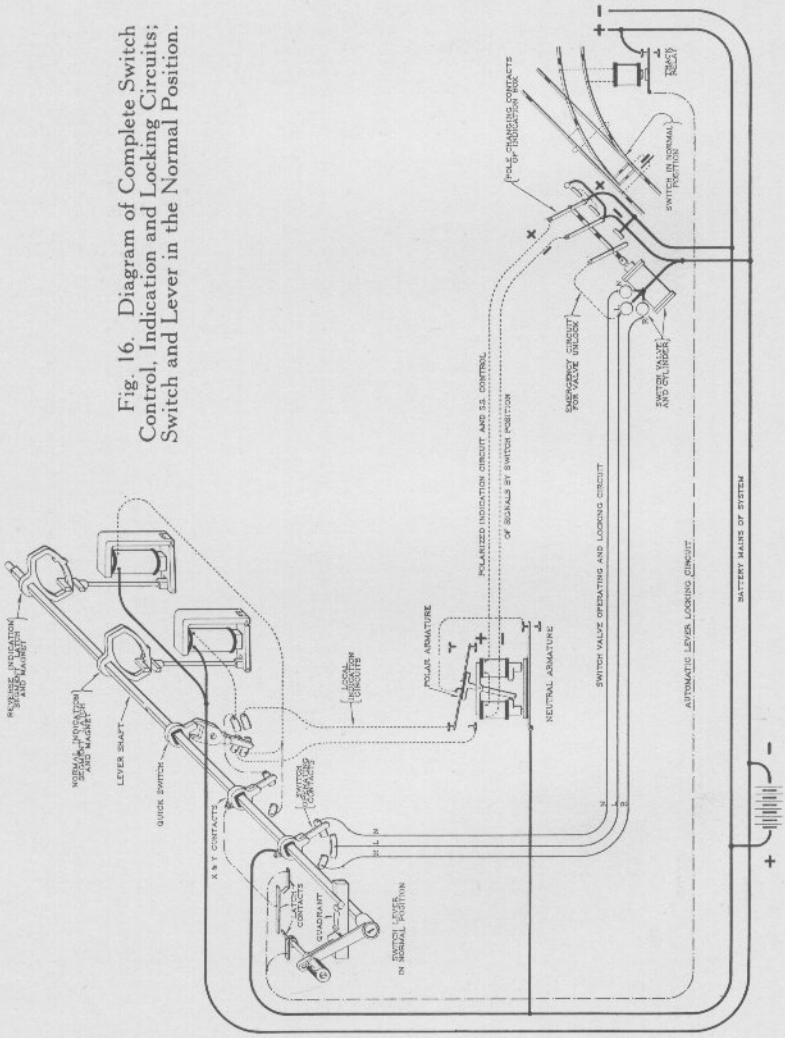


Fig. 16. Diagram of Complete Switch Control, Indication and Locking Circuits; Switch and Lever in the Normal Position.

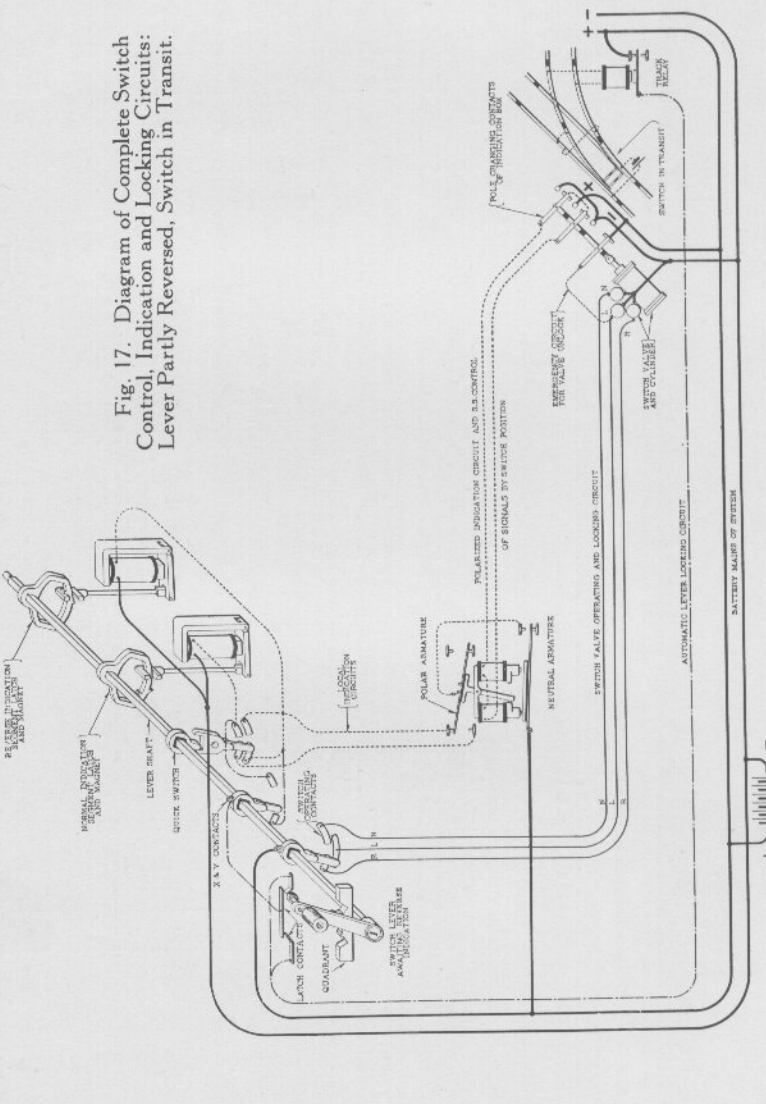
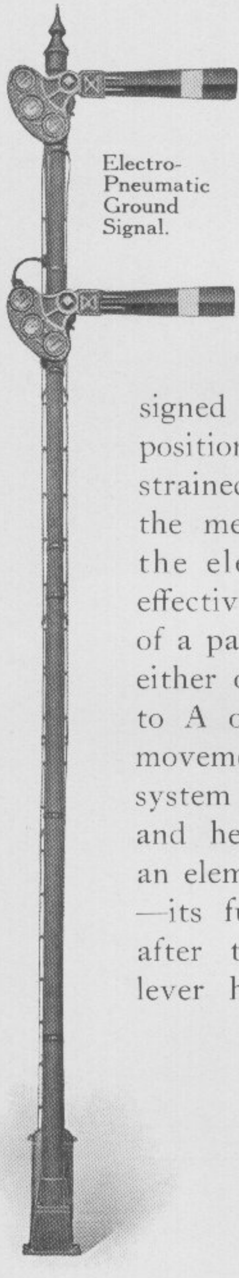


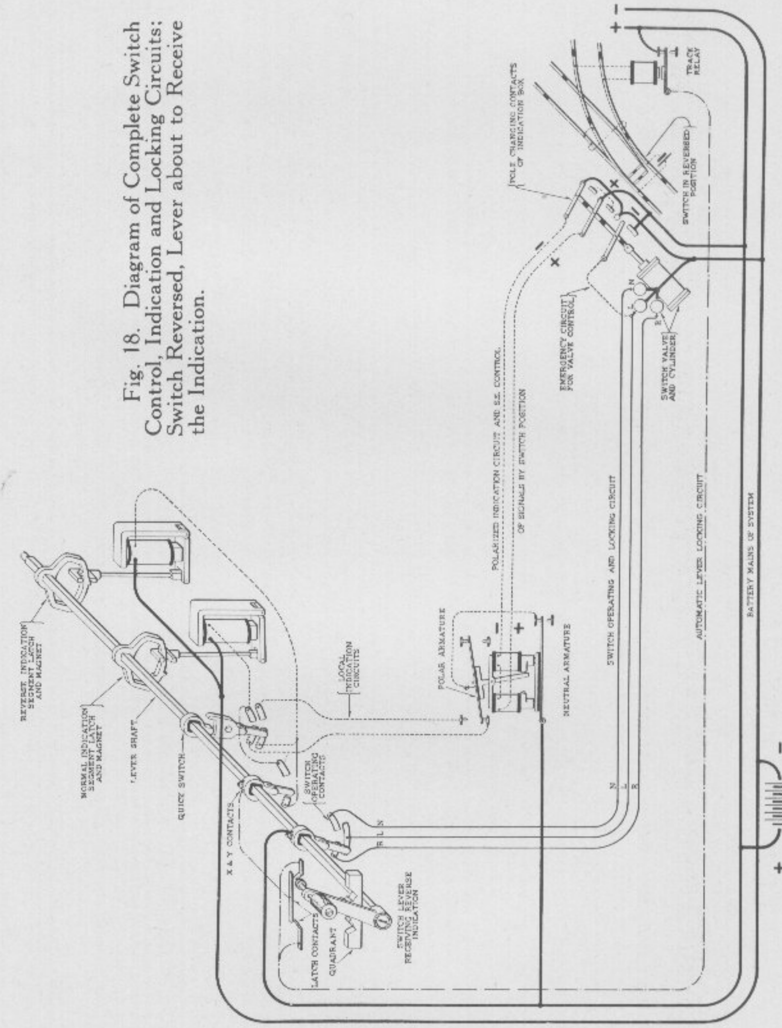
Fig. 17. Diagram of Complete Switch Control, Indication and Locking Circuits: Lever Partly Reversed, Switch in Transit.



Electro-Pneumatic Ground Signal.

is dependent upon the positions assumed at the time by many other levers (as is often necessary) it is impracticable to lock the lever so securely as to prevent a slight movement of it being made when mechanically locked. In consequence of this, it is of importance that the electric locks should be so designed as to engage the lever in any position which it may occupy while restrained from effective movements by the mechanical locking. To this end, the electric lock, while preventing effective lever movement, still permits of a partial movement of the lever from either of its extreme positions (from N to A or from R to E). This partial movement is without influence upon the system of contacts operated by the lever and hence may be totally ignored as an element essential to switch operation—its function being simply to provide, after the effective operation of each lever has occurred, a further, excess, movement to permit, by that excess, the mechanical and the electrical locking of the lever in a wholly safe manner and without resorting to the complication peculiar to preliminary locking.

Fig. 18. Diagram of Complete Switch Control, Indication and Locking Circuits; Switch Reversed, Lever about to Receive the Indication.



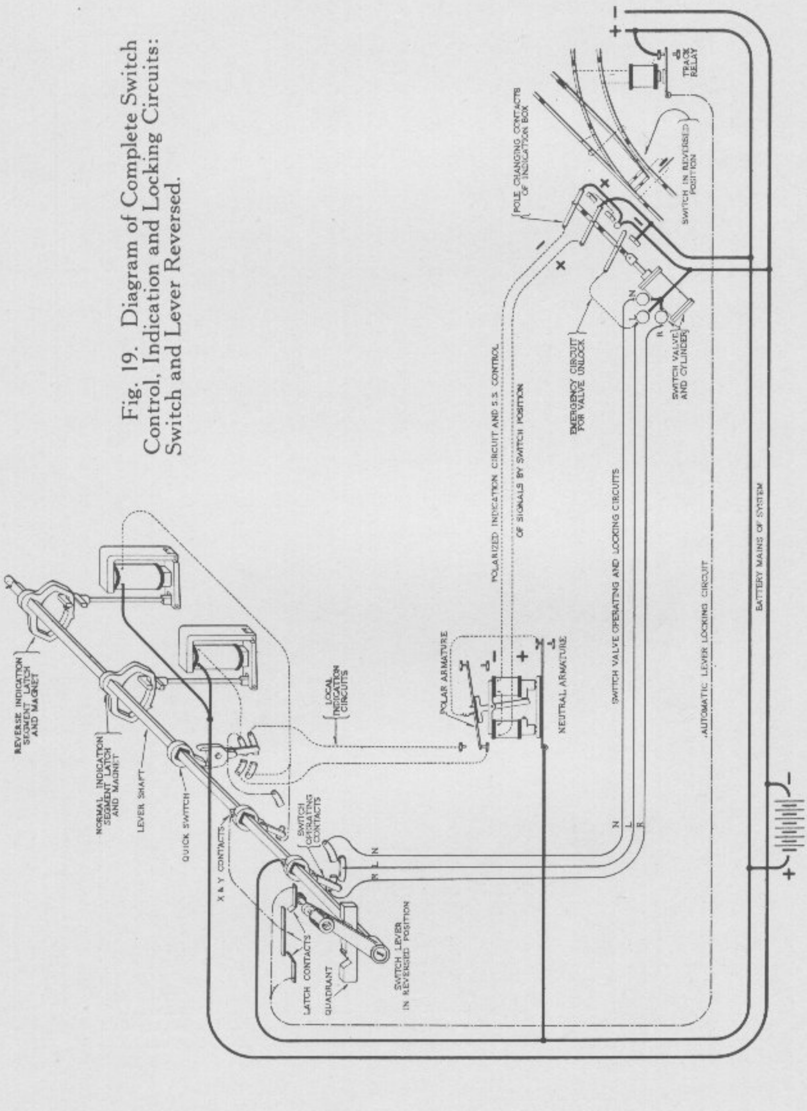


Fig. 19. Diagram of Complete Switch Control, Indication and Locking Circuits: Switch and Lever Reversed.

Preliminary locking by lever catch-rods is indispensable to safe lever operation and control only when the lever itself is not given this excess of stroke or when this excess of stroke is not employed exclusively for the functions assigned, in mechanical interlocking practice, to lever catch-rods. When levers are given this extra throw, the catch-rod or lever-latch becomes simply a means for restraining the lever in one or the other of its extreme positions against inadvertent operation at times when lever operation is unrestrained by the locking. Those positions of the switch lever represented by lines A and E, Fig. 11, may, therefore, be regarded as corresponding with what would be the extreme positions of the lever were the catch-rods employed for preliminary locking purposes, as in mechanical interlocking practice, and were the electric locks applied to the catch-rods and not to the levers. The line D represents the position to which the lever is moved continuously from N, to effect a change of switch position. Beyond this position the lever cannot be moved until the switch, in response to the lever movement, completes its operation and thereby energizes that one of the indication magnets which, through its depressed latch, restricted the lever's movement at position D. Line B represents the indicating position of the lever upon its return operation from R to restore the switch to its original (normal) position, in which position it is restrained by the other indication magnet until that magnet is energized by the responding switch.

In order that the individual functions of the electro-magnets which engage the switch levers may be made as clear as possible, it is desirable to assume, in illustrating their indicating function, that their functions as train actuated lever-locks do not exist. The formation of the segments for the dual duty of switch

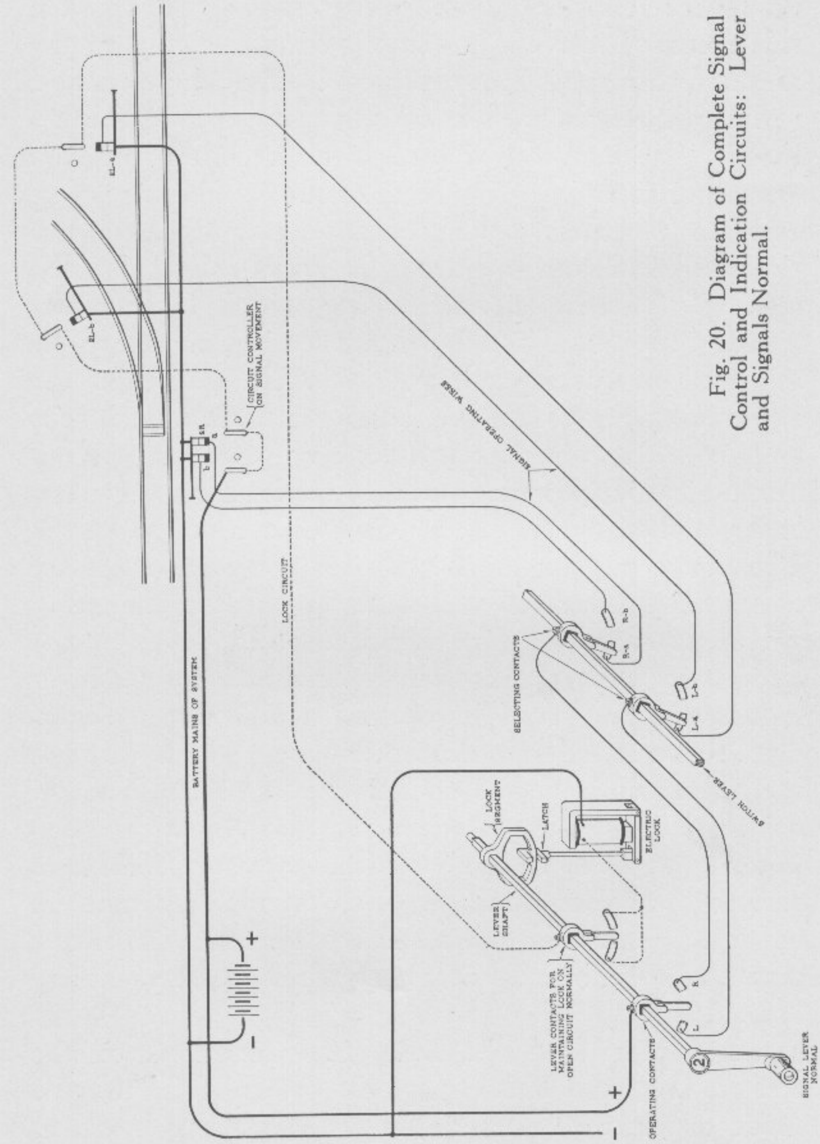


Fig. 20. Diagram of Complete Signal Control and Indication Circuits: Lever and Signals Normal.

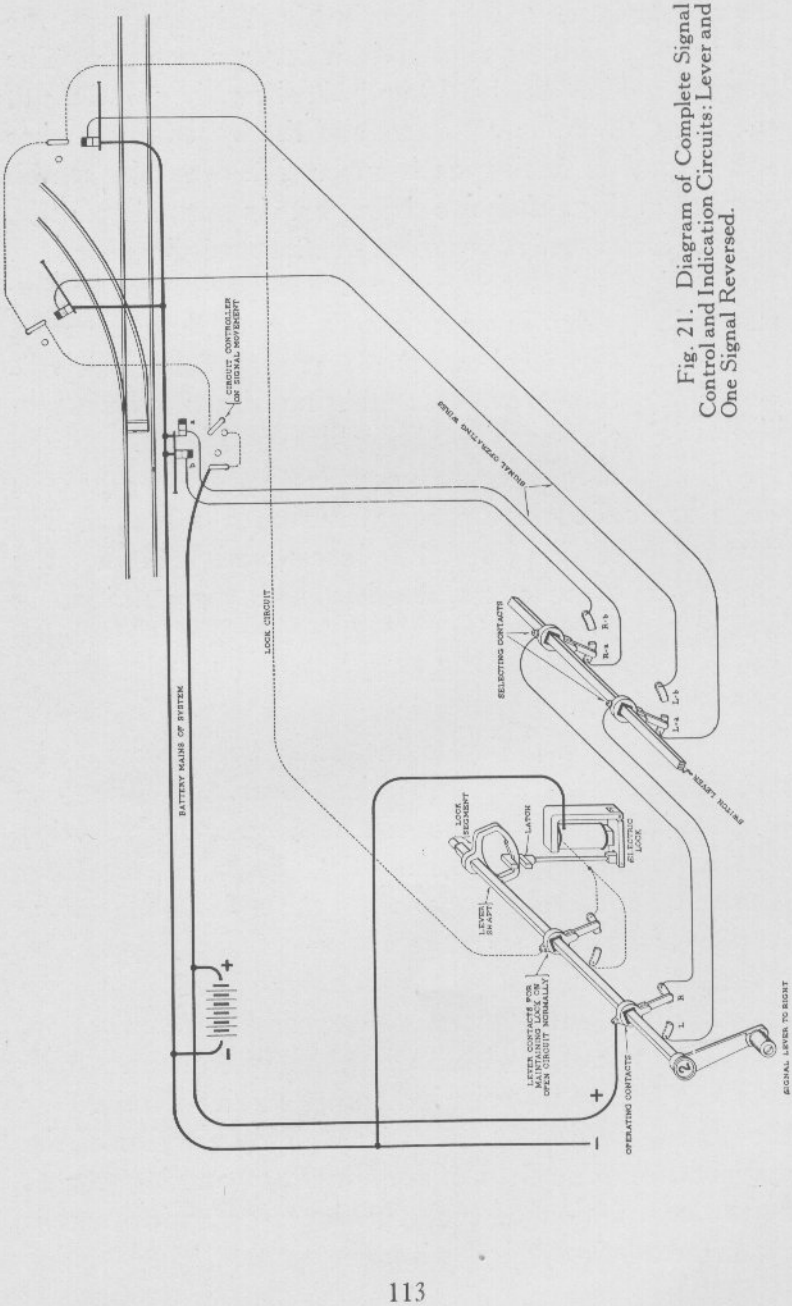


Fig. 21. Diagram of Complete Signal Control and Indication Circuits: Lever and One Signal Reversed.

indication and detector circuit locking involves a modification in the formation of the lug at their upper surfaces only, as will be seen in Fig. 11b, and from the perspective diagrams of switch lever complete. The diagrams, Figs. 16, 17, 18 and 19, show the relations of the lever, the roller contacts, and the indicating latches and segments during each successive event in switch operation. Fig. 16 shows these parts in normal position. Fig. 17 shows the lever moved to effect switch operation. Fig. 18 shows the lever so moved, and (the switch having responded), the lever released for final movement. Fig. 19 shows the lever moved to final position—reversed. During the movement of the lever to shift the switch from normal, the lower magnet, latches and segments alone are called into service; during a corresponding reverse operation of the lever and switch, the upper set of magnets, latches and segments alone are called into service. Preliminary to each lever movement, however, that magnet which lies idle during final lever movement, is in actual practice, actively controlled (by train action upon the switch) as an electric lock to the lever. While one magnet thus permits the use of a lever for effecting switch operation, the other one insures, during lever operation, a correct response of the switch before the final lever movement can be made—this final movement transferring that magnet which permitted it, to the duty of locking the lever automatically by train action, and simultaneously withdrawing the other magnet from that service and into the indicating service required for the next operation of the switch. This transfer of the magnet from one field of usefulness to another occurs at the completion of each full lever operation and is performed jointly by what is termed the "quick

Switch Operation and Control

switch" and by what are designated as "X" and "Y" springs of the contacting system.

The signal levers of the Electro-Pneumatic machines occupy five distinct positions as shown in Fig. 12, when used to their full capacity. By full capacity is meant the use of the lever to the right for the operation of one signal or set of signals and the left for another signal or set of signals—the two sets necessarily conflicting, always, with each other in respect to the route or routes governed by them. This feature of the Electro-Pneumatic machine virtually gives to each signal lever the capacity of two levers and is an important factor in securing that concentration of levers, simplicity of locking and ease of manipulation that is characteristic of the apparatus as a whole. As will be apparent from Figs. 20, 21 and 22, the signal levers normally occupy a vertical central position; when moved to the extreme right, a signal is operated that governs traffic over a given track in one direction; when thrown to the left, a signal is operated which governs traffic over the same track in an opposite direction, or in any direction over any conflicting track, as convenience of manipulation may determine in arranging lever functions. Any signal thus operated to proceed, applies an electric lock to the signal lever and prevents the full return of the lever to the normal until the signal, in response to a partial return of the lever toward normal, re-energizes the lock and releases the lever for this final movement. Positions D and B of the diagrams, Fig. 12, represent those assumed by signal levers when moved from their extreme positions, represented by lines L and R, to restore signals to the stop position and beyond which they cannot be moved, toward their central normal position, until the signal assumes the stop position.

Signal Lever Operation and Control

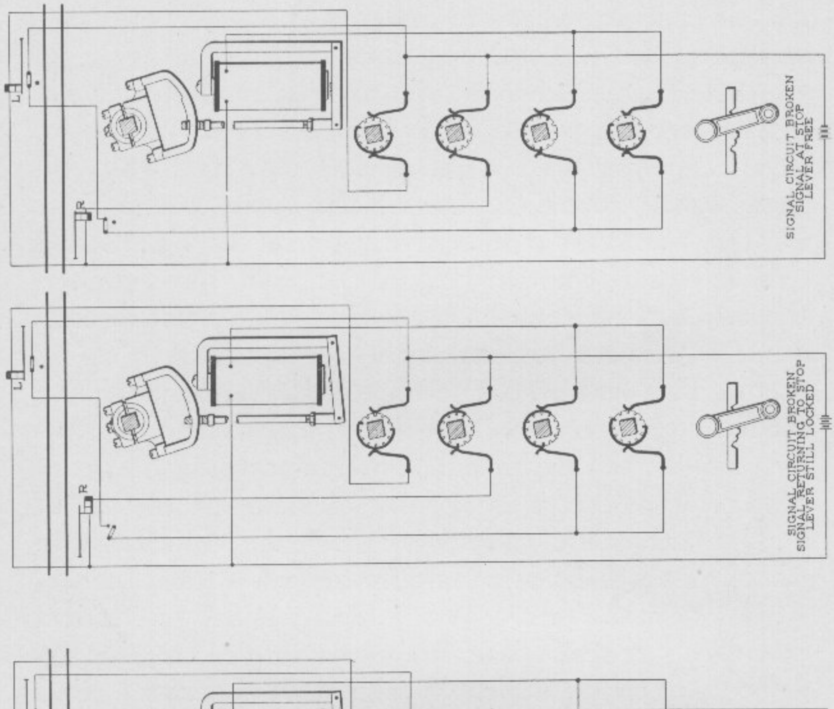
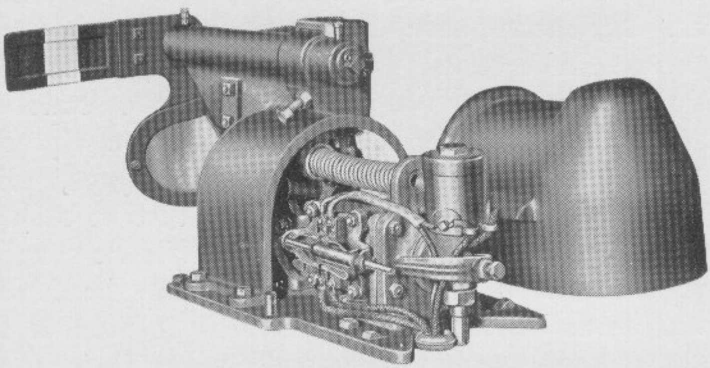


Fig. 22. Diagram of Signal Lever and Circuits for Selecting Opposing Signals.

While it is customary to arrange the switch levers so that these project upwards from their shafts, and to arrange the signal levers so that they project downwards, this is entirely an arbitrary matter. In practically all installations the number of switch levers required exceeds the number of signal levers required—largely by reason of that dual capacity of signal levers just referred to—and it not infrequently happens that switch levers are substituted for signal levers in such cases. It, furthermore, sometimes occurs that the requirements of certain levers in the way of contact equipment, exceed the capacities of the two sectionalized rubber rollers of each lever that this equipment embraces. It invariably happens, also, in such cases that a single section only of other levers is more than ample for meeting their needs in this respect. To give to the former levers the desired capacities, the lower sections of the rollers of the latter are disengaged from their upper sections and connected by links to the overburdened rollers of the former levers so as to operate with them. In this way an almost unlimited capacity for circuit control is assured each lever of the machine, and where unusual conditions assign to the lever the control of many circuits, no complications of design or resort to special equipment to meet its needs is involved.

Circuit Capacity

The vertical arrangement of the rollers has two distinct advantages; first, in permitting of their operation through an angle of 120 degrees—or double the angular throw of the levers, and second, a concentration of the elements of the machine in the interest of the floor space occupied. The 120 degree operation of rollers is of especial value in obtaining, by means of rollers of small diameter, a wide separation of contacts and a close definition of contact control with respect to lever positions, thus insuring permanency of adjustments and entire freedom from extreme care and delicacy in producing it originally and maintaining it afterwards. The panels or "plates" which support the contacting system of this machine are of special moulded insulated material so formed and secured to the machine frame as to prevent distortion due to temperature or humidity changes. To these plates the contacting springs are



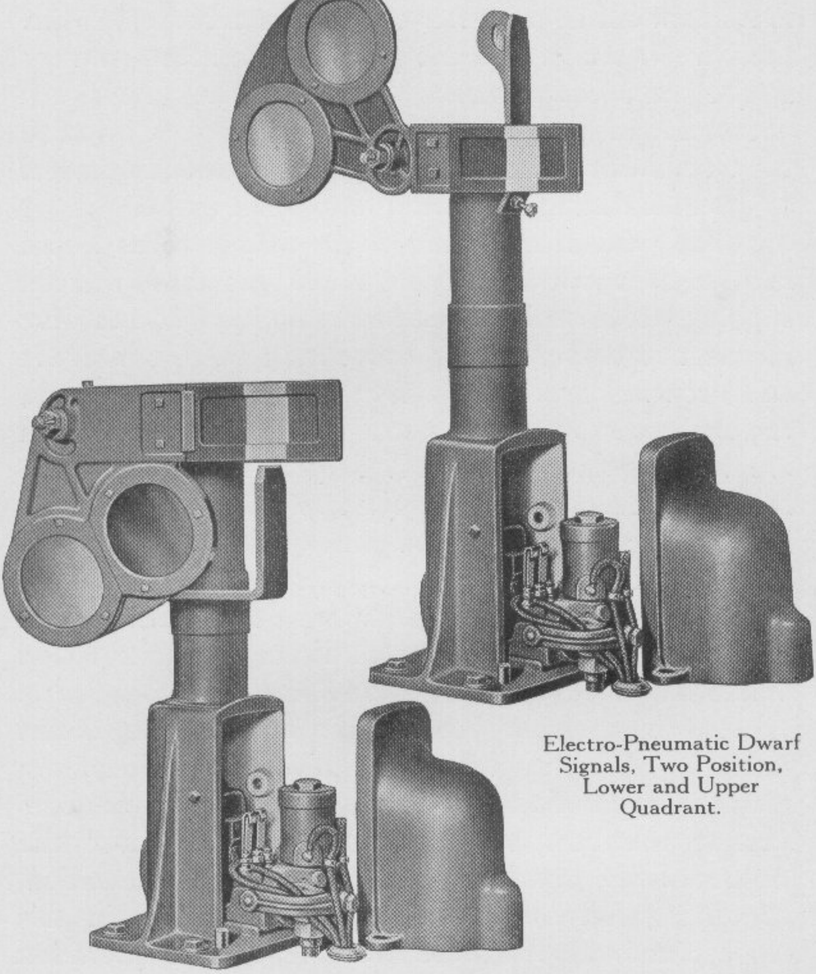
Low Electro-Pneumatic Dwarf Signal,
Two Position, Lower Quadrant.

secured by substantial brass screws which pass entirely through them and into square brass nuts of liberal lengths by which the screw and spring are thoroughly secured. These nuts, being square, and set into vertical grooves, cut in the rear of the plate, are non-turning, while the contact springs lying in similar grooves cut in the front of the plate are likewise held against turning by a single screw through each. The nut by which the screw is secured is of special length where wire connection to a contact spring is to be made, and that portion of the nut which extends beyond the screw is equipped with a second screw and washer for securing the external wire connection. Over the "terminal posts" thus formed, a tube of insulating

Contact System

material is placed; the external wire connection being in a notch cut in the outer end of this tube, and, when the wire is secured to the post by the screw, a very simple and effective means of retaining the tube is thus obtained and a highly satisfactory protection afforded the terminals of the machine against accidental crosses or grounds during inspection, etc., see Fig. 14.

The vertical mounting of the rubber roller would involve some risk of badly fitted contact bands thereon slipping out of position with serious consequences were means not employed for preventing it. To prevent this occurrence, grooves are turned in the rollers, and the contact bands being placed immediately over them are held against movement longitudinally upon the roller by several lugs or projections that are deflected into the groove after the band is applied. The ends of the bands are turned at right angles and inserted in two of the several radially cut slots in the face of the rollers to secure their rotation at all times with the roller. These bands vary in length and in their positions on the rollers to meet the requirements of the circuit including them, in the matter of lever positions. An electrical separation of 3/8 inch is obtained between contacting members, terminal posts, magnets, and the frame of the machine throughout its construction, complying fully with R. S. A. specifications in this respect and adapting the machine to safe operation with any working e. m. f. from 12 to 250 volts. The 3000 volt A. C. insulation test required by the R. S. A. is an important feature of the machine's construction, and a 5000 volt test is entirely practicable where required, without mechanical modification of any sort. The electro-magnets used for locking and indicating purposes are of the single coil type, by which accessibility during inspection is abundantly secured. These magnets remain upon open circuit practically



Electro-Pneumatic Dwarf Signals, Two Position, Lower and Upper Quadrant.

95% of the time, and are wound to 130 ohms resistance uniformly in all cases. The operating e. m. f. customary in Electro-Pneumatic interlocking being but 12 volts, it is obvious that the small current (.09 amperes) used for the operation of each magnet, totals in ampere hours daily to an insignificant amount for the entire machine.

The front plate of the Electro-Pneumatic machine is constructed to recede from the place in which the levers operate and thus to form a compartment under the levers for the housing of the various lamps and contacting devices that are frequently made a feature of lever manipulation in this system. The lamps serve as indicators and inform the operator when a lever may or may not be moved. The usual contacting mechanism that is contained in this compartment has several functions: first, the control of switch lever locks by the catch-rods of the levers so as normally to retain the locks upon open circuit, as a matter of current economy solely; and, second, the retention of these locks positively separated, during lever movements between indicating positions from any possible supply of current energy to them save through the proper channels of the indicating system alone. Upon the efficiency of this provision hinges to some extent the desirability of the adaptation of the indicating magnets (alternatively) to the duty of detector circuit locking. The highly efficient and substantial manner of operating this contacting device jointly by both the catch-rod and the lever, and the joint control of the automatic lock circuit by this device and by certain roller contacts of the machine that, because of the 120 degree angle of roller operation, are simple and certain of action, leaves no room for doubt as to the wisdom of utilizing the indicating magnets for detector circuit locking also. The third function of this equipment embraces, behind each signal lever, when desired, a "latching" push-button, the action of which when depressed is to operate a "calling-on" arm when the usual signal does not respond to the lever's movement by reason of the semi-automatic control of the signal and the presence of a train upon the track it governs. The depression of the button, in such cases, mechanically latches it depressed and, in consequence, the circuit of the calling-on arm is closed until the latch is released. This release occurs

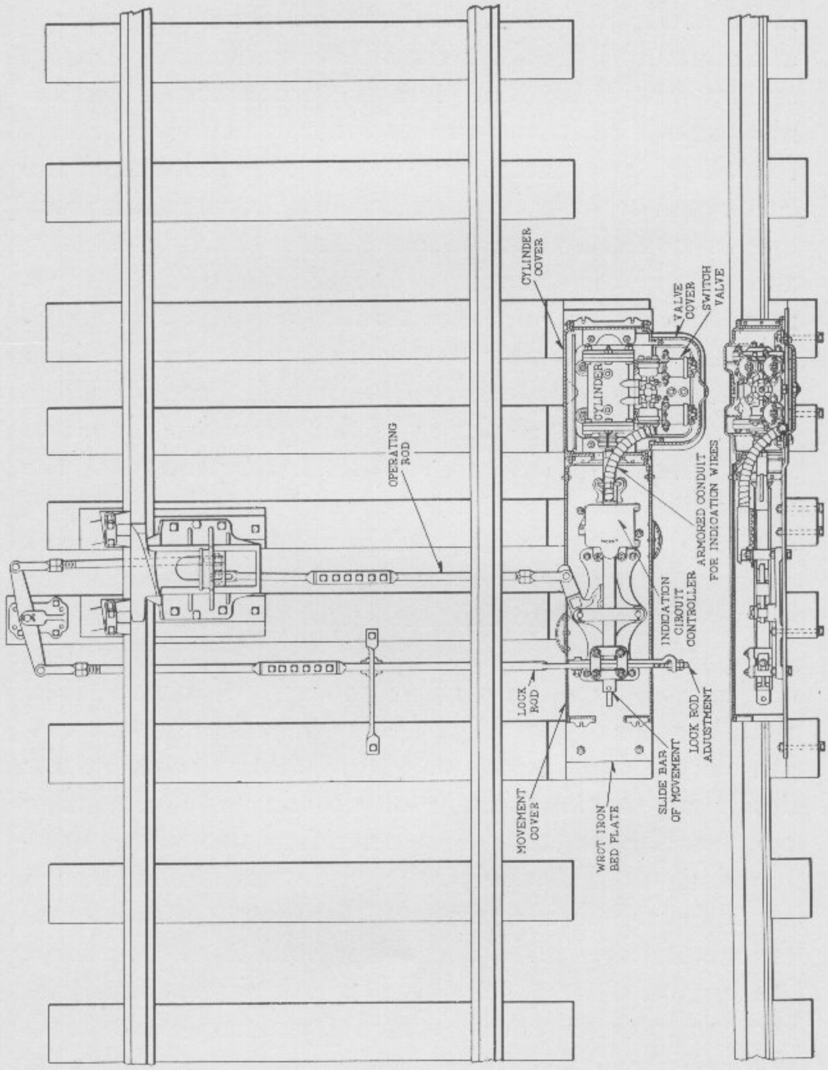


Fig. 23. Electro-Pneumatic Switch and Lock Movement Applied to a Hayes Derail.

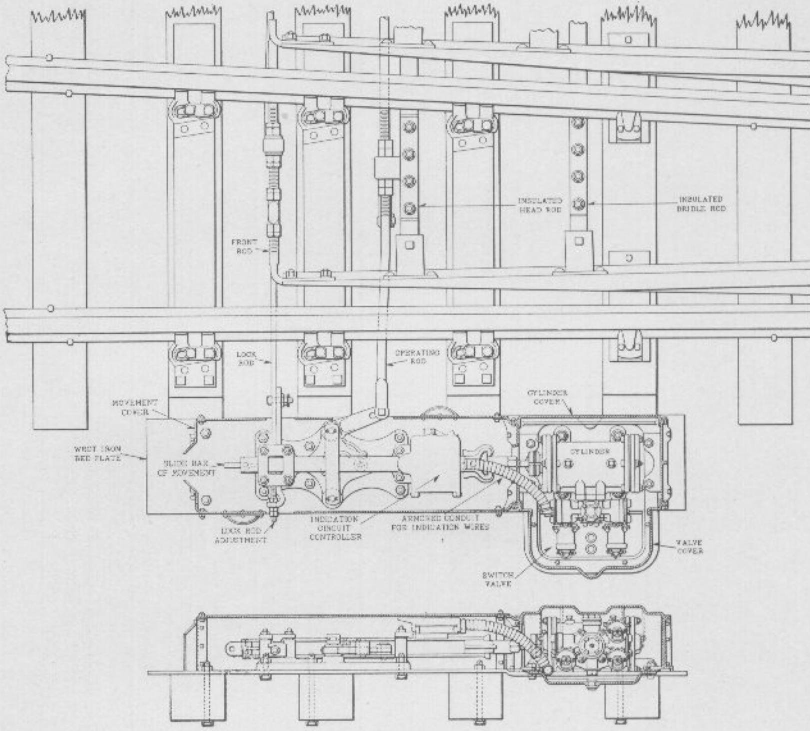


Fig. 24. Electro-Pneumatic Switch and Lock Movement Applied to One End of a Double Slip Switch.

by the partial restoration of the signal lever to normal; i. e., its movement to interrupt the circuit of the signal and thus to cause it to assume the stop position and, thereby, the lever's release for final movement to normal, as in ordinary signal operation.

Switch Operation and Control

Switch Operating Mechanism: Switches, in Electro-Pneumatic interlocking, as in all approved power interlockings, are unlocked, operated and again locked by one continuous operation of the prime mover, the cylinder. This device as a whole is termed a switch and lock movement, the important characteristics

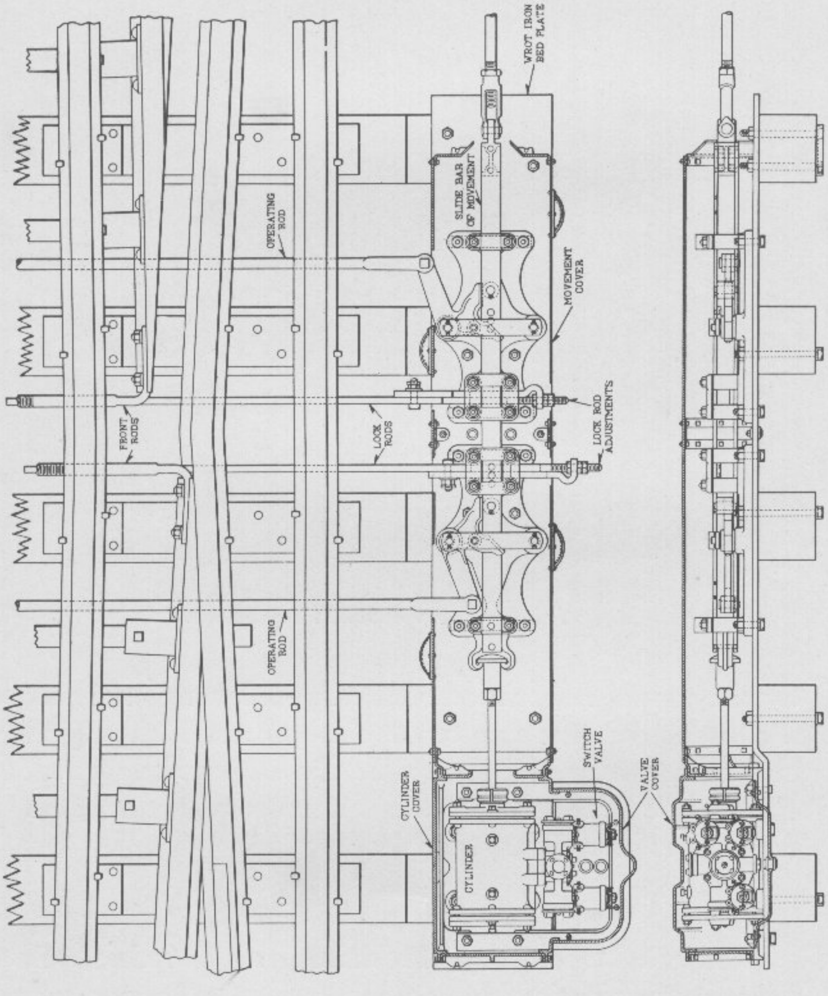


Fig. 25. Electro-Pneumatic Switch and Lock Movement Applied to a Movable Point Frog

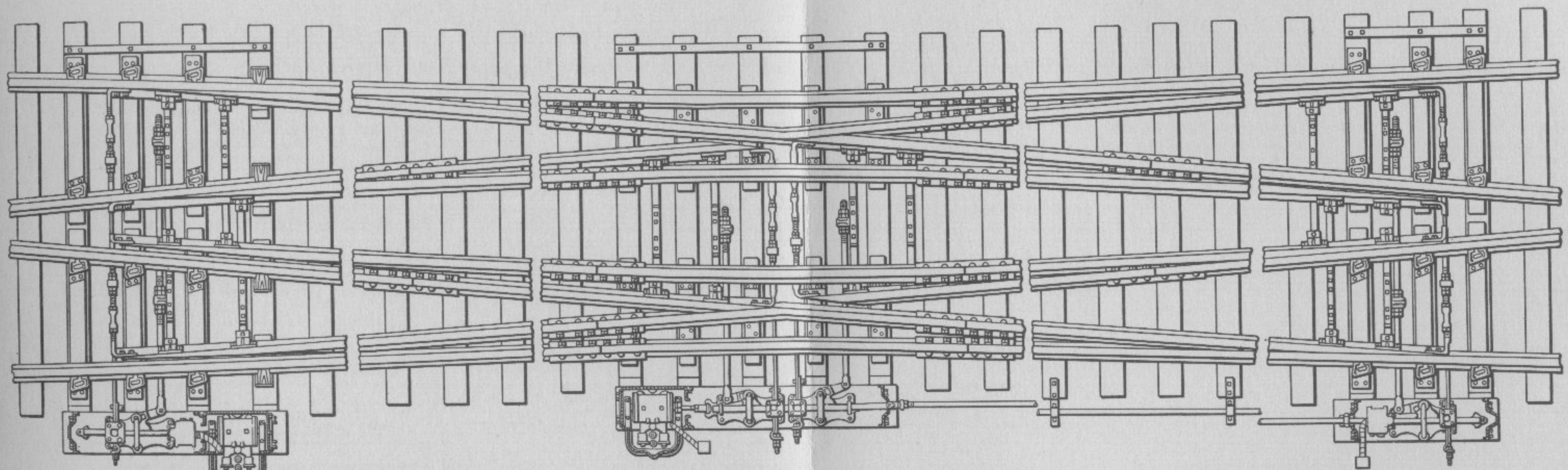
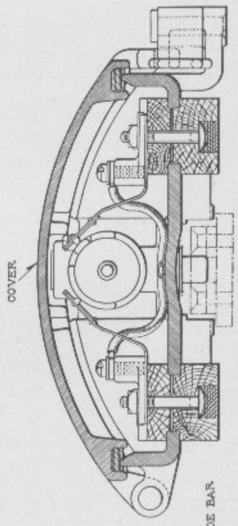


Fig. 26. Electro-Pneumatic Switch and Lock Movements Applied to a Complete Double Slip Switch with Movable Point Frogs.

of which are shown in Figs. 23, 24, 25 and 26. As before intimated, switch and lock movements are applied to the operation of switches of every character and rail section. Variations in character are exemplified by four commonly encountered types: Derails, Simple Turn-Outs, Slip-Switches, and Movable-Frogs. The first three of these types involve no special consideration in their operation by switch and lock movements, other than the selection of adequate cylinders for meeting the particular load characteristics of each. The operation of movable point frogs, however, involves conditions analogous to the operation of two single switches, the theoretical points of which coincide in positions, and the leads of which extend in opposite directions. Switch and lock movements adapted to movable frog operation, hence, must operate and lock two sets of points. The points of each set, furthermore, must move simultaneously, and in opposite directions by independent connections, and they must also be equipped with independent lock rods for insuring the direct and individual locking of each set. Because of this, it is customary to employ two switch and lock movements arranged in tandem, for frog operation. When movable frogs comprise parts of switch layouts, the frogs are operated simultaneously with either end of the slip switch; it is, therefore, the custom in Electro-Pneumatic interlocking, to adapt a single cylinder to the operation of three switch and lock movements in tandem, as in Fig. 26.

Switch and Lock Movement

Since the frogs constitute the larger part of the load to be met in this arrangement, their mechanisms are preferably connected directly to the piston of the cylinder, while that of the slip movement is connected to operate in tandem, simultaneously with the frog movements, as shown in Fig. 26. Such an arrangement



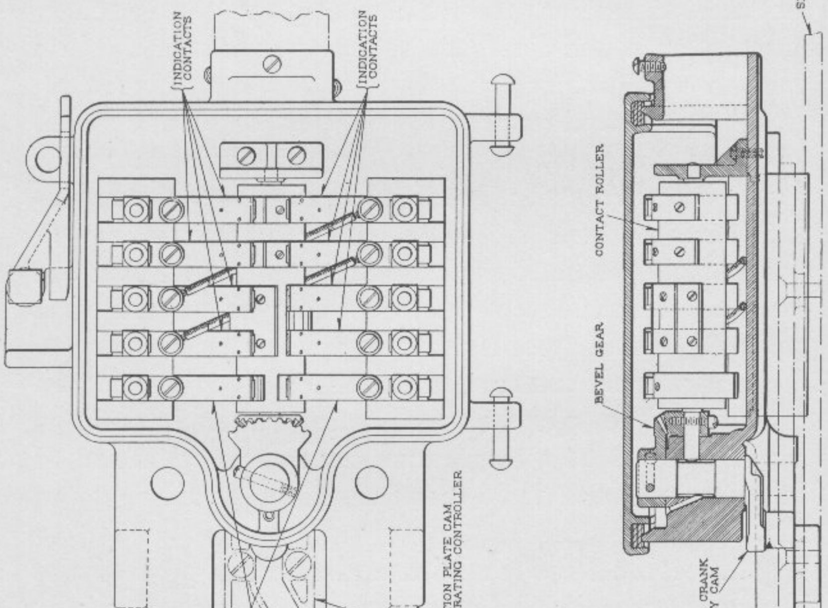


Fig. 27. Pole-changing Indication Circuit Controller.

calls for electric contacts only, on the slip end mechanism for controlling the switch indicating system, since the mechanism (being the one most remote from the operating cylinder) can assume correct positions in response to lever movements only in case the frog mechanisms have also assumed such positions.

In the operation of slip ends individually (independently of the frogs, as is sometimes done) and in the operation of single switches and derailing devices, a single cylinder and switch and lock movement are employed equipped with a single switch valve and indication circuit controller. This equipment is shown in Figs. 23 and 24, and from these illustrations it will be evident that four separate elements are comprised in each layout; 1, the switch valve; 2, the switch cylinder; 3, the switch and lock movement; 4, the indication circuit controller.

Elements of Movement

The valve by which the pressure to and from the switch cylinders is controlled is usually mounted directly upon the cylinder. It may be mounted separately, as is sometimes done on account of small clearances, where electric traction prevails. This method permits of its location clear of possible contact with third rails and the contacting shoes of vehicles. When so mounted, pipe and armored hose connections constitute the air connections between the valve and the cylinder, and the wires of the indicating system alone extend to the switch operating mechanism.

Figs. 28 and 29 represent the valve in section and as mounted upon the switch cylinder. Its construction comprises a simple slide-valve that is shifted by two opposed, miniature pistons actuated by air pressure which are controlled from the switch lever through the medium of two electro-magnets—one upon each cylinder. Through the operation of the slide-valve,

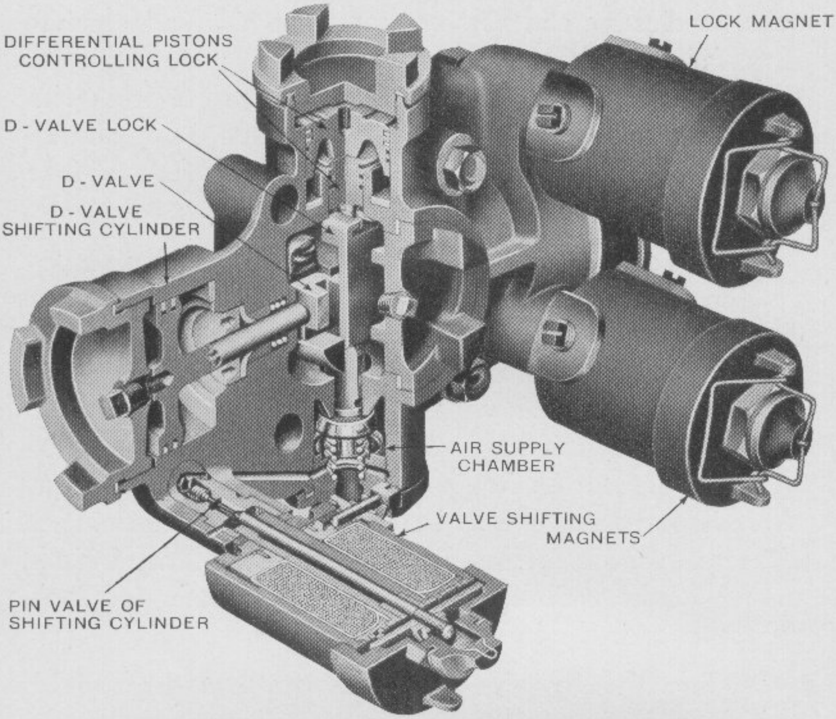


Fig. 28. Switch Valve and Magnets.

air is admitted directly from the air main to one end of the switch cylinder, while the pressure within the other end of the cylinder is simultaneously liberated to atmosphere. Means are also provided for mechanically locking the slide valve after each operation of the switch and upon completion of the final movement of the switch lever thereafter. Not only does this final movement of the switch lever apply a positive lock to the slide valve, but after so locking the valve, it cuts off the air supply to the slide valve chamber, and hence to the switch cylinder. This is done that freely fitting pistons may be used in the cylinders without incurring that loss of power due to slight leaks there which would be of moment if the pressure were maintained against them after com-

Switch Valve

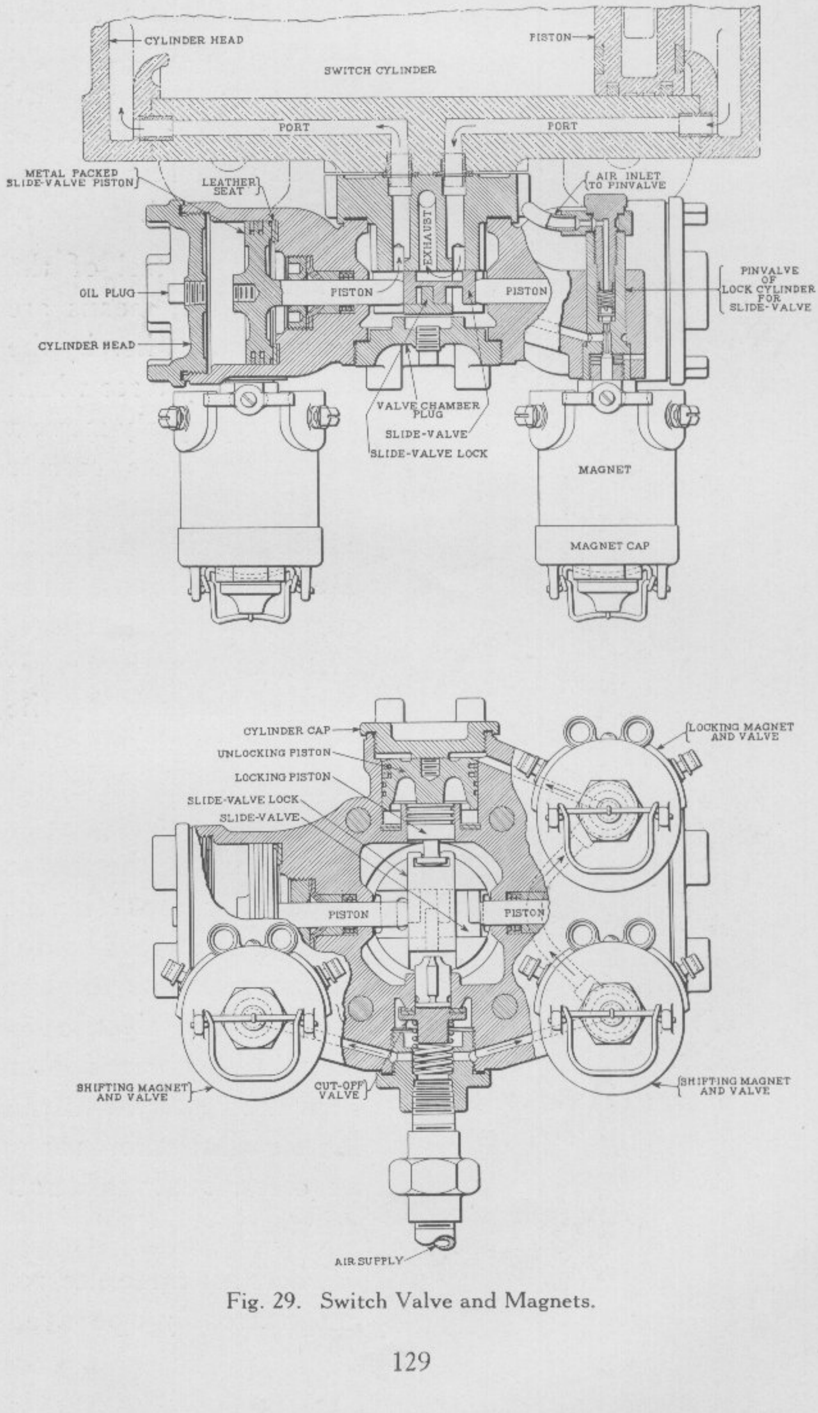
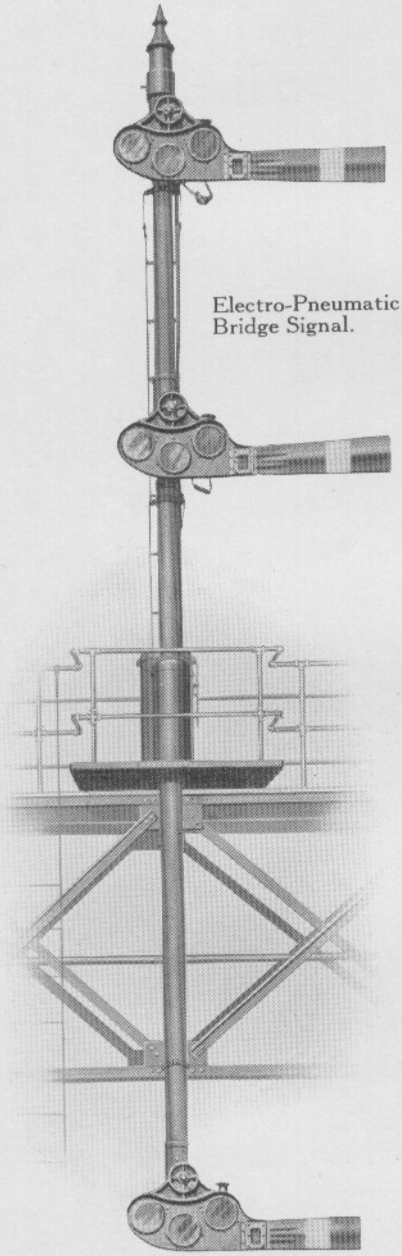


Fig. 29. Switch Valve and Magnets.



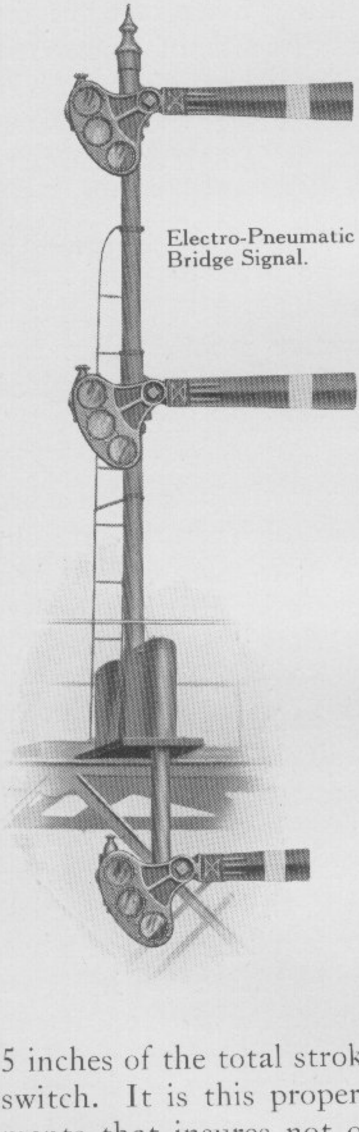
Electro-Pneumatic Bridge Signal.

pletion of their stroke. Loss of air through D-valves, pistons and stuffing boxes while the switch is at rest is completely avoided.

In the control of the switch valve, means are incorporated whereby the action of any force which might improperly move a switch from its correct position will instantly re-admit the air pressure to the cylinder and thus oppose such tendencies as effectually as they were opposed formerly by the constantly maintained air pressure within the cylinder. This is analogous to the closure of the motor circuit by electrically operated switches by similar attempts to shift the switch in electric interlocking by means other than the motor, with the result that the motor at once resists such attempts.

There are three electro-magnetically operated pin valves embraced in the shifting and locking of the slide-valve by which the movements of pneumatic switch cylinder pistons are effected. The magnets of these pin valves are connected each by a separate conductor to individual contacts actuated by the switch lever during its movements from one position to the other. One of these magnets is energized normally to retain air pressure constantly against one of the two miniature slide-valve pistons and, hence, positively holds this valve in one of its two positions. One of the other magnets becomes energized as the first mentioned one becomes de-energized when the lever is shifted to cause switch reversal. The application of air pressure thus to the other miniature piston, simultaneously with the discharge of air from behind the first one, causes the slide-valve to shift and thereby to reverse the piston of the switch cylinder. Such action of the slide-valve, however, can occur only after the third magnet and pin valve have been actuated to unlock the valve and simultaneously to admit the pressure from the air main into the slide-valve chamber. The energization of this third (lock) magnet occurs the instant the switch lever is shifted from either of its extreme positions, and hence the slide-valve remains unlocked and the pressure remains within the slide-valve chamber at all times save when the lever is in its completely normal or in its completely reversed position. Movements of switch levers into these extreme positions can occur only when switches and their levers coincide in position and when the switch is thus securely locked mechanically, and hence the locking of the slide-valve and the release of air from the valve chamber can take place only after complete switch and lever operation have occurred and complete coincidence of position of both has been assured.

Pin Valves



Electro-Pneumatic Bridge Signal.

Cylinder

Switch Cylinders: The cylinders of Electro-Pneumatic switch and lock movements are uniformly of 8 inch stroke and of diameters varying from 5 in. to $7\frac{1}{2}$ in. according to the load assigned to each in service. Metal packed pistons are used and the construction in general is one of extreme simplicity and durability.

Switch and Lock Movement

Switch and Lock Movements: These comprise a slide bar moved in a longitudinal direction by the cylinder to unlock, operate and again to lock the switch through the medium of an alligator-jaw crank engaging it. The total stroke is 8 inches, $1\frac{1}{2}$ inches of this being used at each extremity for locking the switch, and thus but 5 inches of the total stroke is actually used to shift the switch. It is this property of switch and lock movements that insures not only the full operation of the switch, but mechanical locking of it also after each preliminary lever movement and before the indicating circuits are affected to permit the final complete lever movement that must precede the use of the switch through signals in interlocking practice.

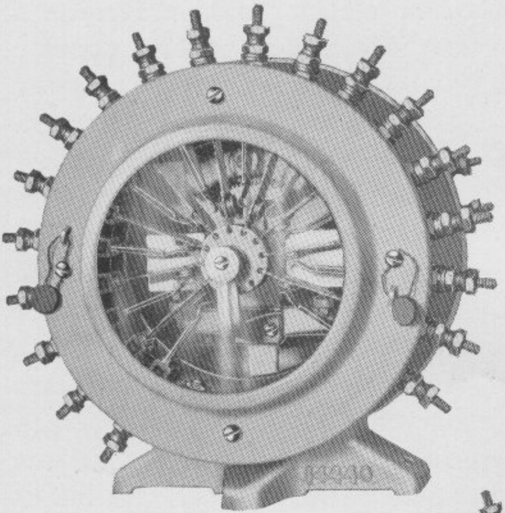
Detector Bars: When detector bars are made a feature of Electro-Pneumatic interlockings they operate continuously with the piston of the cylinder from the slide-bar of the switch and lock movement.

Detector Bars

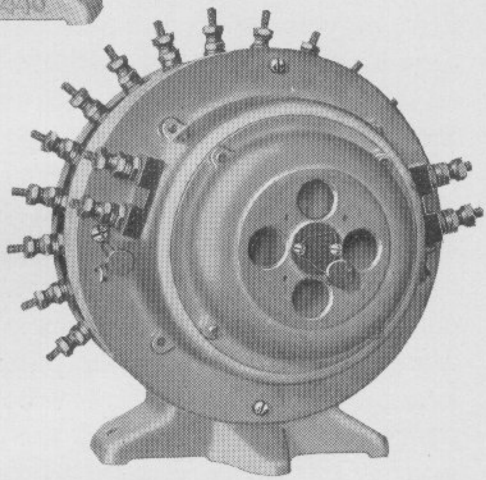
The first part of the piston's movement employed primarily for unlocking the switch is also employed for the elevation of the bar above rail level. A train standing upon or moving over a switch obviously prevents the elevation of the bar, and hence the unlocking and movement of the switch under trains. During that part of the piston's stroke that effects switch operation, the bar travels idly in its elevated position without material resistance; and during the final movement to lock the shifted switch the bar is depressed to its former position below rail level.

Since detector bars constitute the chief loads to be met by the switch motors of power interlockings their elimination, upon the score of power economy and operating speed is desirable. Since modern practice embraces, in power interlocking, the automatic locking and releasing of switches through the medium of detector circuits and sectional route locking by train action in a manner that precludes the possibility of switch levers being operated while trains are approaching or passing over interlocked switches, the value of the detector bar in this service is confined solely to cases where improper or irregular lever movements are resorted to—as during blockades, wrecks, or like derangements. For these reasons detector bars are not regarded as an essential feature of power interlocking and the cost of their application and maintenance usually exceeds the value of the protection they afford in this field.

Indication Circuit Controller: This device is mounted directly over the slide-bar of the movement and is actuated positively thereby. The device comprises an oscillating drum of insulating material



Radial Polyphase Relay, Three Position.



carrying contacting plates which make and break electrical contacts with a system of flexible contacting fingers included in the circuits of the indicating system at predetermined points in the operation of the switch and lock movement, Fig. 27.

Normally, a current flow is maintained through two contacts of this device in one direction, and through two of its other contacts in an opposite direction. This current, through two isolated conductors which extend to a polarized relay at the interlocking machine, maintains a normally active state of that relay to retain closed certain contacts and to retain open certain other contacts. Upon full reversal of the switch and

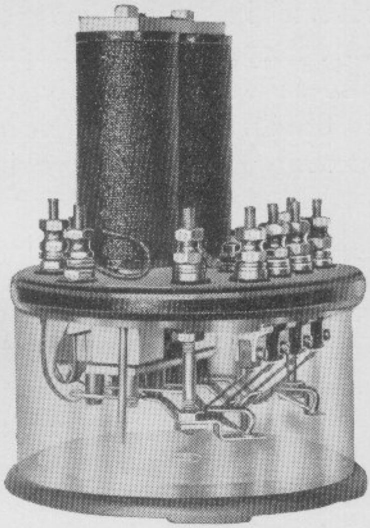
Indication Circuit Controller

lock movement a reversal of the flow of current is produced by reason of the changed relations then occurring between the contacting members of the indication circuit controller. The polarized relay is thus caused to reverse its influence upon its contacts and hence closes those contacts that formerly were open and opens those that were formerly closed. The contacts of the relay thus repeat the two positions of the switch and lock movement, and are therefore employed for controlling not only the normal and reverse indication magnet of switch levers during switch operation by simple local circuits, but are used also as a means wholly within the interlocking tower to obtain a very simple and effective control of the current supply to every signal of the system by actual positions of each and every switch over which it governs. This method is designated as the "SS" control, and is obtained without recourse to any facing point circuit controllers or additional conductors or devices external to the tower which are necessary to other methods.

"SS" Control

Obviously, this joint control of the indication magnets and that of the current supply to signals is not to be supported upon the grounds of this simplicity alone. Inherent in the method are elements of safety that insure immunity from faulty operations arising from any causes whatever that make it superior to any methods heretofore embraced in any power interlocking for like purposes. Naturally, the relay should be energized only when the switch is in one or the other of its two extreme positions and securely locked there. To insure that during the unlocked condition of the switch (and during its operation) the relay will be de-energized with certainty, the indication circuit controller interrupts the current supply to both indicating wires, and it also forms a shunt or short-circuit between them or very low resistance as an added safeguard.

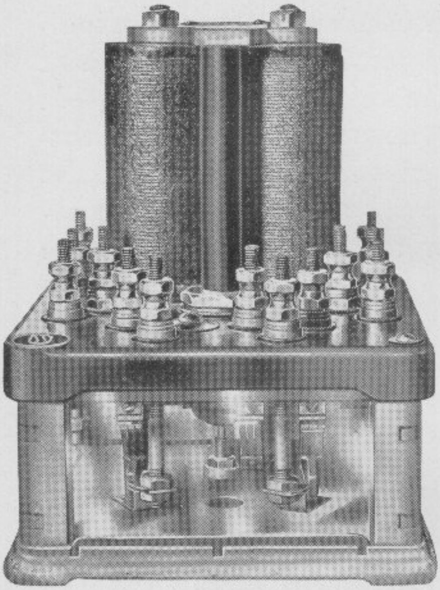
By this method both indicating wires are maintained at the same (zero) potential until the switch is positively locked in one position or the other—the direction of current flow in them being distinctive for each switch position and hence positive in its selection of the indication magnet or signal released by it. The method is equally positive in its application to a single switch, crossover or to any number of switches operated by a single lever.



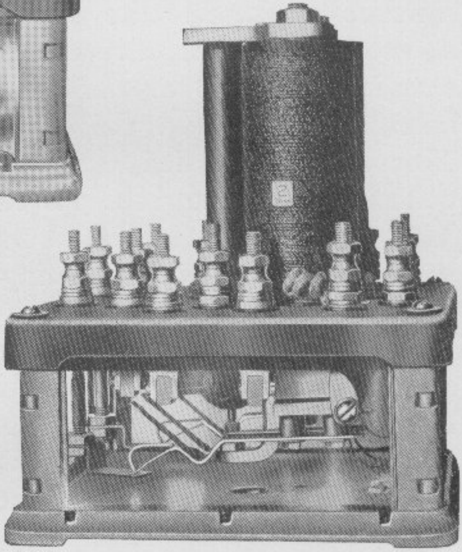
Model "13" D. C.
Neutral Relay.

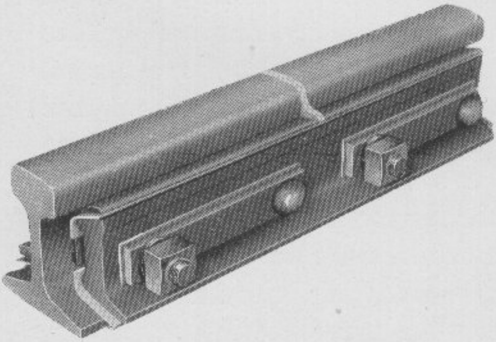
The operation of a single switch by a lever of the Electro-Pneumatic interlocking machine; the control of the lever's final action to release signal levers by the complete response of the switch to preliminary movements; the continuous, active control of each signal governing traffic over each switch by switch position; and the restraint of lever operation by trains while standing upon or moving over switches, are all embodied in the diagrams, Figs. 16, 17, 18 and 19, which are presented to show chiefly the successive events in switch operation by lever movements and the control of lever action by responding switch action.

Fig. 16, represents the switch lever in its normal position, the switch also normal, the indicating system in corresponding condition and the switch as unoccupied by trains and its lever free to be operated.



Model "12"
Polarized D. C. Relay.





Keystone Insulated Rail Joint.

Fig. 17, shows the lever operated as far as the indicating segments and latches permit of, the switch valve as having responded and the switch as responding—at mid-stroke. It shows the effect (the shunting of indicating wires) produced in the indicating system by the mechanical unlocking of the switch prior to and during its change of position.

Complete Switch Circuits

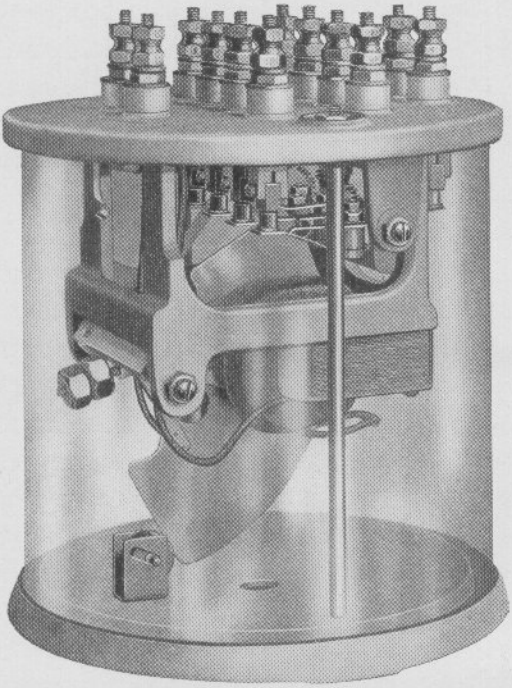
Fig. 18, represents the conditions of Fig. 17, excepting that the switch has fully shifted, locked and indicated in response to the partially reversed lever; the effect of this complete reversal of the switch being to energize that one of the indicating magnets which heretofore restrained the lever from further action. This is accomplished through the medium of the polarized indicating relay, already referred to, which jointly controls the indication magnets and the current supply to all signals governing movements over the switch to which they pertain.

Fig. 19, shows the relation of parts and the condition of circuits that follow the full and final movement of the switch lever that is permissible after the switch has fully moved and indicated in response to the preliminary lever movement, as illustrated in Fig. 17. In Fig. 19, the lever, switch, polarized relay, quick switch and other lever contacts are in what are recognized as their full reversed positions, positions removed in the extreme from those assumed by like parts in Fig. 16, where full normal positions are shown.

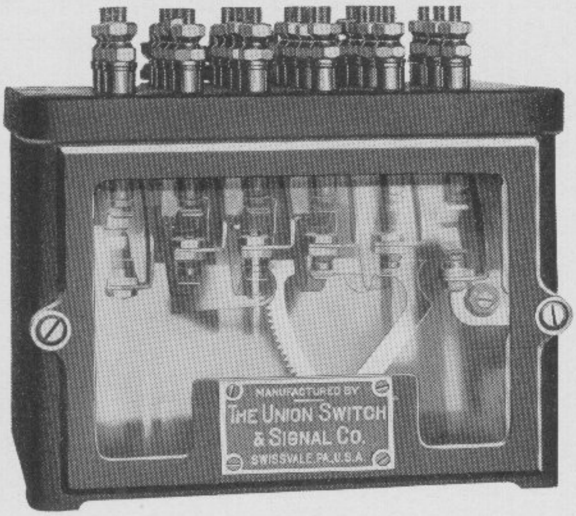
It will be observed from Fig. 15, that upon the assumption that a signal lever has been operated to permit a train to move over the switch, the switch lever shown is mechanically locked in the position it assumes, and this fact secures the lever, the switch-valve, the switch, the indicating circuits and the polarized indicating relay in the following respective conditions; the lever normal; the normal switch valve-magnet energized; the slide-valve held and locked positively in normal position by air pressure; the switch resting without pressure in its cylinder in its normal position and mechanically locked there; the two indicating wires maintained at different potentials of a given polarity; the polarized indicating relay energized to close its neutral contacts and its normal polar contacts; a source of electric current including the neutral contact and one of the closed polar contacts that constitute parts of a circuit which includes also the open contacts of the quick switch and the helix of the normal indication magnet; a second circuit employing the neutral contact of the polarized indicating relay and the other one of the closed polar contacts as the source of current supply to those contacts actuated by signal levers that primarily operate the one or more signals that govern train movements over the switch.

Safety Factor in Signal Control

Obviously, under this assumption the switch lever cannot be moved until the signal lever is placed normal and the signal is in the stop position. The operation of the switch therefore by its lever compels a prior act of the signal lever which withdraws or withholds train rights over the switch. The operation of the switch by other means than its lever, as by the malicious or accidental manipulation of its operating mechanism, will be first accompanied by an interruption of the electric energy in the indicating wires and then a shunting of these wires against influence from foreign sources. This produces a de-energization of the indicating relay, the effort of which is to cause it immediately to cut off the electrical energy, through its contacts, by which each signal governing movements over the switch is controlled, and thereby to place at stop any such signal as may at the time be in the pro-



Vane Relay.



Model "12" Polyphase Relay, Three Position.

ceed position, or, should all of them be in the stop position at the time, prevent the operation to proceed of any such signal. In other words, the improper operation of a switch in this manner establishes the same condition of the indicating relay, as is established by failure of it to operate properly by its lever, and maintains that condition until the lever and switch are made again to coincide fully in position. When in ordinary operation the switch assumes a reversed position by virtue of a partial reversal of its lever, as in Fig. 18, the indicating relay becomes again energized, but by current of a reversed polarity from that existing when the switch and lever were normal. The effect of this is to shift the polar contacts of the relay to establish current through the reverse indication magnet and the closed contacts of the quick switch, and thus to release the lever for final movement to its full reversed position. This final movement causes action of the quick switch again to open the circuit of the reverse indication magnet, and so to connect the normal indication magnet with the open polar contacts of the indicating relay as to prepare that magnet for its next indicating function. This is shown in Fig. 19.

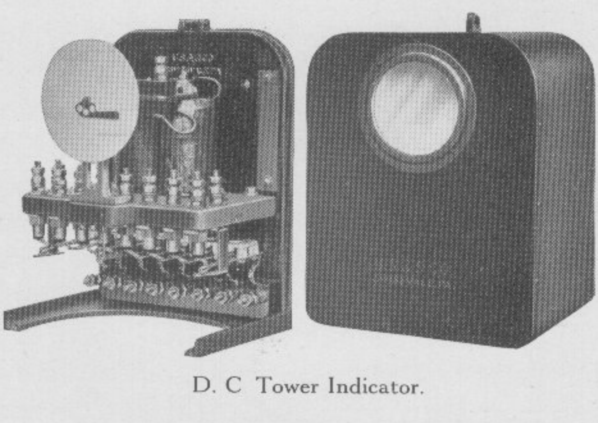
The Quick Switch

The control of the indication magnets by the quick switch in this manner involves the use of but one magnet at a time for indicating purposes, and hence, leaves at all times one of the magnets free for other duties if desired. It is this fact that prompted the alternative use of each indication magnet for detector circuit switch lever locking by trains in the Electro-Pneumatic system.

"X" and "Y" Contacts

To render this effective, two contacts operated by the switch lever are employed, that are designated as "X" and "Y" contacts, for the purpose of throwing, alternatively, the indicating magnets into circuit with the contacts of a track relay that embraces the switch rails in its control. In this way, trains entering upon the switch cause that one of the indicating magnets that was last used for switch indicating purposes to remain upon open circuit and therefore to prevent initial movements of the lever, until the train has passed clear of the switch. The locking circuit thus formed also passes through a contact that is acted upon jointly by both the catch-rod and the lever—a contact closed as the catch-rod is elevated to energize the lock, if the track is unoccupied, and which is opened again by the lever during its movements between its positions of engagement by the locks. This is done by the latch to economize in current energy when the lever is at rest in either the normal or the reversed position, and by the lever absolutely to disconnect both magnets from any possible current influence save that peculiar to the indicating system, as soon as the lever moves beyond the influence of the automatic track circuit control of levers and into that entirely separate field of control that embraces only the switch indicating system.

Because of the vitally important functions performed by the indication system in Electro-Pneumatic



D. C Tower Indicator.

power interlocking, i. e., first, the coincidence in position of switch and lever before final lever movement can be made, and second, the continuous and active control of signals by switch position thereafter, every precaution that could be consistently taken to insure reliability of action under all probable conditions has been taken in its arrangement. The separation of the indication circuit of each switch from electric contact with any part of any other circuit between the switch and the interlocking machine, was the first step; the use of individual circuits so arranged for each switch or set of switches operated by a single lever was the second step; the use of a current of one polarity for indicating one position of the switch, and the use of a current of an opposite polarity for indicating the other position of the switch, and means for shunting or short-circuiting the two indicating mains at the switch until the switch is properly locked in one or the other of its two positions, constitute the third provision; the fourth provision embraces the use of the polarized indicating relay at the interlocking machine so adapted as to control jointly the current supply to both the indicating magnets of a switch lever and to each and all signals governing traffic over the switch or switches operated by the lever.

These features are self-evident from the four diagrams, Figs. 16, 17, 18 and 19. The degree of protection afforded by the method may be given special study under all four of the successive stages of switch operation from normal to reverse, or vice versa.

Especial care has been exercised in the design of the indication circuit controller used in this system to insure absolute reliability of operation, extreme current capacity of contacts, great durability both in its wearing parts and in the character of the insulations employed throughout its construction. Provision for

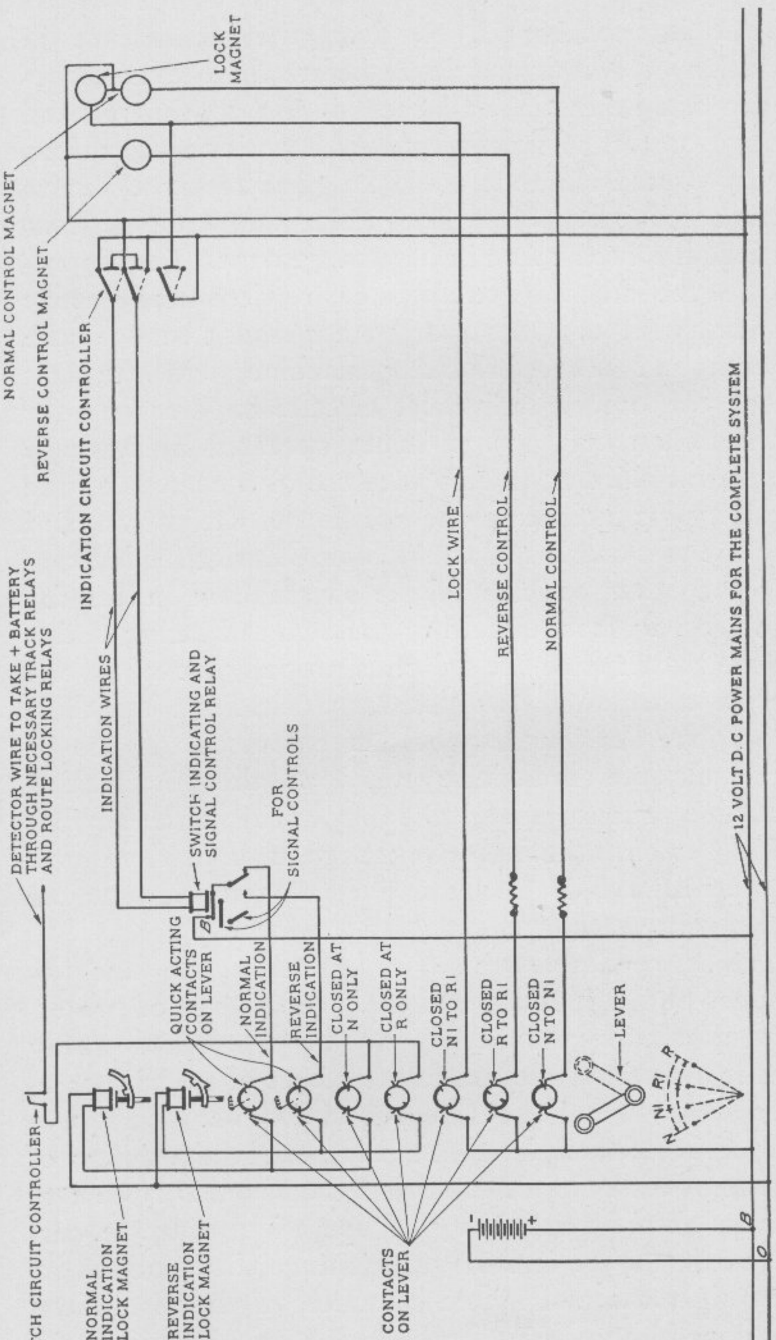


Fig. 30. Diagram of Complete Control, Indication and Locking Circuits for Single Switch with D. C. Indication.

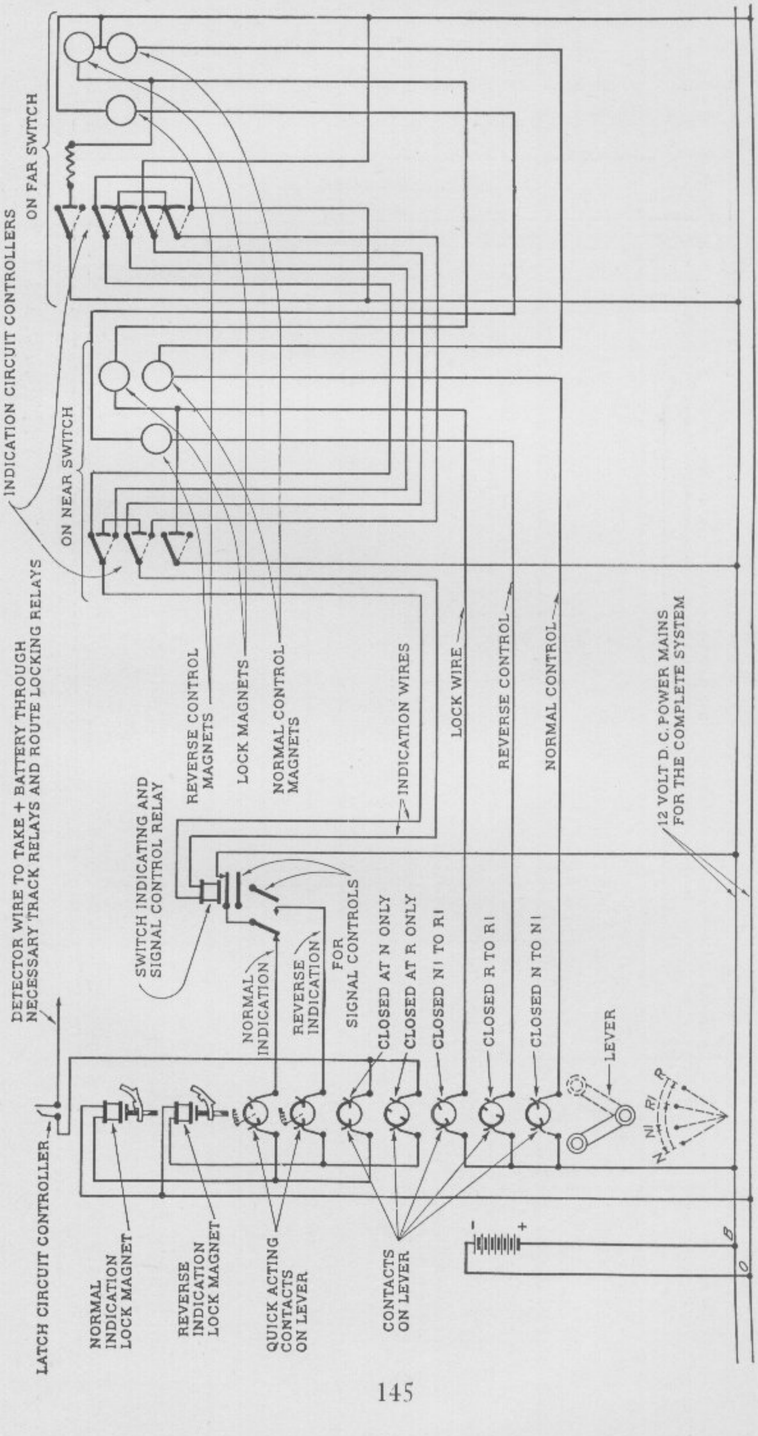


Fig 31. Diagram of Complete Control, Indication and Locking Circuits for Crossover with D. C. Indication.

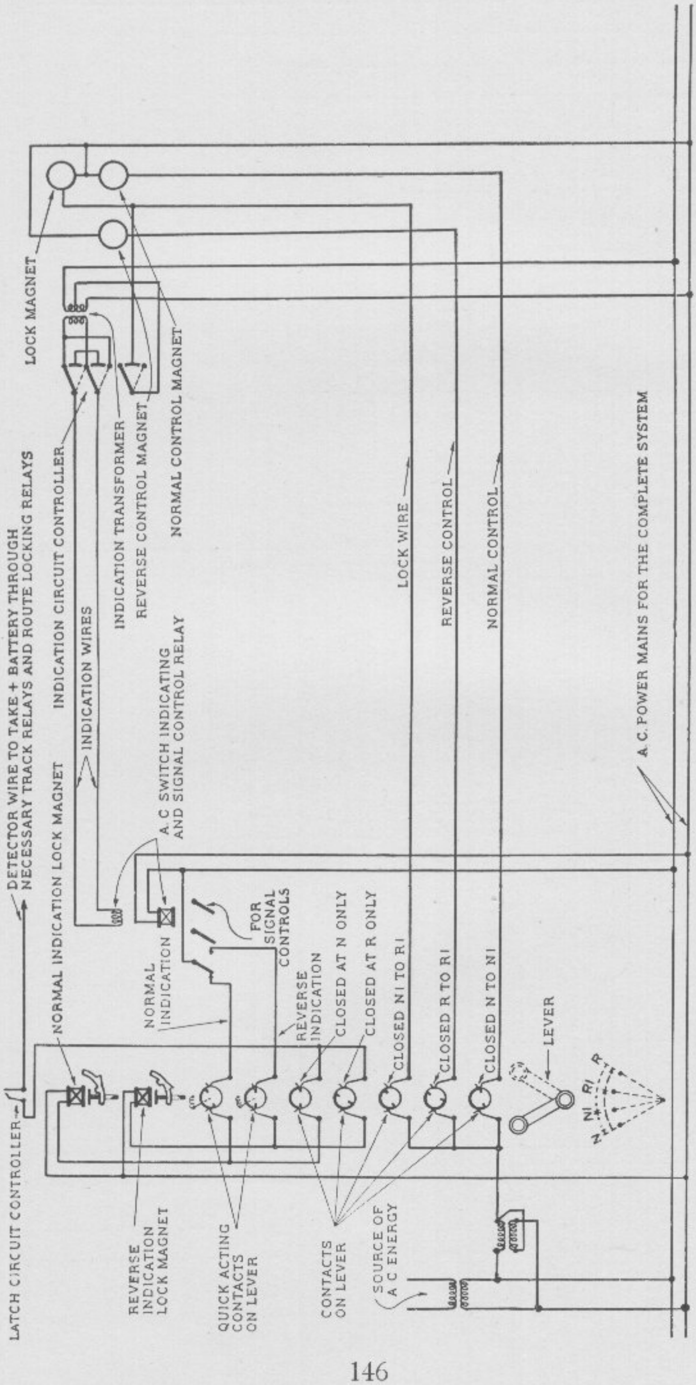


Fig. 32. Diagram of Complete Control, Indication and Locking Circuits for Single Switch with A. C. Indication.

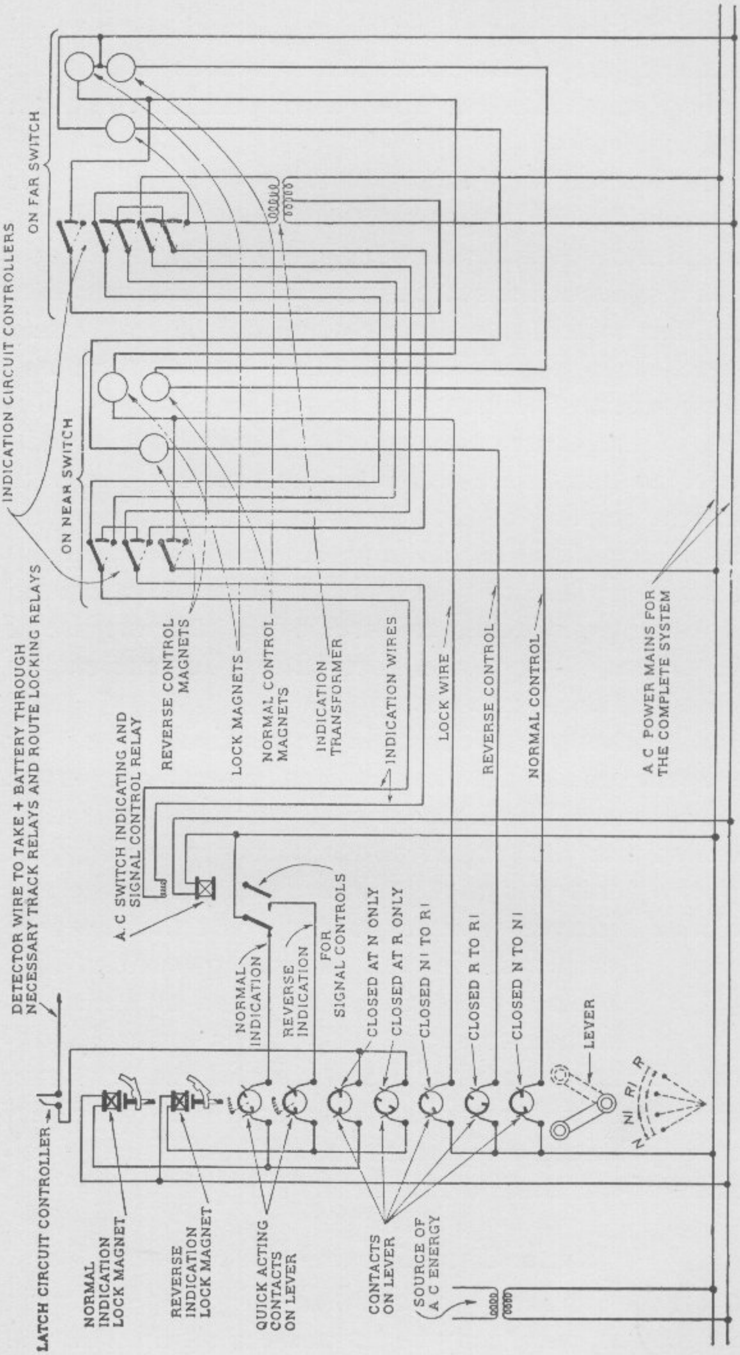


Fig. 33 Diagram of Complete Control, Indication and Locking Circuits for Crossover with A. C. Indication.

locking the box by pad-lock is made, and an armored conduit conveys the indication wires to a suitable junction point with the other wires peculiar to switch operation.

In addition to those contacts essential to the indicating system proper, one additional contact is provided in the indication box for applying current directly to the magnet of the switch valve lock at all times, save when the switch is completely normal or completely reversed and properly locked there—this contact and the connections necessary to this end are clearly indicated in the diagrams, Figs. 16, 17, 18 and 19, and insures an immediate action of the switch cylinder to resist the shifting of the switch by any but legitimate means. Figs. 30, 31, 32 and 33 show conventional diagrams of these circuits which include the operation of both single switches and crossovers, and the use of both Direct Current and Alternating Current energy for the indicating circuits.

Alternating current being extensively used for the operation of automatic block signals and track circuit control, because of the added safety thus obtained and the greater power economy resulting, it frequently happens that at interlocking sites there is available a source of alternating current that may be employed in the indicating system. To utilize it for this purpose, a small transformer to supply the energy for each indicating circuit is located at the switch and an alternating current polarized relay is substituted for the direct current polarized relay in the tower. No other modification of the D. C. arrangement is required.

A. C. Indication

Signal Operation and Control

Signal Operating Mechanism—Fig. 34, shows, in cross section, what may be termed the signal motor of the system: comprising the magnet and pin valve

Mechanism

already described, and the cylinder and metal-packed self-aligning piston by which the signal is operated from one of its positions to another. Where a signal embraces three positions of indication, two such devices are employed to act jointly upon it, one for each proceed indication displayed.

Each device is modified in the arrangement of its elements to meet the needs of dwarf signal construction, to obtain that compactness of design which these signals demand because of the restricted spaces in

Flexibility of Application

which they are frequently required to be placed. The mechanism is also frequently adapted to other duties than that of signal operation—such, for instance, as the operation of automatic train stops, highway crossing gates and bells, and the bolt-locking of outlying switches, drawbridges, etc., the operation of gate-valves, ventilators, circuit breakers, whistles and like appliances remotely located, yet demanding reliable and rapid response to the action of attendants or to the automatic action of other controlling mediums. In signal operation, the pistons of these motors have a uniform diameter of 3 inches (7 sq. inches area) and a stroke of 2¼ inches for dwarf signals and 4¼ inches for high signals.

Attached to every Electro-Pneumatic signal motor is a circuit controller that actuates certain electric contacts at predetermined positions of the signal. These contacts control the electric locks of signal levers whereby the latter may not be restored to normal until the signals which they operate have first assumed the stop position; they also control the circuits of other signals and govern the display, by the other signals, of those indications which relate to conditions more or less common to both.

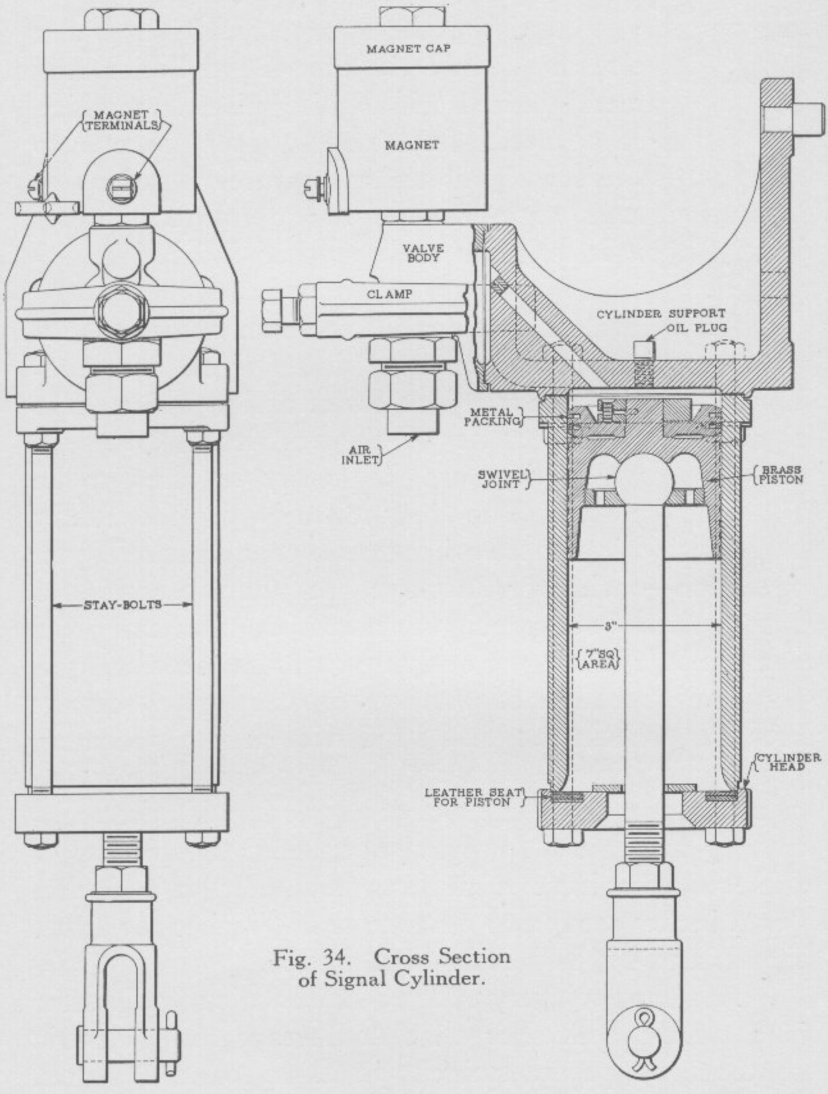


Fig. 34. Cross Section of Signal Cylinder.

In three-position signals, while a single cylinder, valve and magnet are employed for each of the two proceed indications displayed by such signals, the air supply is direct from the main to that valve and cylinder only by which the caution or 45 degree position is displayed; the air supply to the other valve and cylinder being drawn from

Three Position Signals

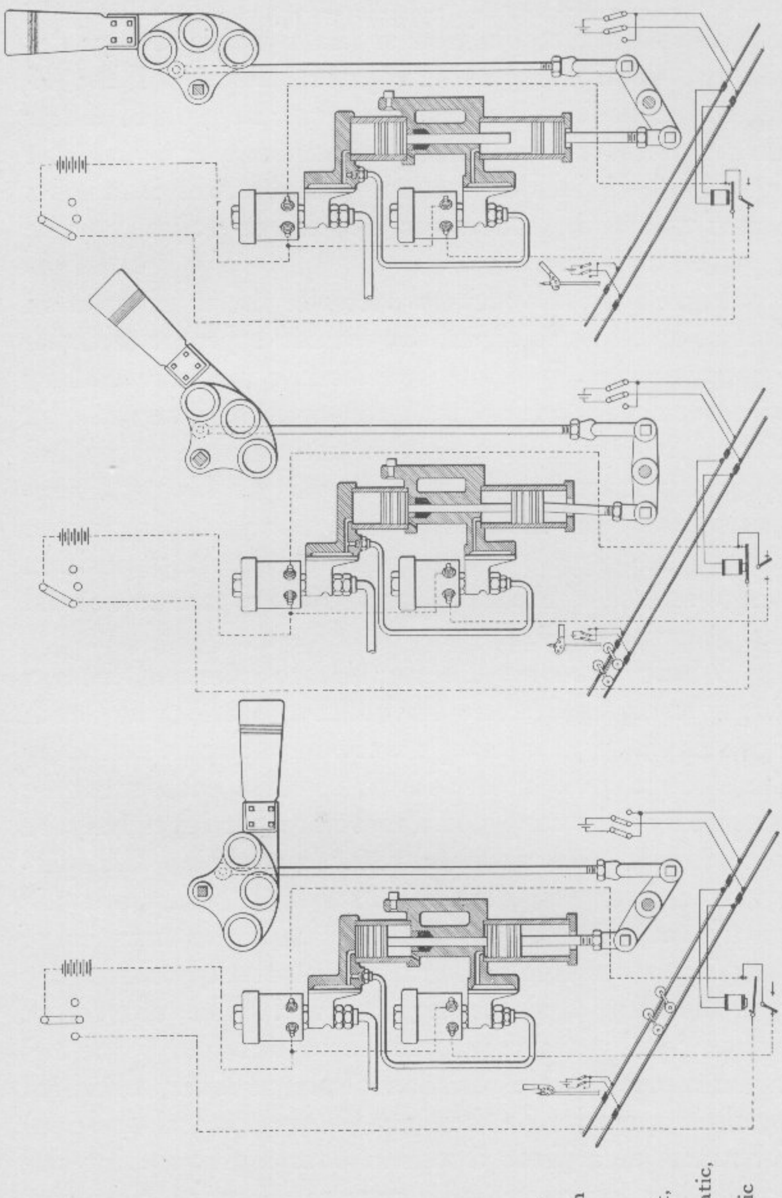


Fig. 35. Diagram Showing Operation of Three Position, Upper Quadrant, Semi-automatic, Electro-Pneumatic Signals.

the 45 degree position cylinder. This is done to insure that the 90 degree position of the signal is always dependent upon the complete prior activity of the 45 degree mechanism, and that the interruption of either the air pressure or the electrical current by which the signal is held in the vertical position will insure its return therefrom whichever magnet or valve may be deprived of power.

Fig. 35 shows sectional views of the three-position Electro-Pneumatic signal movement together with its joint operation from the interlocking machine and by automatic train action upon the track it governs. Fig. 22 is a diagram illustrating the method of selecting and operating several signals from a single Electro-Pneumatic lever and the manner of insuring the return of any of the signals so operated to the stop position before release of the lever for its final return to normal can be accomplished.

Where two or more signals are operated from a single lever, in Electro-Pneumatic interlocking, each signal is made to interrupt a common circuit including the electric lock of the lever, so that each must be returned to the stop position before the lever may be put normal and another route signaled. The perspective diagrams, Figs. 20, 21 and 22, illustrate this control of the lock circuit and also the manner of selecting a number of signals, by switch position, for operation by a single signal lever. The control of signals in this manner is made of two-fold value because of the double function of signal levers obtained by their operation to the right (from a central position) for routes of a given direction over a given point and to the left for routes of a reverse direction that conflict with the first mentioned routes. The semi-automatic control of a group of signals thus operated is possible from a single track circuit, frequently, and by means of a single contact of the track relay. These features grow conspicuous in their influences to concentrate the control of many functions within comparatively simple and hence very trustworthy instruments, and are of especial value in route locking and in the control generally of signals and lever locks by train action.

It is obvious that Electro-Pneumatic signals may be of two or three positions; upper or lower quadrant; right hand or left hand; one arm or two or more arms as desired with no modifications excepting those of the supporting structure—the signal post. The signal is equally well suited to control by both A. C. and D. C. energy, the only modification required being in the magnet by which the pin valve is actuated. These magnets are interchangeable on all signals.

Route Locking

In order to illustrate the basic principles upon which sectional route locking is arranged and, at the same time, to show its relation to other prospective features of Electro-Pneumatic interlocking, the diagram, Fig. 36, is presented. The track layout is of the simplest form necessary to the purpose, the two switches therein serving quite as well as a greater number of switches in a more complicated track plan to illustrate the automatic locking of all switches in a given route and the individual release of each after the passage of the train beyond the fouling limits embraced in the two track leads of each. These two switches serve also to illustrate the principle of selecting signals by switch position, when a number of signals are operable from a single lever. It will be observed from the plan that the rails of each switch are included within separate track circuits, and that these circuits embrace both leads as far as their fouling points, and extend in each direction to the

Track Plan and Circuits

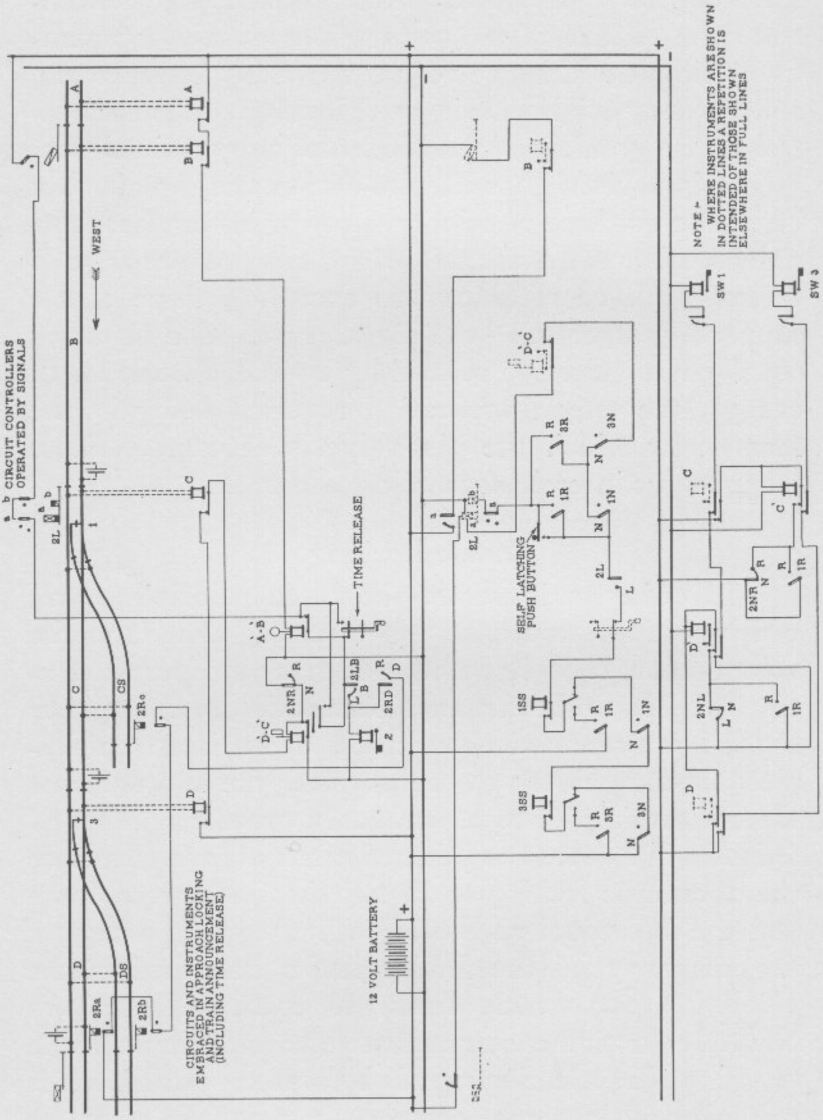


Fig. 36.
Diagram of
Sectional
Route
Locking
Circuits.

signals governing movements over these two switches. A track circuit also extends from the signal which primarily governs the first switch to the preceding signal, usually called the "distant" signal. A fourth section also extends from this distant signal to a point preceding it 3,000 feet or more. These sections are designated on the plan by the letters D, C, B and A. The switches are designated by the numerals 1 and 3, corresponding with the numbers of the two levers assigned to their operation. The signals are all operated by lever No. 2; the three eastbound signals being operated by the lever thrown to the right and the two arms of the westbound signal by the lever thrown to the left—this being possible because each of these signals conflicts with each other signal under all circumstances.

The operation of signal 2L-a for a westbound train requires that switches 1 and 3 be set and locked as shown, before lever 2 may be moved to operate the signal. The operation of lever 2 to the left through the mechanical locking of the machine locks levers 1 and 3 normal, and hence the switches 1 and 3 for the route governed by the signal so long as lever 2 remains moved from its normal position.

It will be evident, therefore, that even though signal 2L-a be restored to the top position by the partial return of the signal lever toward normal, the switches of the route still remain mechanically locked. It is evident, too, that whether lever 2 is retained out of its normal (central) position by choice or by compulsion, the switches remain locked with equal security. The return of signal 2L-a to normal, ordinarily, releases the lever for its restoration to normal; where route locking is in vogue, this release of the lever by the signal's return is made dependent upon an added condition. This con-

Approach Locking

dition is that a train has not, previous to the signal's return, entered upon the track circuits A or B. If the train has so entered, its approach is automatically announced to the operator by annunciator A'-B', and the electric lock of lever 2 is retained upon open circuit during the train's presence upon either of the sections. Before the annunciator A'-B' can be re-energized to release the lock 2, the train must have left sections A and B completely. If its leaving was by permission of signal 2L, the train naturally entered upon section C before it left section B. This act causes, through relay C, the indicator D'-C' to become de-energized before the annunciator A'-B' becomes re-energized and releases the lock of lever 2 whereby that lever becomes free to be put normal and the mechanical release of switches 1 and 3 becomes possible. The release of lever 2 by indicator D'-C' when this indicator is de-energized has another important function. If a second train enters section A-B before lever 2 is restored (this lever having been thrown to clear signal 2L for a previous train), indicator D'-C' will not pick up, being a "stick" indicator. The release circuit, through a back contact of indicator D'-C', will remain closed and allow the leverman to restore lever 2 although the lock circuit of lever 2 is open through indicator A'-B'. The signal lever may also be restored while a train is in section A-B by the use of a time release, the operation of which is described in a subsequent paragraph. Should lever 2 be restored to normal after a train has accepted Signal 2L, the release, mechanically, of levers 1 and 3 that follows is without danger, because the entrance of the train upon section C (that necessarily preceded this event) caused, through relay C, the interruption of the electric lock circuit of lever 1, and through stick relay C', the interruption of the electric lock circuit of lever 3; thus effectually retaining these levers still locked against operation, but by direct electric means peculiar to each.

While switch levers are thus locked automatically in groups by train action upon the first switch of the group, their release must occur not in like manner by the exit of the train from the last switch of the group, but each lever must be released individually as the train passes over its switch and clear of the fouling limits of the switch leads. The movement of the train westward off of section C and into section D causes relay C and stick relay C' to become re-energized and the electric lock of lever 1 released. Before this occurs, however, relay D has been de-energized, by the entrance of the train upon section D in its movement from section C, and hence the circuit of lock 3 is continued open at relay D, notwithstanding its closure at relay C', and lever 3 still remains locked until the train passes entirely clear of section D and until relay D becomes thereby re-energized.

Switch Locking

It will be observed that stick relay D' is not operated with relay D, for were this done, the lock circuit of lever 1 would be opened thereby and the release of switch 1, which is desirable, would not follow the train's exit from section C. The action of the train on section D, and the consequent de-energization of relay D, would not open the circuit of relay D' because of a "by-pass" formed by lever 2 when that lever is not in a position for governing eastbound traffic. This by-pass bridges the open contact of relay D and prevents the action of relay D for westbound traffic; when lever 2 is thrown to the right, however, for signaling eastbound traffic, the train's action upon section D operates not only relay D, but also the relay D', thereby opening the lock circuits of both levers 1 and 3. Upon passing on to section

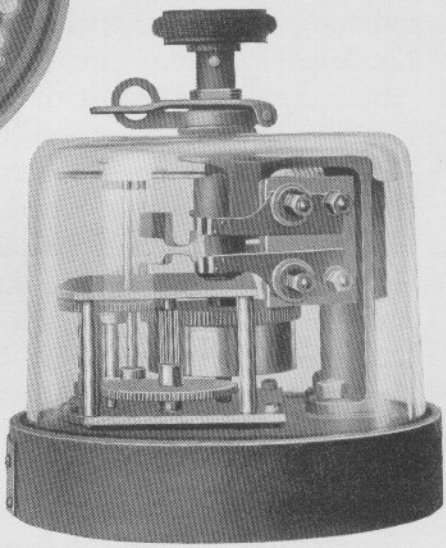
C, relay C only is de-energized and not relay C', as when the westbound train entered section C from section B. Relay C' is thus retained in an energized state by virtue of a by-pass formed by lever 2 when that lever is in any position other than that employed for eastbound traffic, and hence when the train moves from section D into section C, the re-energization of relay D closes the lock circuit of lever 3 and releases switch 3 for possible operation. This would not occur did not the relay C' remain energized, through the by-pass referred to. The lock circuit of lever 1 is necessarily opened by relay C before the exit of the train from section D into section C fully occurs, so that after the occurrence, when both relay D and relay D' are energized, the circuit of lock 1 remains open at relay C and until the train passes clear of section C, whereupon switch 1 may be moved if desired.

It will also be observed that when switch 1 is reversed, a by-pass is established on stick relay D' which causes this relay to remain energized regardless of the condition of track relay D. The purpose of this by-pass is as follows: With switch 1 reversed and a westbound train having not yet cleared section D, if signal 2R-c were cleared for a second train to move from siding CS to the main line, stick relay D' would open if it were not for this by-pass and switch 1 would be locked and remain locked as long as the first train stood on section D, thus preventing all movements of traffic over switch 1 in its normal position. A similar by-pass acts on stick relay C' and prevents switch 3 from being locked while a train is passing into siding CS after having accepted signal 2L-b. This latter feature is not very important with this particular layout, but with a more complicated arrangement of tracks and switches it is essential to prevent the tying up of several parallel train movements under the conditions cited.

Approach Detector and Section Locking

That feature of automatic lever locking by trains, which is peculiar to the action of trains prior to their entrance upon the switches of the interlocking, is gener-

Fig. 37. Clockwork Time Release.



ally referred to as approach locking, and embraces also the automatic announcement of trains. That feature which involves the action of lever locks by train movement over the switches of the interlocking, is generally termed detector locking and sectional route locking. The latter feature embraces, besides the automatic locking and releasing of switch levers, the semi-automatic control of signals by trains through the medium of track circuits common to both.

In the diagram, Fig. 36, the circuits peculiar to the operation and control of the two westbound signal arms only are shown in the interest of simplicity. The top arm only is under automatic control by trains (through the indicator D'-C'), since the lower arm is here assigned to movements into either one of the two sidings whether these be occupied already or not, and also to the main track D, only in case that track is already occupied, and the top arm is hence restrained against operation by indicator D'-C', for such train movements. The use of the lower arm in this capacity is as shown not possible by lever action alone, but demands in addition the operation of a push button which is mounted behind the signal levers so that its operation is convenient only when the lever is moved from normal—a movement that must necessarily precede the effective use of the button for clearing the "calling-on" arm. This button, when depressed, closes a pair of contacts in the signal circuits that are effective to clear the calling-on arm providing the high speed signal above it is in the stop position, and providing also that the signal lever 2 is moved to the left.

Calling-on Arm

The current supply to both arms is also drawn through contacts of a device known as a "time release," Fig. 37, and already referred to in a general way. This is done in order to insure that the first act of its operation will be to open the signal circuit and thus prevent any possible operation of the signals until the device has been again returned to its original position. The operation of the time release to unlock electrically during emergencies a lever properly held locked by train action, requires first, a distinct action by the leverman, and second, that a sufficient period of time must elapse, following this action, to insure that the train, which is locking this lever, has either stopped or is traveling at a reduced speed, before the lever is restored to its normal position. It is also to compel the restoration of the time release to its normal position after each operation (before signals can be again operated for traffic movement under them) that signal circuits are thus controlled by contacts on the time

Time Release

release. The current supply to both signals is further drawn through contacts of other devices than the indicator D'-C' and the time release. In order to insure that a misplaced switch, wrongfully set from any cause out of coincidence with the new position of its operating lever, and to insure also that a lever which from any cause assumes a position at variance with that of the switch it operated, may effectually prevent the display at such times of any signal giving proceed rights over the switch, this current supply is also drawn through the contacts of the switch indicating relay and through corresponding contacts operated by the switch levers.

When several signals are controlled by one lever, the control circuits are also carried over the additional contacts on the switch levers to determine which of the several signals is to operate. For example, with switches 1 and 3 normal, if lever 2 is moved to the left signal 2L-a will be cleared, but if either of the switches 1 or 3 is reversed signal 2L-b will be cleared.

Signal Selection

The control of the switch indicating relays jointly by lever and switch position has already been described, and is clearly illustrated by the four diagrams, Figs. 16, 17, 18 and 19. The semi-automatic control of signals in its simplest form and as applied to 3-position signals, is shown diagrammatically in Fig. 35.

In adapting the Electro-Pneumatic interlocking system to the requirements of any particular track and signal lay-out, the first step is to group the switches for operation by the least number of levers possible, numbering the switches to correspond with the levers assigned to their operation. The second step is to group in like manner the signals for operation by the least possible number of levers, numbering the signals to correspond with the levers assigned to their operation. The switches and signals being thus designated clearly by the number of their operating levers and the size of the machine being thereby established, the mechanical locking of one lever by another or by others is next worked out, as in mechanical interlocking practice. This constitutes the third step in the development of an interlocking. The mechanical locking of Electro-Pneumatic machines is greatly simplified, as compared with that which would be required of a purely mechanical machine adapted to the same track and signal layout, by reason of the much greater capacity per lever of the former and the consequently reduced number of levers it requires.

Laying Out a Plant

The fourth step consists in subdividing the track layout into track sections in such a manner, that, as far as is practicable, the rails of each pair of diverging, converging or intersecting tracks shall comprise a separate section throughout that portion of each wherein each fouls the other. Track sections are also formed of the rails of tracks lying between the sections referred to, and these track sections are primarily for the automatic locking and releasing of switch levers by trains (in lieu of detector bars), but are also utilized for the semi-automatic control of signals by trains, where this practice is employed. The fifth step consists of laying out the detailed circuits for the control of signals, approach locking of signals, detector and sectional route locking of switches, etc., according to the requirements as described in these paragraphs.

Track Circuits and Electric Locking

Check Locking, or Locking between Towers.

The first requisite of a safe method of preventing the simultaneous entrance of trains from opposite directions onto a piece of common track is the interlocking of the two signal levers by which movements to such

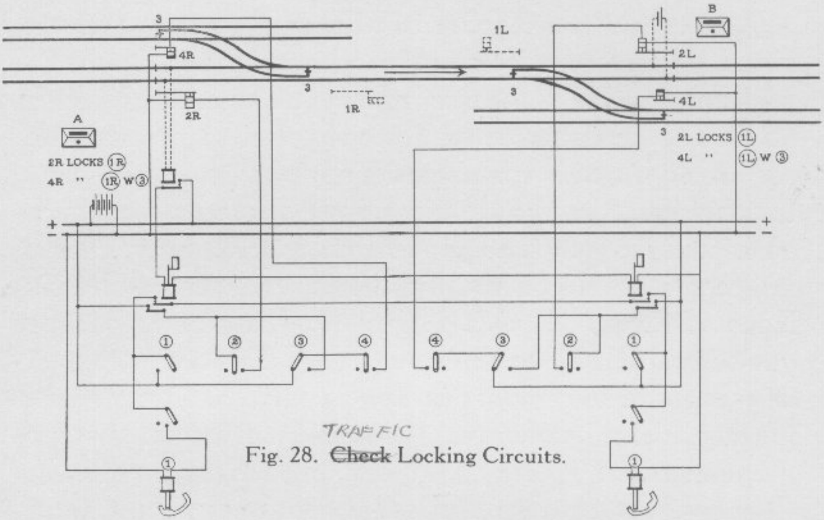


Fig. 28. ~~Check~~ TRAFFIC Locking Circuits.

a track are governed. When both levers are comprised in a single machine (both signals embraced in the same interlocking) this interlocking is done mechanically and in a very simple way well understood. When, however, the levers constitute elements of two separate machines (the signals embraced in two different interlockings), the locking is not practicable by purely mechanical means and is accomplished electrically. Usually, more than one signal governs train movements for each interlocking over a "gauntlet" track. To obtain the simplest circuits and the least number of instruments, contacts, etc., for the protection sought in such cases, an independent lever in each interlocking is employed as a "master" lever and it is to those levers that the electric locking is applied—these levers (through the mechanical locking of the machine) being locked by each signal lever of the machine giving train rights over the gauntlet track. In the assumed case, shown in the diagram, Fig. 38, lever 1L of Tower "B" and lever 1R of Tower "A" are the master levers while 2L and 4L are the actual signal levers of Tower "B" and 2R and 4R are those of Tower "A."

Between the signals of the two towers a track circuit is formed that controls directly an indicator in each tower. The indicator informs the operator at each station of the entrance and exit of trains from the track sections lying between them. They also serve as means for the direct semi-automatic control of the signals of each tower by trains. Primarily, however, these indicators are employed for the control of the electric locks of levers 1R and 1L by train action upon the gauntlet track. The direction of traffic over the track is established by joint action of both towermen in placing their respective "master" levers in proper predetermined positions. While both towermen must thus co-operate to establish conditions essential to any given direction of traffic, each operator has full power to control the signal indications of his own apparatus—

Circuits

granting or prohibiting train movement to the gauntlet track at will after consent of the opposing tower has been obtained. In this control, however, he is restrained from either intentionally or accidentally granting to his neighbor the right to use the gauntlet track until it is wholly unoccupied by trains, and until all signals governing movements to it are at stop, and their operating levers are in the normal position. With these conditions prevailing, that one only of the master levers which granted permission for traffic movements from the tower remains free to be operated at will. Upon the reversal of this lever a similar lever in the opposing tower is electrically unlocked and is then free to be shifted to release mechanically those signals at that tower by which a like unrestricted use of the gauntlet track is reserved to train movements to and from it under the signals of that lever exclusively.

Thus the gauntlet being unoccupied, and each towerman being made aware of this by his indicator, A may desire to move a train under signal 2R to B. This he can do under the conditions prevailing, because signal lever 2R is free to be moved when master lever 1R is thrown to the right as shown. This action of lever 2R, however, operates the signal only upon condition that the current supply to the signal is not interrupted by either or both of the tower indicators. A train acting upon the authority of signal 2R operates that signal automatically to stop through the medium of the track circuit and the tower indicators controlled therefrom, and simultaneously retains the locks of levers 1R and 1L upon open circuit until it passes completely from the track circuit.

While levers 1R and 1L may at any time be placed in their central position, that one at A (lever 1R) may be moved only to the extreme left at all times while that one at B (lever 1L) may be moved only to the extreme right at all times. The application of the electric locks to these levers by train action restrains but one of the master levers against full reversal. For the direction of traffic shown in the diagram lever 1L, Tower "B," is so restrained, while for traffic in the opposite direction lever 1R, Tower "A," is likewise restrained.

When the train has passed clear of the gauntlet track section both indicators give evidence of the fact and the master levers may then be operated to change the direction of traffic. Reversal of 1R locks mechanically signals 2R and 4R against operation while reversal of 1L releases signals 2L and 4L for operation. A westbound train now acting upon authority of signal 2L or 4L de-energizes both indicators and retains both electric locks upon open circuit as before. Now, however, it is lever 1R that is restricted against full operation in reverse by the train until the latter has passed clear of the gauntlet section—thus automatically holding traffic over the gauntlet to conform with its own direction.

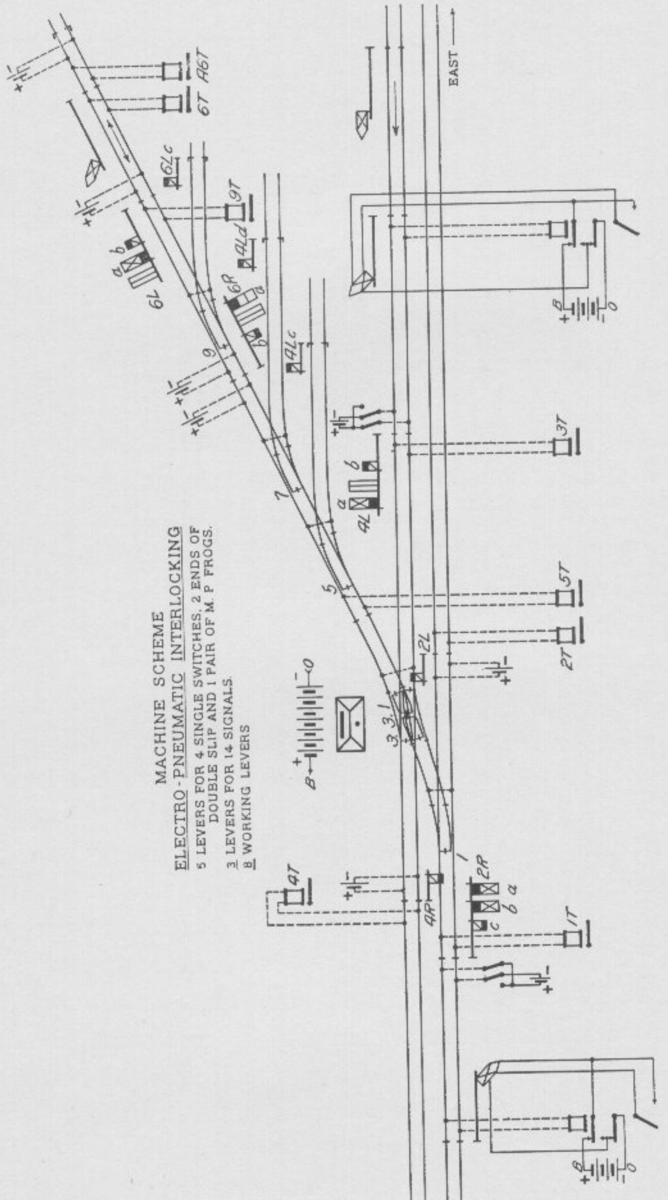


Fig. 39. Complete Layout of Small Electro-Pneumatic Interlocking Plant.

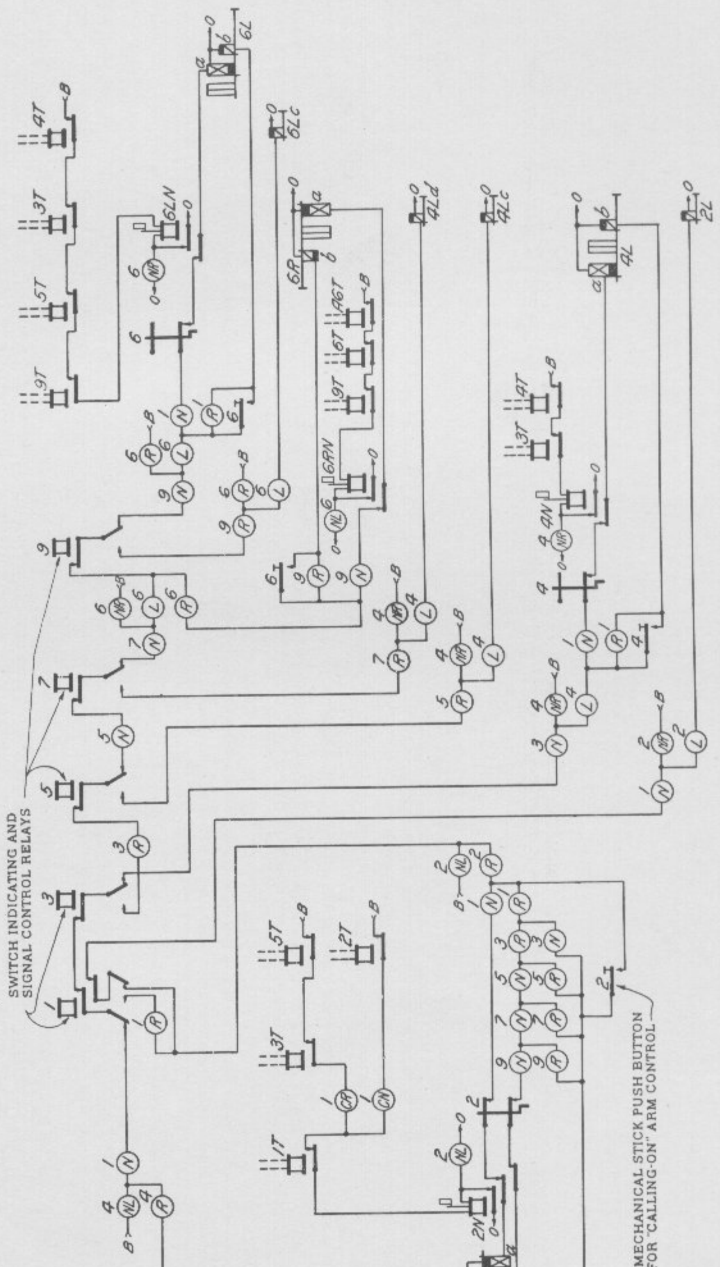


Fig. 40. Signal Control Circuits for Plant Shown in Fig. 39.

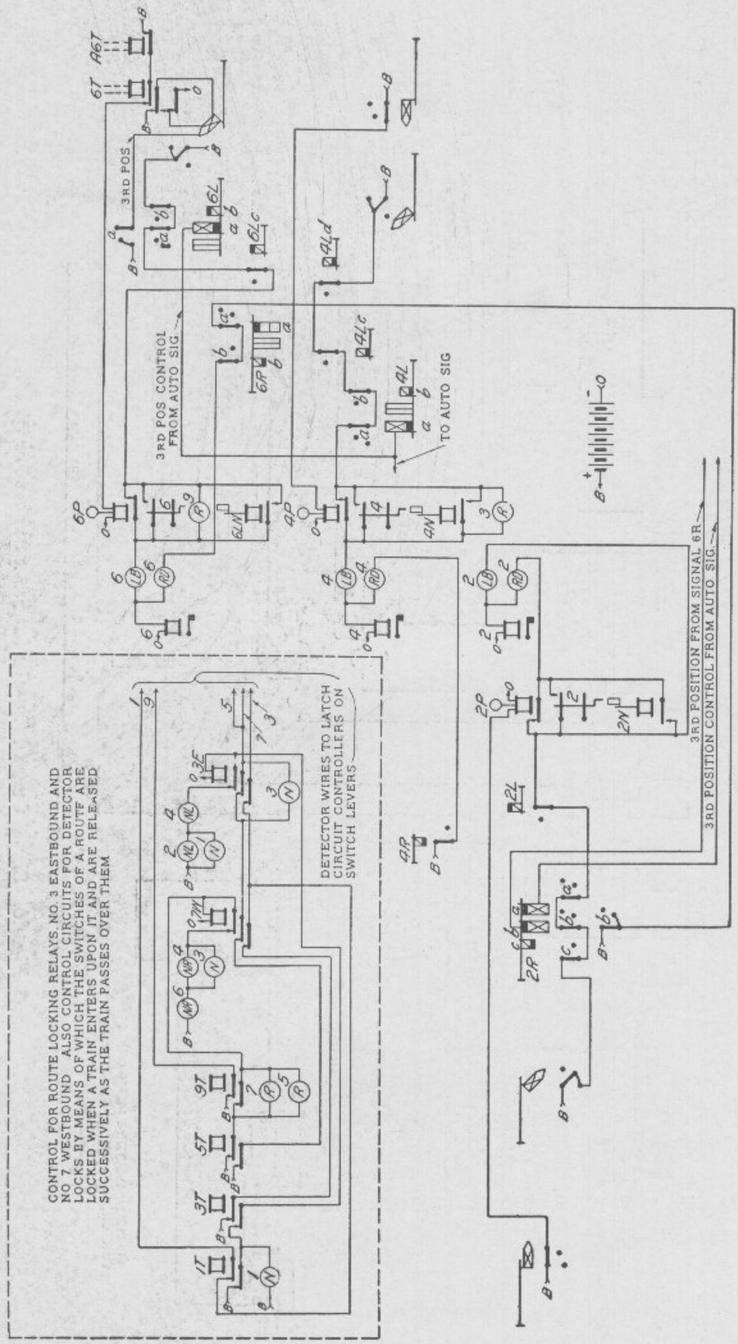
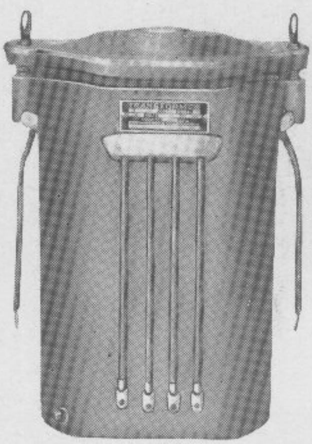
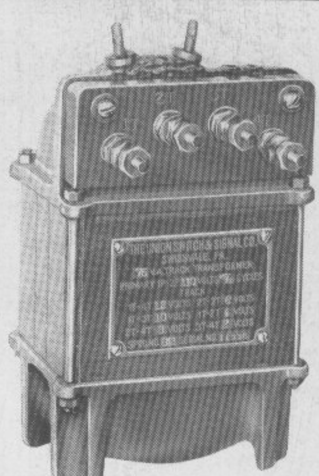


Fig. 41. Control Circuits for Third Position of Signals and for Electric Locking for Plant Shown in Fig. 39



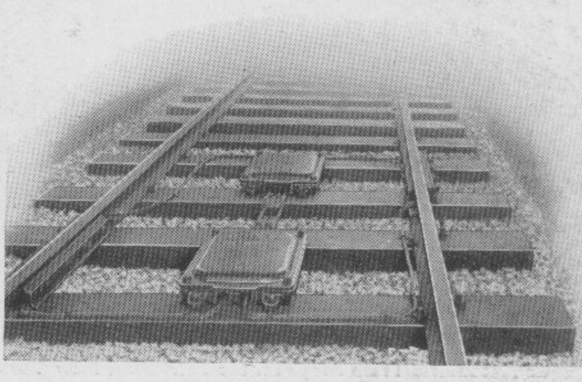
Line Transformer.



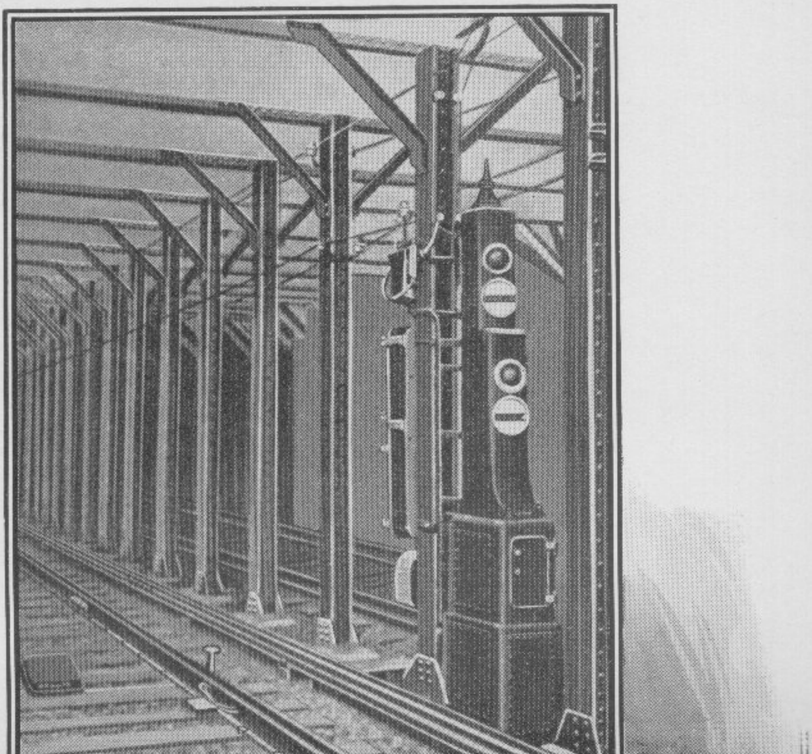
Track Transformer.

Complete Circuits

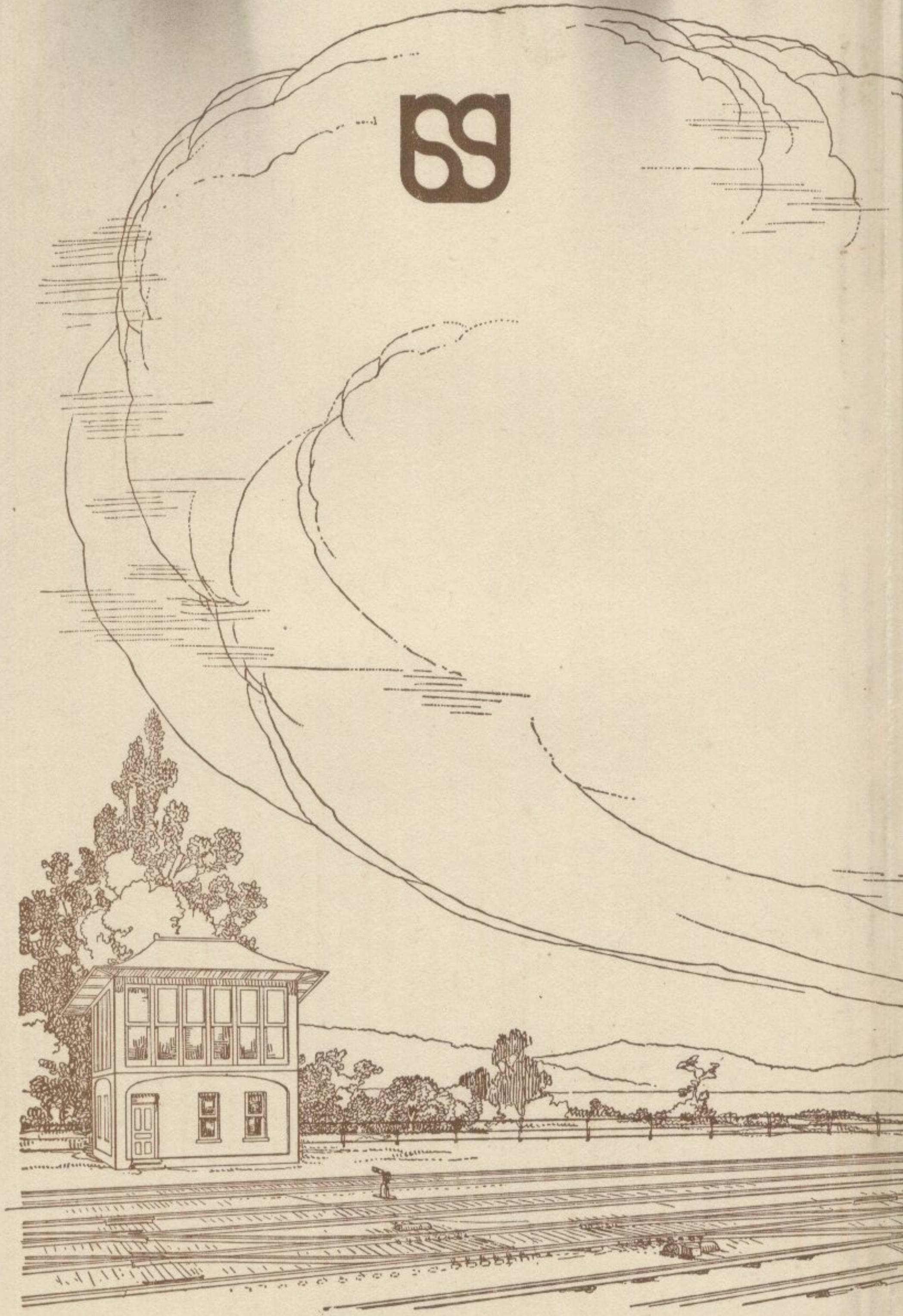
Fig. 39 shows a complete small interlocking plant together with track circuits for the control of the various features of the system. Figs. 40 and 41 show the complete controlling and electric locking circuits for this plant. These features have already been described in detail and are typical of standard practice.

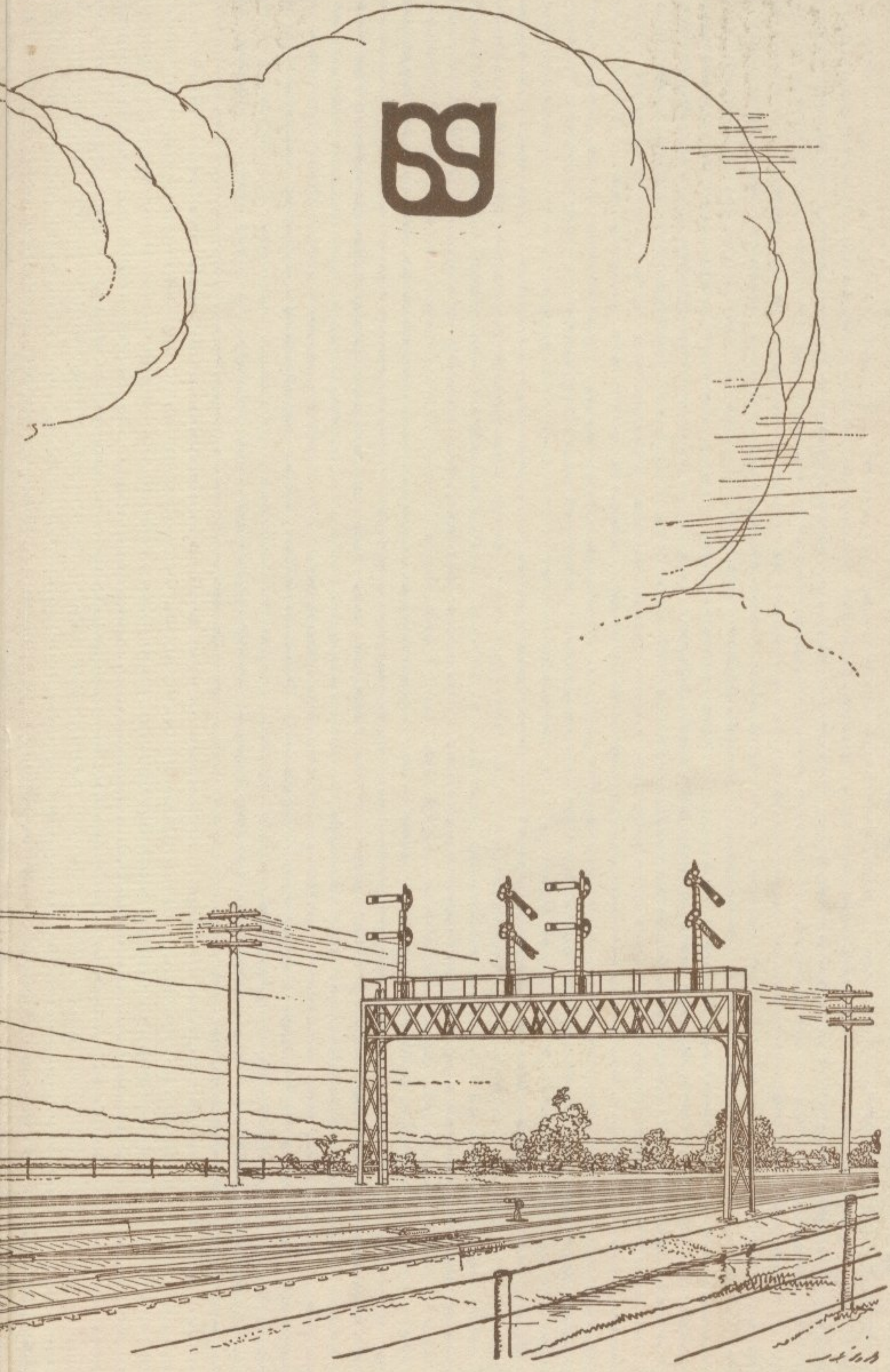


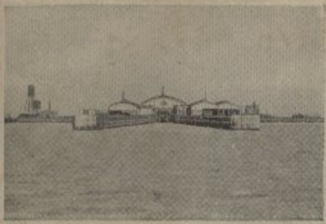
Impedance Bonds.



Electro-Pneumatic Automatic Train Stops on the Interboro, New York City.







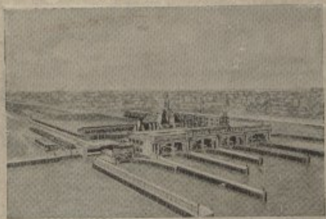
Oakland Pier, So. P. Co.

Memphis Union Station

ELECTRO-PNEUMATIC ·INTERLOCKING·

The Union Switch & Signal Co. Swissvale, Pa.

Boston North Station



Jersey City Terminal, C.R.R. ot N. J.

Hudson Terminal, H.&M.

Broad St. Station, Philadelphia

Park Row Term., Brooklyn Bridge, N.Y.

Jamaica Terminal, L. I. R. R.

BULLETIN No. 73