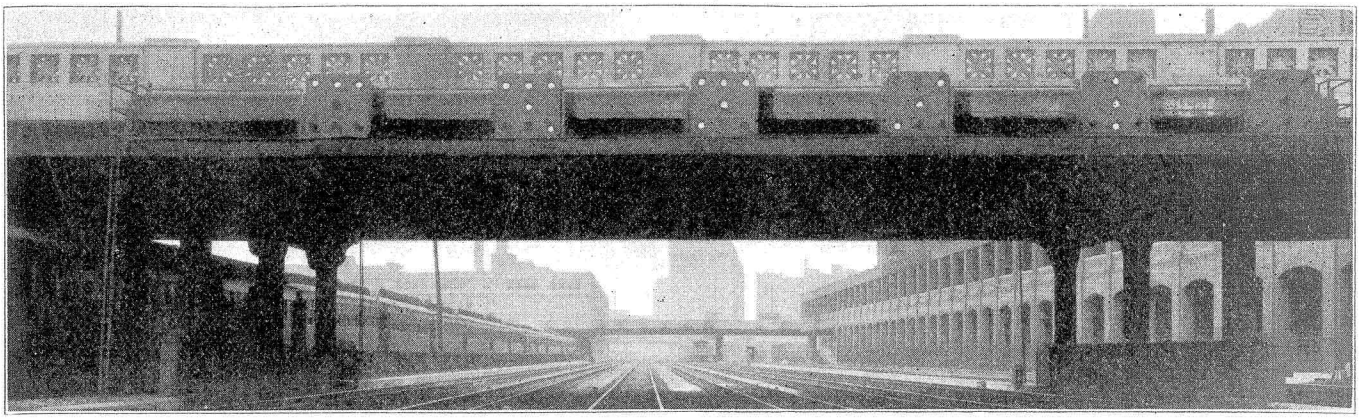


*Light Signals on South Side of Taylor Street Bridge Showing Different Indications*

# Interlockings of New Chicago Station

## Extensive Layout, Using Electro - Pneumatic System Includes Five-Indication Position Light Signals, Master Release and Progressive Signaling

*By Thomas Holt*
Signal Engineer, Chicago Union Station, Chicago.

THE new Chicago Union Station is entering the final stage of construction. In size, traffic and facilities it will rank with the two great terminals at New York. This station is an example of advanced terminal design in which beauty and utility have been combined to an unusual degree.

Notwithstanding the extensive size of the layout, the tracks, concourse and all main station facilities are on the same level. It is said to be the largest one-level station ever built, being in this respect unique among large terminals. The terminal is double end with two sets of stub tracks abutting on opposite sides of a wide transverse concourse. Platform tracks are arranged singly instead of in pairs; passenger and baggage movements are kept separate by assigning alternate platforms for each purpose.

The signal and interlocking plants embody distinctly new features, including four-indication dwarf signals, five-indication high signals, circuits providing progressive indications without change of lever movement and master time release levers selecting between two time elements.

### Track Layout and Signaling Scheme

Daily traffic at this station averages 265 trains handling approximately 50,000 passengers every 24 hours. The number of movements over the interlocking system averages 1,310 daily, including backup movements of empty coaches to and from coach yards, switching movements in making up trains in stations and handling mail cars between trains and mail terminal building.

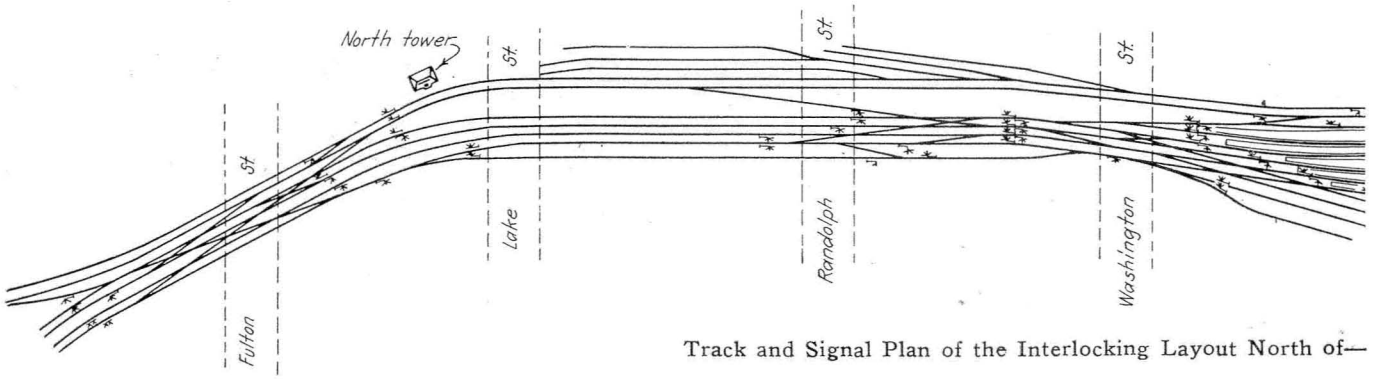
The south end of the station has 14 stub tracks with platforms varying in length to accommodate trains from 7 to 18 cars with their locomotives, allowing 70 ft. for each car. The north end has 10 stub tracks with platforms varying in length to accommodate trains from 9 to 18 cars with their locomotives. The total car capacity is 191 cars in the south end and 141 cars in the north end. There is a six-track main line approach in the south interlocking and a four-track main line approach in the north interlocking.

A single through track on the east side provides for train movements between each end of the station and in addition to this track there are two through tracks belonging to the Pennsylvania. This road has two divisions operating in the station and uses both ends, hence requiring a through line. The south end of the station is used by the Pennsylvania, Chicago, Burlington & Quincy and the Chicago & Alton while the north end is used by the Pennsylvnia and the Chicago, Milwaukee & St. Paul.

The signal and interlocking system for the operation of trains is divided into two parts consisting of one complete plant for each end of the station. The plant governing traffic at the south end controls 36 high signals, 70 dwarf signals, 38 movable point frogs, 76 double slip ends and 42 single switches covering a length of 4,800 ft. The plant governing the traffic at the north end controls 2 high signals, 57 dwarf signals, 15 movable point frogs, 30 double slip ends and 41 single switches covering a length of 3,200 ft.

### Train Operation Controlled Design of Layout

The track layout for each interlocking plant is arranged with the switches in two distinct groups, one group adjacent to the entrance to the train sheds—the other group adjacent to the entrance to the Chicago Union Station property where trains are received from the coach yards or sent to the coach yards in addition to the regular out-bound and in-bound trains; hence each interlocking machine is divided in two parts and is really two machines in one frame—the locking being cut between each section of the machine with the exception of those parts of each machine where electric check locking would have been necessary, had the layout been operated as two plants with central point of control at each group of switches. At




Track and Signal Plan of the Interlocking Layout North of—

these points the locking bars run through and mechanical locking takes the place of electric check locking.

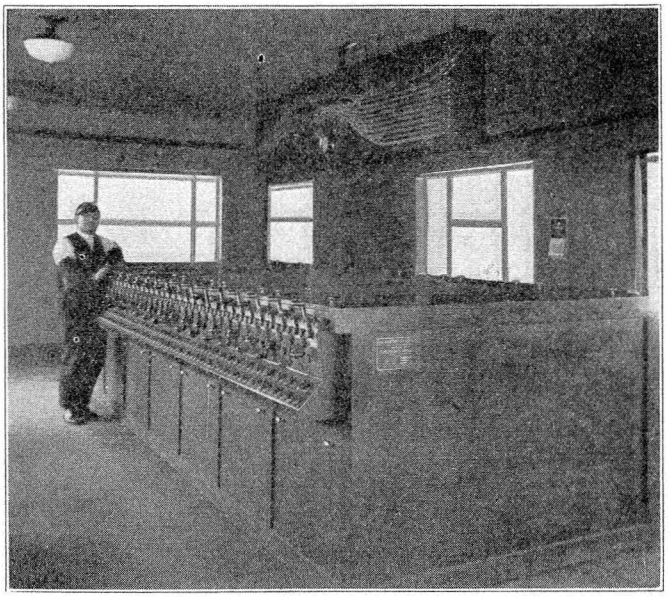
The operation of the station requires that all passenger trains must be handled twice; out-bound trains must first be backed in from the coach yards and incoming trains must be backed out to the coach yards, after delivering passengers. This routine requires a close co-ordination in the operation of the two groups of switches to give a smooth and complete movement between the station and coach yards and retain at the same time clear tracks for the movement of outbound and inbound trains. Careful consideration of this operating feature led to the adoption of one central point at each end of the station for the control of all switches and signals. Concentrating the control at one point eliminates the exchange of information necessary to co-ordinate train movements. If each group of switches had been controlled from separate points, delays would have resulted from conflicting ideas between interlocking station operators at the separate points as to just how trains should be run on the other group of switches.

The keeping of each machine in two distinct parts was found to be of great advantage in the installation of the system as the track layout at the station end in each case was installed considerably in advance of the coach yard end and benefit was derived by putting the station ends of each interlocking in service as soon as possible after the permanent tracks were in place.

### Electric and Air Power Distribution Systems

Electric power for the operation of the interlocking systems is furnished by the Commonwealth Edison Company at a pressure of 12,000 volts, fed from a loop circuit which can be supplied with power from generating stations at different points. In addition to this loop circuit there is a direct line between the main building of the Chicago Union Station Company and the generating plant and an emergency connection to a substation which has several direct lines to generating stations.

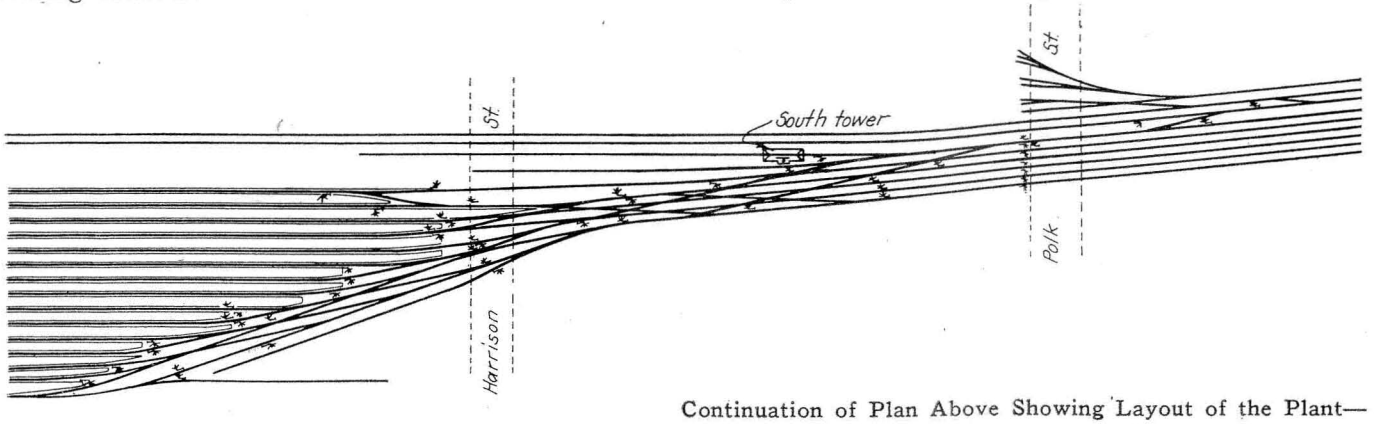
This power is stepped down to 2,300 volts single-phase through duplicate transformers and distributed to the interlocking system over two power lines, each line having its own transformers where the voltage is changed to 110 volts to serve the interlocking system. Power is normally on both of these lines with transformers on one line normally serving the interlocking system.



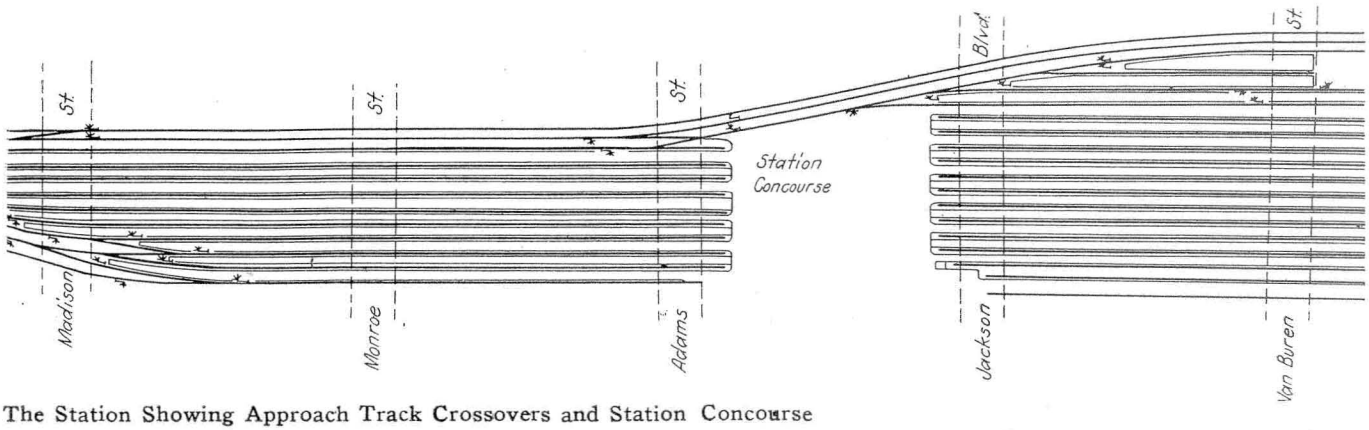
Machine in North Tower

An automatic transfer equipment is installed at each transformer location which will instantly cut the transformer of the emergency line in service should power fail on the normal feed. This power lights the interlocking towers, feeds the motor-generator sets in the towers, lights all signals, feeds the track circuits, lights the illuminated track diagram and lever lights and is used for all signal indication and check locking between the interlocking towers.

Compressed air at 70-lb. pressure is furnished from




Continuation of Plan Above Showing Layout of the Plant—




The Station Showing Approach Track Crossovers and Station Concourse

two steam-driven compressors of 500 cu. ft. per minute capacity each, located in the Chicago Union Station Company's heating plant. In addition to furnishing air for the operation of the switches, these compressors furnish air for the operation of the main sewer ejectors, for cleaning all electric motors in the Chicago Union Station buildings, for automatic heat control in the buildings, for the barber shops and beauty parlors, for pneumatic tools in the shops, track bumping posts for charging and testing air brakes in the trains, and to operate oil burning apparatus for cleaning snow and ice from switches.

The air is run through a water after-cooler which reduces the temperature to 60 deg. and before being fed to the main air line is again run through an outside air cooled condenser. The main air line runs continuously on both sides of the track layout with cross-leads between the two sides at the proper points to insure air pressure to all functions should a break occur at any point in either main line.

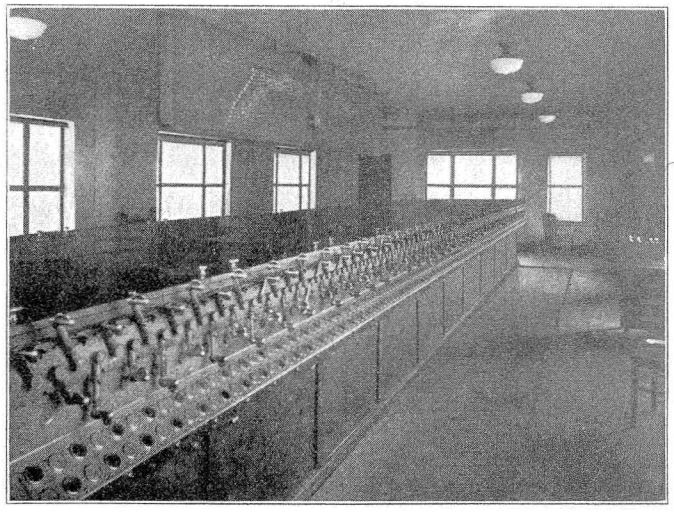
### Interlocking Towers and Machines

The interlocking towers are of fireproof construction consisting of steel and concrete with brick facing and tile roof. Floors are all of concrete with built-in chases for wires. The towers are of two stories with relays, motor-generators and storage batteries on the first floor.

Located in the top floor of each tower is a Union Switch & Signal Company's Model-14 electro-pneumatic type interlocking machine, equipped with two rows of lever lights which are used for providing a visual indication as to the condition of the section locking for the switches and the position of the signals.

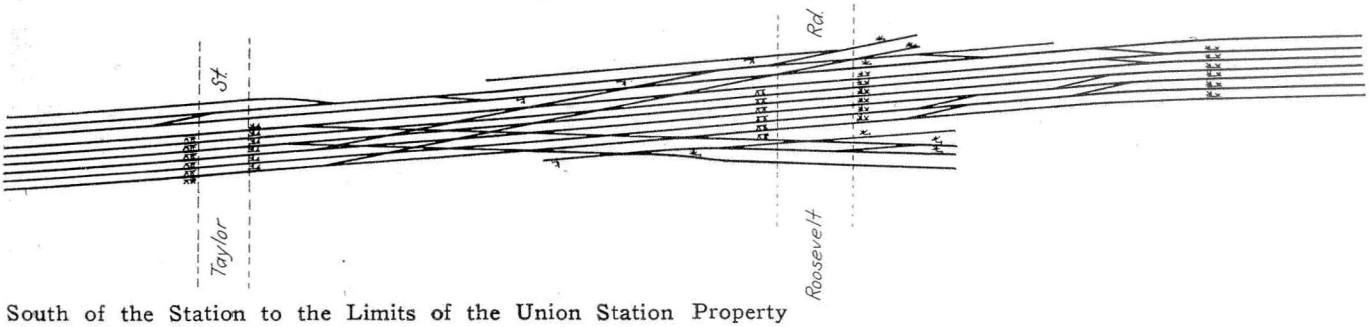
The track models are of the illuminated spot-light type. The south plant model has 194 spot-lights for track circuits, 2 for traffic direction between plants and 28 for train starting, a total of 224 spot-lights.

throughout and consist of a front plate ⅛ in. thick mounted on an angle iron frame so as to form a shallow box, while the rear plate is in the form of removable doors for access to the interior. Luminous spot-light indicators are mounted in the rear of the front plate. Tracks are indicated by a double line diagram of white lines on a flat black background, and all signals, switches, slips, movable point frogs and other features of the signaling system are shown in white. The scope of track circuits is shown by filling in



The Two Machines in the South Tower Appear as One

between the white lines, indicating the rails, with colors, each color sufficiently distinct from its adjacent color to differentiate clearly between them. The length of a track circuit is shown by the length of its particular color. The spot lights are placed as nearly in the middle of each track circuit as possible and show a green light when the track circuit is clear and



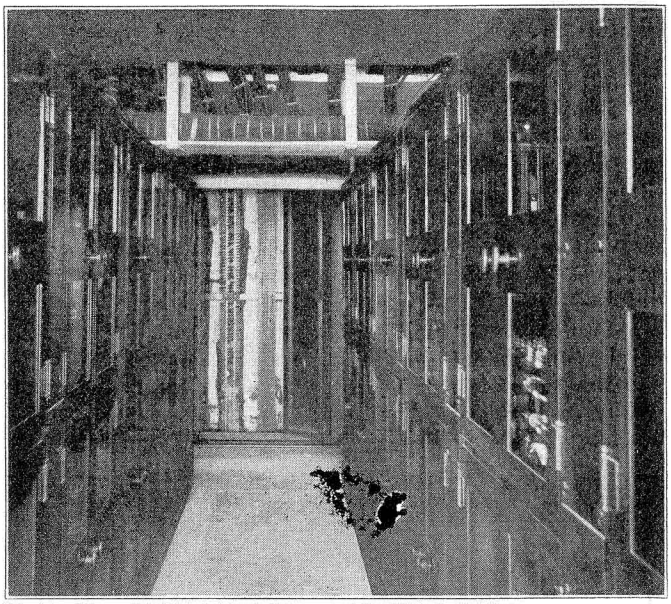

South of the Station to the Limits of the Union Station Property

The north plant model has 87 spot-lights for track circuits, 2 for traffic direction lights between plants and 20 for train starting, a total of 109 spot-lights. The track models are of metallic structure

no light when the track circuit is occupied. The lights for traffic direction also show an arrow pointing to the direction in which traffic is set up.

Multiple unit-type tower instrument cabinets, of steel

construction with glass doors, are placed back to back in rows at right angles to the interlocking machine, on the floor below. The entrance for wires between the interlocking machine and instrument cases is through a slot in the top floor running the full length of the interlocking machine and covered by the machine case. A wire chase is also provided between each section of cabinets. These instrument cabinets are arranged in double tier having six cases per tier with a space of

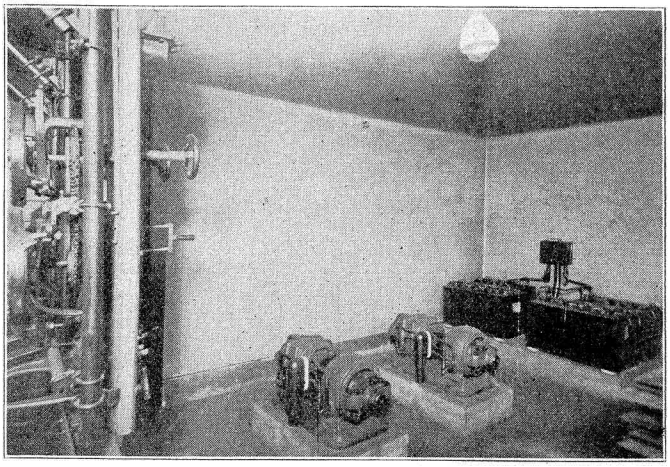


Steel Relay Cabinets and Terminal Cabinets in the Rear

3 ft. 4 in. between each row of cases making an aisle from which 24 cases are accessible. There are 144 cases in the south tower, housing 674 relays and 96 cases in the north tower, housing 342 relays. All wires coming into an interlocking tower are connected to terminals in a terminal cabinet, which is built of No. 16 gage cold rolled furniture steel, all parts of sections being riveted and welded together, properly reinforced and rigidly constructed. The doors have vault handles, and a three-way locking device. Strips of ebony asbestos transite board 1 in. by 6 in. by 8 ft. are mounted 8 in. from the back of this cabinet running vertically, to which all wires are attached on A. R. A. terminal posts.

### Battery and Charging Equipment

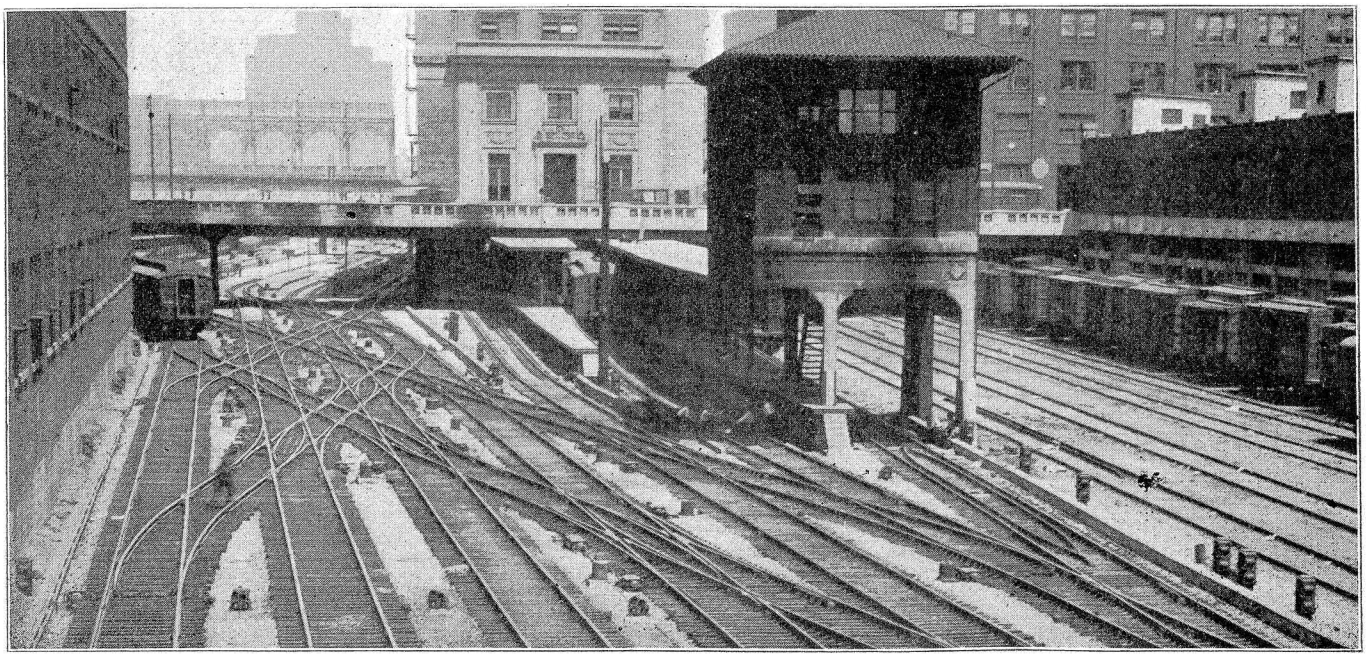
The switchboard, motor-generators and storage battery are all housed in the same room. The storage batteries, of 500 ampere-hour capacity iron-clad Exide, consisting of two sets of 14 volts each assembled in sets of 3 and 4 cells are mounted on a concrete platform 6 in. above the floor. These storage batteries are used to control the switch valve magnets, switch indications, signal control and route locking relays. The motor-generators and switchboard are of the General Electric Company's make, there being one motor-generator for each set of batteries.



Enclosed Type Storage Battery and Motor-Generator in South Tower

Switch movements are Union Switch & Signal Co.'s electro-pneumatic Type-A1. The cylinders for the operation of single switches are 5 in. in diameter, for the slip ends, 6 in. in diameter, and for slip ends in connection with movable point frogs 7 in. in diameter. All cylinders have a 12 in. stroke.

All of these switch movements are equipped with U. S. & S. separately mounted Style-C cut-off type



Interlocking in the Immediate Vicinity of the South Tower, Looking North Into the Station Platform Tracks

valves, which effect a great economy in air consumption.

### Special Design Position Light Signals

The signals are of the position-light type. The high signals consist of seven lights built up with two rows of lights, three lights to each row. The distance between the lights is 18 in. and the distance between the rows is 36 in. The seventh light is placed midway between the two rows directly in line with the two

| HIGH SIGNAL | DWARF SIGNAL | NAME | INDICATION |
|---|---|---|---|
| | | STOP SIGNAL | STOP |
| | | CAUTION SIGNAL | APPROACH NEXT SIGNAL PREPARED TO STOP |
| | | CLEAR SIGNAL | PROCEED AT AUTHORIZED SPEED |
| | | PERMISSIVE SIGNAL | PROCEED WITH CAUTION PREPARED TO STOP SHORT OF TRAIN OR OBSTRUCTION |
| | | SLOW SPEED SIGNAL | TRACK IS SET TO DIVERGE OVER SLOW SPEED TURNOUT<br>TRACK IS UNOCCUPIED TO NEXT SIGNAL OR TO END OF INTERLOCKING LIMITS<br>PROCEED AT SLOW SPEED PREPARED TO STOP AT NEXT SIGNAL OR AT END OF INTERLOCKING LIMITS |

Diagram and Explanation of Position Light Indications

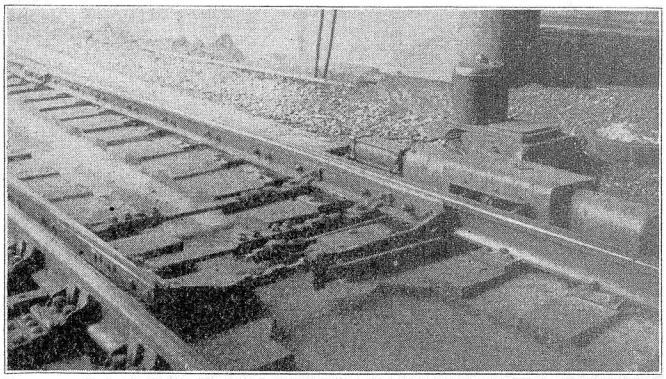
center lights of each row thus giving a square signal with a distance of 18 in. between lights in the vertical and horizontal rows and a distance of slightly greater than 21 in. between the lights of the diagonal rows.

The standard position-light signal as used elsewhere has 9 lights with 8 lights spaced equidistant on the circumference of a circle 18 in. from the ninth light which is the center of the circle, thus making a round signal. The change in the design of the high position signal was necessitated by the need of a small signal which would give five indications and be small enough to be placed on the overhead street viaduct. These viaducts are of a very attractive design and cross the tracks approximately every 800 ft. with but 17 ft. head room above the top of rail.

To have used a standard semaphore signal to give the five indications required, three semaphore arms would have been necessary and this would have taken a signal approximately 24 ft. in height. To have used the standard position light signal or a color light signal to give the five indications required would have necessitated two units for the position light signal and three units for the color light signal, requiring a height of approximately 11 ft. for the position light signal and 21 ft. for the color light signal. These signals would have required signal bridges on both sides of these viaducts, which would have almost entirely obliterated the view of these attractive structures.

The size of the high signal as used is 4 ft. 2 in. square and the five indications given are as follows: The top row of horizontal lights indicate *stop;* the top row in combination with the two diagonal lights to the right indicate *permissive;* the top row in combination with the two left hand diagonal lights indicate *slow speed;* the three diagonal lights in the upper quadrant indicate *caution;* the three vertical lights indicate *clear.*

The dwarf signals are the standard position light dwarf signal type consisting of four lights and giving four indications: Stop; permissive; caution, and clear. The addition of the fourth indication to the dwarf signal is a new development in signaling and makes the dwarf signal particularly suited for signaling a busy terminal to allow trains to occupy tracks to full capacity and the addition of the fourth indication allows



Switch Layout Where Tracks Are Set in Concrete

the connecting of the dwarf signals into a complete signal system, giving complete information for the governing of traffic at the maximum speed allowed in the terminal territory.

The dwarf signal at *clear* indicates that the next signal is at clear or caution. The dwarf signal at *caution* indicates that the next signal is at stop but the track is unoccupied to the next signal. The dwarf signal at *permissive* indicates that the track is occupied immediately ahead and that the movement should be made with caution, prepared to stop short of a train or obstruction. The dwarf signal at *stop* indicates that the route is not set. Use is made of the permissive signal in governing movements to stub end mail tracks and coal tracks at the power house.

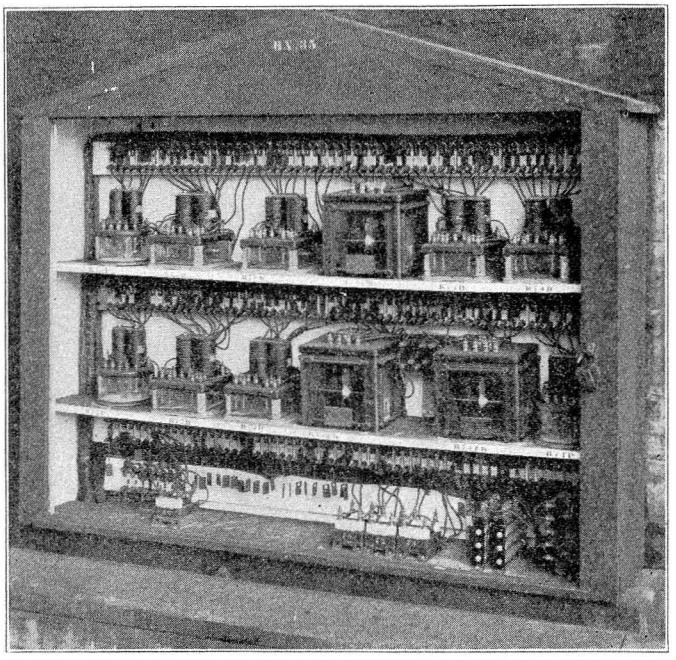
### Master Release Simplifies Circuits and Operation

The connecting of dwarf signals into a signal system with each signal having a distant indication and the quickness of light signals in change of indications, made it necessary to provide time releases for unaccepted dwarf signals as well as for high signals. This would have required 106 time releases in the south plant and 59 time releases in the north plant. The standard clockwork time releases would have taken so much space in the towers as to be almost prohibitive.

Consideration was given to a release attached to each signal lever which operated when the lever was pulled and introduced the time element when the lever was restored to normal with a special circuit which released an accepted signal at once. This type of release could have been applied readily to the machine without requiring additional tower space, but the time element device would be forced to operate each time the lever was pulled, and after considering the number of operations required of these signal levers each day

it seemed unreasonable to expect a mechanical device, as delicate as required for this type of time release, to stand this service. An attempt was then made to design a time release which was operated only when an unaccepted signal was taken away.

This led to the development of what we call a "master release." This release is attached to a lever in the interlocking machine and is of the mercury type. All signal indication circuits are cut through this release lever in its normal position and a special pick-up circuit for each lock release relay is closed with this lever in the reverse position. A multiple circuit is provided around each normal contact of the lever through the back contact of the signal slotting stick relay and the permissive stick relay in series. This permits the operation of the universal release lever to release an unaccepted signal without disturbing the



A Relay Case at One of the South Viaducts

operation of levers for signals which have been cleared and will be accepted by a train.

The master release as finally adopted has two time elements—one of 12 sec. duration and one of 36 sec. The selection of the time interval is entirely automatic and governed by the indication presented by the signal which is taken away. If the signal displays a permissive indication, the 12 sec. time element only is effective, but if a less restrictive indication than permissive has been displayed, the 36 sec. time element governs. The final arrangement has two master time release levers in each interlocking machine—one centrally located in the levers for each group of switches —for convenience of operation.

### Progressive Signals Have Semi-Automatic Feature

The rapidity of change of light signal indications, made possible the use of what we call the "progressive" signal. If there is no change in the route set up, and the push button controlling the permissive indication is operated while the block immediately ahead of the signal is occupied, the signal will indicate *permissive* but will change automatically to a less restrictive indication as the route is cleared ahead, thus avoiding the necessity of restoring the signal lever to normal and reversing it again after each train movement. This arrangement has been found of great benefit during the rush hours, giving speed to signal operation and at the same time giving the best possible signal indication for train movements at all times. This result is accomplished by having an additional pick-up circuit for the slotting stick relay through the permissive stick relay in the energized position in addition to its pick-up circuit through the normal contact of the lever.

### Circuits

"SS" control is applied to all signals through contacts in the vertical controllers on the back of the machine and the "KR" polarized relays, operated from circuit controllers on the switch movements, thereby checking electrically the mechanical locking in the machine and providing against the misplacement of a switch from the ground that does not correspond to the line up in the interlocking machine.

Route locking circuits are applied to all switches which electrically lock all switches of the route lined up immediately upon a train accepting the signal governing over this route. Sectional release circuits are applied, to release all switches just as soon as the train has passed over them, thereby keeping all functions free for use to the maximum extent.

### Wires, Cables and Duct Lines

No wires are less than No. 14 A. W. G. except those used in the interior wiring of the towers where No. 16 A. W. G. is used. The wires are made up in braided underground cables from twin to 29-conductor, this being the maximum size used. The wires are run in a continuous cable from the terminal case in the interlocking tower to a terminal case located at the cross leads leading out to the functions to be controlled. From this point to the function, steel taped cables are laid in the ballast resting on a concrete slab which is a minimum of 8 in. below the bottom of the ties. This slab is continuous under all switches throughout the entire project.

Concrete trunking and capping is used extensively through the entire system for main line runs, while all cross leads are in steel taped cables. Where concrete trunking could not be located, fibre conduit was used, being encased in reinforced concrete and placed beneath the track slab. The concrete trunking is rectangular in section, 8 in. in height and 9 in. in width, inside measurement. Each section is 8 ft. in length and weighs 350 lb. being supported at the ends by concrete piers. The capping is in 4-ft. lengths and weighs 75 lb. per length. Both trunking and capping have ¾ in. overlapping joints. The lap on the capping is arranged so that both ends on each length are lapped on the same side, with the lap reversed on the adjacent section to allow removal of the capping at any point in the line.

The track circuit connections are made in special potheads which were designed for this particular installation. These potheads are placed adjacent to the rails and steel taped cables containing four No. 9 A. W. G. copper wires are brought to this pothead through the bottom of the concrete foundation and attached to standard A. R. A. terminals. From the other side of these terminals No. 6 A. W. G. 40 per cent copperweld wires are run out of the pothead and fastened to the rails with standard A. R. A. channel pins.

Track circuits are all fed with alternating current averaging 4 volts pressure. This current is supplied by track transformers with one 110-volt primary giving 5, 7, 9, 12, 14 and 17 volts, on four secondaries with taps. All track relays are located in the interlocking tower making necessary a booster transformer at the

relay end of the track circuits, which raises the voltage to an average of 100 volts for transmission to the tower. Rails are bonded with two No. 6 A. W. G. copper clad wires. The track circuits are continuous throughout the entire system, no dead sections being greater than 5 ft. in length. They are of the single rail type with both rails insulated at signal locations. There are a total of 212 track relays housed in the south tower. This has worked out advantageously in that only 20 track repeater relays were required.

### Special Insulated Joints Developed

Special track construction at frogs and diamonds prohibited the application of standard insulated joints at these points and forced the development of a special type of insulated joint for use at these points. These joints are of four types: Type-A which insulated the frog ends where a short guard rail is placed between filler blocks between frog legs; Type-B where the filler block only, is placed between the legs of the frogs; Type-C where guard rail and running rail are insulated in the diamond crossings; and Type-D where the rail is insulated as it is attached to a solid manganese frog.

Narrow Clearance Required Special Relay Case

Above—Pot-Head for Outlet of Track Wires
Below—Junction of Concrete Trunking and Underground Conduit

The special features of these insulated joints are the angle bars which are of the continuous type, but are made to extend the entire width of the base of the rail instead of half the width of the base of rail as used in the standard joint. These insulated joints have stood up exceedingly well in service, lasting, in our heavy traffic condition, two years without renewal.

### Train Starting System

The system of intercommunication between conductors, gatemen and interlocking operators employs three-indication colored-light signals located adjacent to the station concourse, with one signal for each station track, two-indication spot-lights at the entrance gate for each track and two-indication spot-lights on the illuminated track model in the interlocking tower. Push button control switches are spaced approximately every 250 ft. on the train shed columns, in passenger platforms for the use of trainmen. The push buttons for gatemen are placed at the gates directly beneath the spot lights. The push buttons for tower operators are placed on the operator's desk in the interlocking tower. The operation of the train starting system is as follows:

First—The conductor pushes the button nearest to his location on the platform, lighting the red spot-light on the illuminated track diagram in the interlocking tower which is placed at the end of the track corresponding to the track from which the train is leaving and if the information is received at the tower the red light is lighted in the colored light signal suspended in the train shed adjacent to the station concourse and beside the track from which the train is leaving.

Second—If the tower operator is prepared to handle the train he pushes the button on the operator's desk, thus changing the colored light signal near the concourse to yellow, changing the light on the illuminated track diagram to yellow and lighting the yellow spot light at the gate.

Third—The gateman after closing the gate immediately pushes his button at the gate, changing the color light signal to green and the spot light at the gate to green—thus permitting the train to leave, providing the proper indications of interlocking signals have been received.

Fourth—The train immediately upon accepting the first interlocking signal, automatically puts out all train starting lights.

### Conclusions

The station end of the south interlocking plant was placed in service, March 1, 1924, and the station end of north interlocking plant was placed in service, December 2, 1924. Improvement in train operation was experienced immediately after getting these plants in operation. Observations of train movements, together with reports coming from enginemen, back-up men and supervising officers have proved the worth of five signal indications in operating a busy terminal.

The engineering work for this installation was performed jointly by the signal engineers of the Chicago Union Station Company and the Union Switch & Signal Company, who manufactured the interlocking apparatus and supervised the installation.