Interlocking on the North-Western Terminal*

A General Description of the Signaling System and Details of Construction

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In the passenger depot there are 16 tracks which terminate at the north end of the station in a six-track throat, which, in turn, divides into two approaches, one to the north and one to the west, each approach having four tracks.

The approach to the north extends to the junction with the Wisconsin and Milwaukee divisions at a point near Division street. Each of these divisions has two main tracks. The west approach joins the four tracks of the Galena division near Noble street.

As the North-Western is a left-hand operated road the four tracks on the Galena division are used as follows: Track No. 1 (south) west-bound scheduled trains; No. 2 (next north) east-bound scheduled trains; No. 3 (second north) west-bound empty coach trains; and No. 4 (north) east-bound empty coach trains.

The following method of operating trains on the north branch was adopted:—12 o'clock midnight to 12 o'clock noon: Track No. 1 (west) all north-bound scheduled trains; No. 2 (next east) south-bound Wisconsin division trains; No. 3 (second east) south-bound Milwaukee division trains; and No. 4 (east) empty coach trains for yard;—12 o'clock noon to 12 o'clock midnight: Track No. 1 (west) north-bound Wisconsin division trains; No. 2 (next east) all south-bound scheduled trains; No. 3 (second east) north-bound Milwaukee division trains; and No. 4 (east) empty coach trains for the station. During the day at times of light traffic Milwaukee division scheduled trains are sometimes run in the direction of traffic on track No. 4 to avoid interference with the Wisconsin division trains. Within the limits of the Division street interlocking plant trains are received from or sent to the tracks north in the direction of traffic in which the tracks had previously been used.

Owing to the extent of the territory covered by the switches in the depot yard and for the junction of the north and west approaches, two interlocking plants were installed, and provision was made for operating on all tracks in both directions between them. The normal operation of these tracks is, however, as follows: Numbering from the west, tracks 1 and 2 carry all trains for the west approach and tracks 3, 4, 5 and 6 are the same as tracks 1, 2, 3 and 4 on the north approach.

INTERLOCKING PLANTS.

There are five interlocking plants in the terminal: (1) Lake street, which includes all the switches in the terminal yard; (2) Clinton street, which includes all the switches at the junction of the north and west approaches; (3) Noble street, at the junction of the west approach with the Galena division; (4) Division street, at the junction of the north approach with the Wisconsin and Milwaukee divisions; and (5) Carpenter street, governing the cut-off between the north approach and the old Milwaukee and Wisconsin division tracks.

Train movements on the north and west approaches and through the interlocking plants, except Lake street, are protected by automatic block signals or by the automatic control of the interlocking signals.

It will be noted that there is an apparent duplication of derails on some tracks within the Clinton street plant, Fig. 2. The derails farthest from the fouling point were installed to comply with the Illinois rules requiring 500 ft. of protection on main tracks for facing moves, while those nearer the fouling point protect against trailing moves, and, since they are located at clearance points, allow conflicting routes to be set up as soon as a train passes them instead of holding these routes until the train passes the derail farthest away.

SIGNALING.

In developing the signaling to be used the then standard practice of the road, which combined the use of the two-position lower quadrant semaphore signal for interlocking with the disc signal for automatic blocking, was compared with the three-position upper quadrant semaphore signal for all purposes. The latter was adopted with the result that but 90 signals were required, instead of 150 under the old standard, and the number of signal aspects was reduced and the method of giving information to the engineman simplified. Fig. 4 shows all aspects of the signals used. The green light means proceed; red, stop, and the combination of red and green, which is the North-Western standard, signifies caution. The lamp which is used in the combination light has but one burner; a reflector furnishes the two lights. This lamp was designed in 1889 by E. C. Carter, chief engineer, and has been the standard of the North-Western since that time.

At the Lake street plant information as to the position of the signal ahead as well as the proceed and stop signals is given by one dwarf signal, using three positions. This secures the safe handling of trains at reasonable speeds, and results have shown the absolute safety and reliability of the practice. At this plant, also, the third position of the last signal governing trains inbound into the depot is used to indicate that the track under the trainshed is clear. The dwarf signals, Fig. 5, are all motor driven, and, except at the Lake street plant, are used in the horizontal and diagonal positions only.

For tracks which are signaled so that trains may be operated in either direction at any time, traffic levers are installed in each

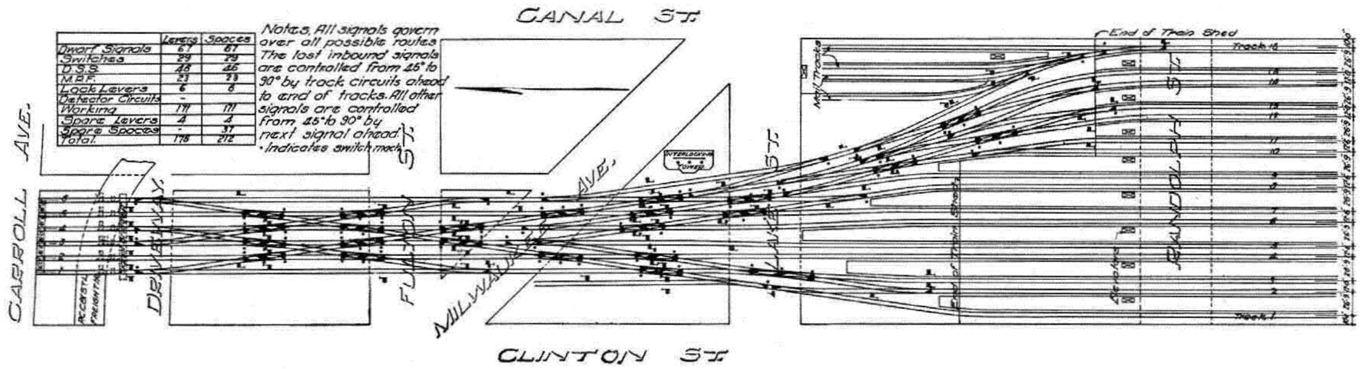

Fig. 1. Plan of Lake Street Interlocking.

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of the interlocking machines in order to prevent trains being started in the opposite direction on one of these tracks at the same time as, or against, an approaching train, and to provide protection in case of emergency when it is necessary to reverse traffic on any of the other tracks. These levers are controlled in the same manner as the signal levers in manual blocking machines so that signals cannot be given for a movement on to a track until the traffic levers controlling the movements to that track are in the proper position in the towers at both ends of the track.

COMMUNICATION AND INFORMATION.

The means of intercommunication between the various points on the terminal comprise: (1) conductors'-towermen's-gatemen's annunciator system; (2) telautograph; (3) various automatic train annunciators and indicators; (4) illuminated track diagrams; (5) lights over levers; (6) the intercommunicating system; and (7) the telephone systems.

The system of annunciators, generally known as the "C. T. G." system, is used for the starting of trains from the station. Each of the depot tracks holds two trains, and the "C. T. G." equipment for each track is, therefore, in duplicate. Four boxes containing conductors' lights and push buttons are mounted on posts on the platform, the equipment including two telephones on each platform. The directors' table in the Lake street tower has three lights, and a push button for each of the two possible trains on each of the 16 tracks in the trainshed. The gatemen's lights are on the concourse, and the push buttons are on the track side of the gate posts of the partition dividing the main concourse from the trainshed. For through trains the conductor pushes his button one minute before leaving time. This lights the top light on the director's table in the Lake street tower and the first light on the gatemen's indicators reminding them that it is about leaving time. If the director can handle the train on time he replies by pushing a button which puts out the top light and leaves the second light on his table and puts out the first and lights the second light at the gate, and also lights the top light of the conductor's indicator. When it is time for the train to leave the gateman closes his gate and, after giving the last passenger who went through sufficient time to get on the train, he pushes his button. This extinguishes the second light at the gate, puts out the conductor's top light, and lights the lower one, and puts out the second and lights the third of the tower director's lights, thus advising both conductor and director that the train may leave. The conductor then signals the engineman to proceed, which he does if the interlocking signal indicates that he may. The restoring of the first signal to stop automatically restores the annunciator system. For suburban trains the conductor pushes his button 10 seconds before leaving time and receives no answer, as, to avoid congestion, these trains must leave on time. Before a train which has discharged its passengers can back out of the station a signal must be received from the director. This system gives the tower director absolute control of all trains in the depot so that he can make the utmost use of track room; and in actual practice has proved to be simple, rapid, and easily understood.

The Gray telautograph system, having three transmitters and nineteen receiving stations, was installed for intercommunication between important points. There are transmitters in each of the two division dispatchers' offices and in the Lake street tower. Receiving stations are so distributed that when a train is indicated to Lake street from Clinton street its time of arrival and the number of the track on which it will be placed are recorded so that every employe about the station who should know of the arrival of trains is given information.

A complete telephone system also covers all points between which communication is desirable. There is a direct line between adjacent towers, and a local system at each plant. A permanent telephone was also installed on each home signal bridge and a jack for portable phones in each manhole and

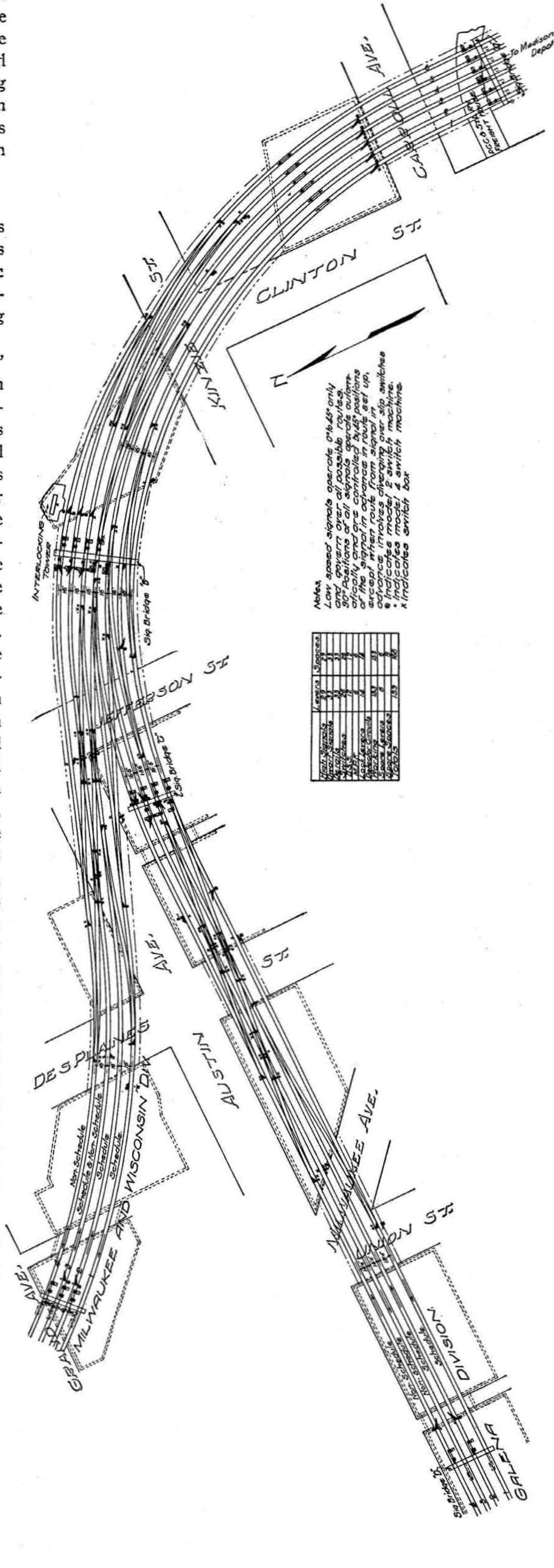


Fig. 2. Plan of Clinton Street Interlocking Plant, Showing Junction of North and West Approaches.

junction box. This gives a desirable facility of communication between trainmen and towermen and between the repair and maintenance forces and the tower.

Annunciators, comprising a relay operating a small disc and a vibrating bell and controlled automatically by means of the relays of the track circuits, announce to the towerman the proximity of approaching trains. When a detector circuit is occupied a small light mounted under ground glass over each switch lever is extinguished and the lever must not be moved. When the track is free the light burns.

In addition to lever lights, illuminated track diagrams were installed in the Lake and Clinton street towers. The front of each is made of wire glass. The tracks, signals, switches and their respective parts are in yellow. The ends of the track circuits are indicated by black lines, and the spaces between tracks are filled in with dead black. Behind the glass faces are tin boxes mounted on an aluminum back, each box being about four inches deep, four inches long, and one inch wide, and containing one four-watt, 14-volt lamp.

The lamps are controlled in a manner similar to the lever lights so that as a train passes through the plant its progress is clearly shown by the lights going out as it successively occupies the different track circuits representing the sections on the diagram. When there are no trains in the plant the entire track layout is illuminated. The occupancy of the depot tracks and the tracks adjacent to each plant is shown in the same manner. The necessary information is so clearly and completely shown in the illuminated diagram that it is possible on stormy days, and always at night, to operate the terminal without the towerman seeing the trains.

For communicating between towers as to movements and character of trains a push button scheme known as the "Intercommunication System" was developed. Small telephone lamps in horizontal rows and in columns, the former representing the classification of trains and the latter the track numbers, are mounted in the tower's, and are arranged so that the necessary information may be transmitted from one tower to another by manipulation of buttons.

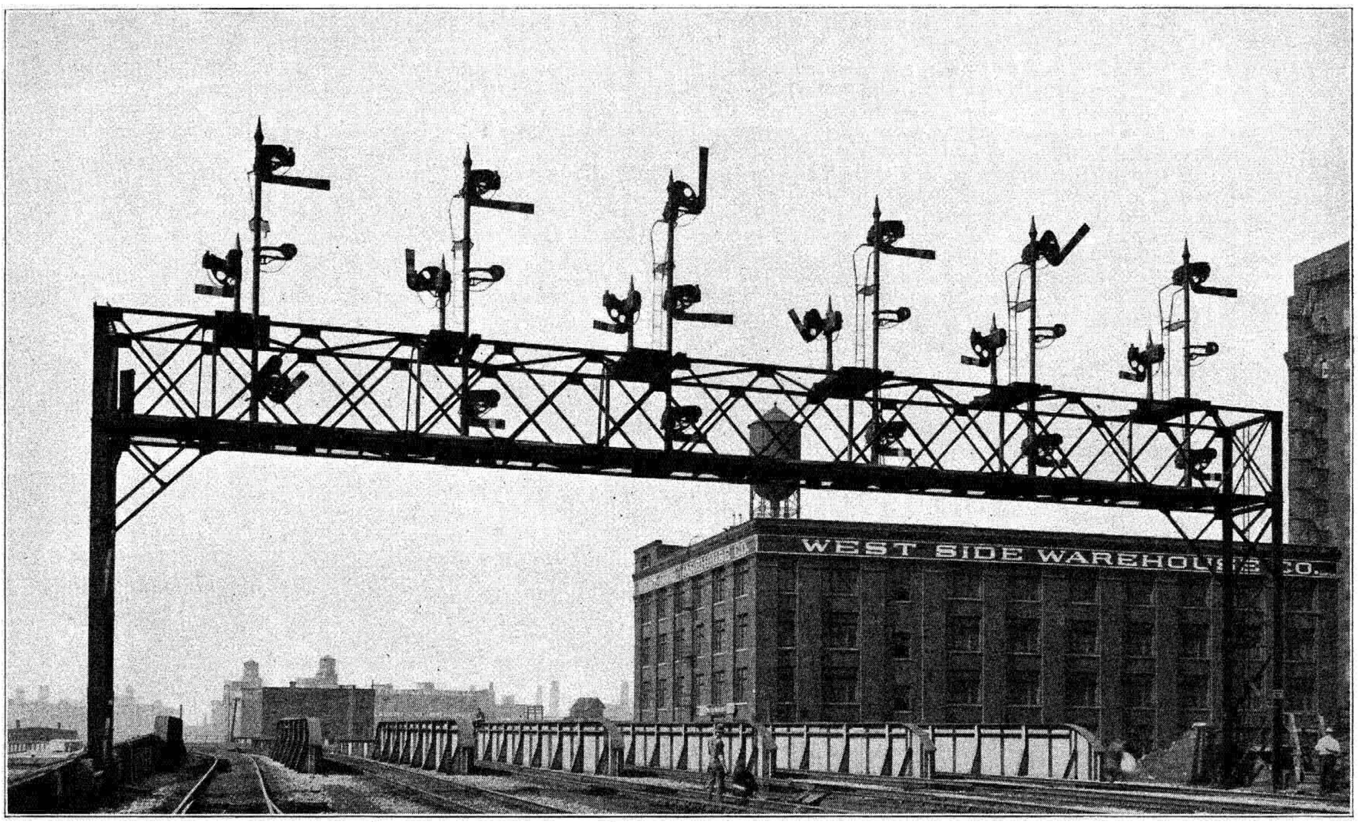


Fig. 3. Bridge A, Between Lake Street and Clinton Street Towers. Signals on High Masts Are Controlled from Clinton Street Tower, and Signals on Low Masts from Lake Street Tower.

INTERLOCKING MACHINES.

The interlocking machines are all of the standard unit-lever type made by the General Railway Signal Co. Special provision was made in their design for the lever lights and also for the combination board on the back of the machines through which the low voltage circuits are controlled. An oak case entirely encloses the machine, and each door is sealed closed in order to prevent improper manipulation.

TRACK AND CONNECTIONS.

The General Railway Signal Co.'s standard No. 4 switch movement is used for everything except derails, to which standard No. 2 movements are applied. All switch rods are insulated, and the switch tie plates cut so as to leave a space of not less than two inches between the ends.

There are no detector bars on the switches and derails of the Lake and Clinton street plants, detector circuits only being used at these points. In the other three plants, where a higher average speed of trains is maintained, both detector bars and detector circuits are employed.

CIRCUITS.

In operating switchboard circuits the power comes through the main power switchboard to the interlocking machine. The ammeter is inserted in the positive wire so that the leverman may watch the current used to operate the switches and signals and can tell whether they are working properly. At Lake and Clinton streets several ammeters are placed on the turret of the interlocking machine, as shown in Fig. 7, instead of having one on the operating board. Each of these controls a section of the machine.

The positive current is fed to the bus bars located on the machine. The negative is split into sections depending upon the size of the plant and each common wire passes through the circuit breaker on the operating switchboard. Each of these circuit breakers is controlled by a polarized relay on the board, and one on the interlocking machines for each lever controlling units in the section of the plant fed by that common. Whenever current flows through the polarized relays in the direction opposite to that of the indication current (as it will in cases of crosses or grounds) the polarized relay will open and in turn will open the circuit breaker and cut power off from that section of the plant. If the current still flows it will find a path

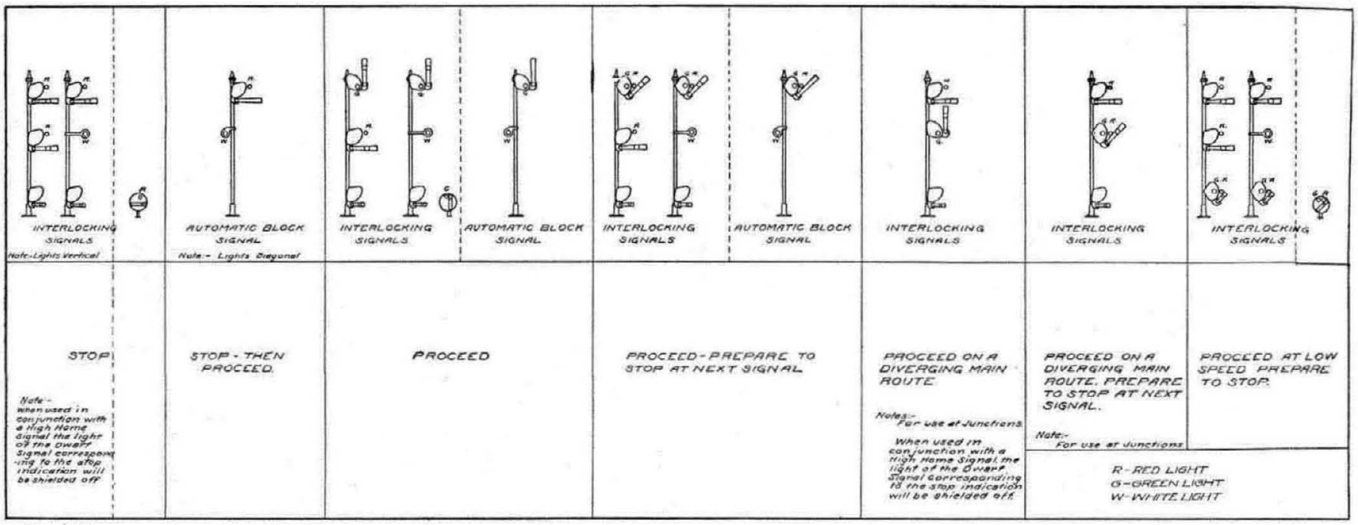


Fig. 4. Signal Aspects.

through a relay which is in multiple with the points of the circuit breaker and this will cause the red lamp to be lighted; and as long as this relay is energized the main circuit will be held open so that closing the circuit breaker will not restore

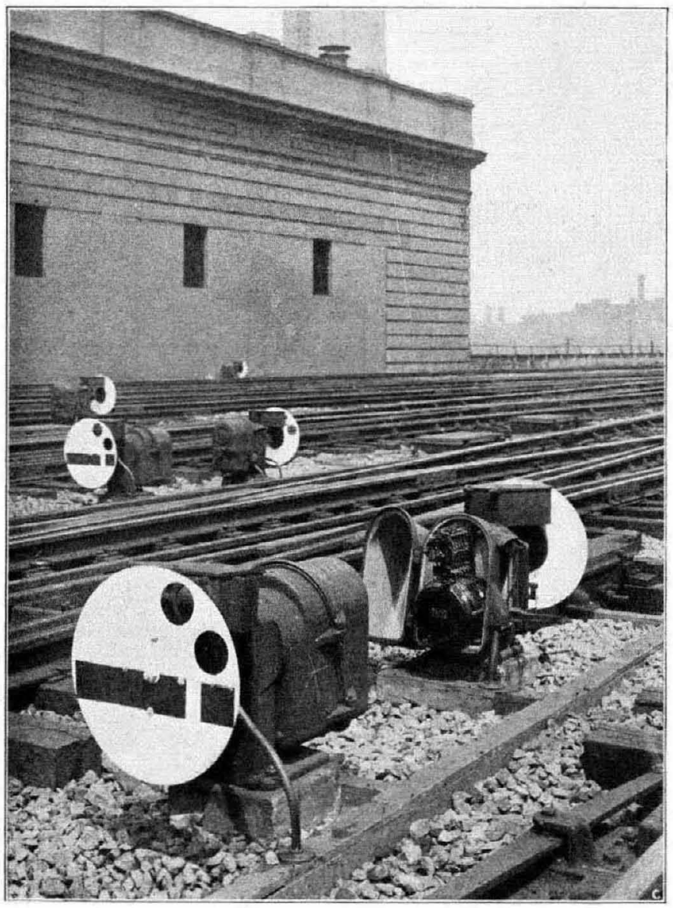


Fig. 5. Showing Type of Dwarf Signal Used.

the current while the trouble exists. Clearing the trouble, however, automatically puts out the red light and closes the circuit. A two-candle power, 110-volt lamp with a suitable switch is used as a ground detector.

The dwarf signals are of the Model 2-A type made by the General Railway Signal Co. The motor is geared directly to the spindle on which the blade is mounted and to which are also connected springs to force it back to its normal position when released. The motor while running backward generates current which energizes the indication magnet and releases the lever. The load imposed on the generator brings the mechanism to an easy stop, accomplishing the purpose of a dash pot. The common wires for the dwarf signals pass through switch boxes on all facing derails to insure that the derails are off the track before the signal can be cleared.

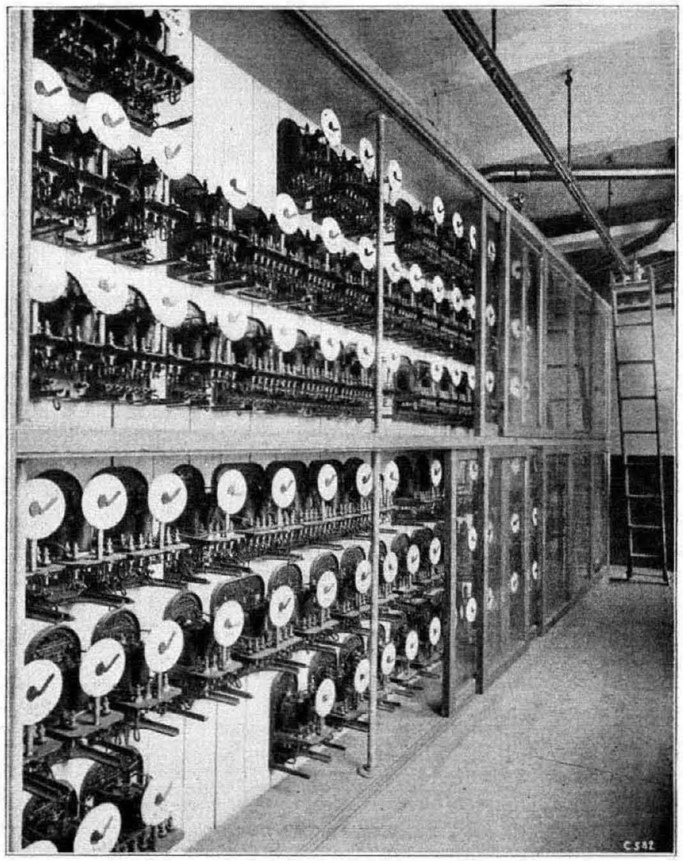


Fig. 6. West Relay Rack in Lake Street Tower.

The high signal mechanism is of the same type as the dwarf, the interlocking signals being operated at 110 volts. All high signals are slotted. The common wire from the signal motor is selected through the derails and facing point switches in the route as a check on their position. Current for operating

the signal from 45 deg. to 90 deg. is taken from the control wire locally and is governed by a line relay, the control of which passes through the slotted relay to the signal lever and is selected through the proper switch levers to the next signal in advance, where it passes to battery through a circuit breaker which is closed from 45 to 90 deg.

The approach signals are similar to the interlocking signals but operate on 16 volts instead of 110. As these do not furnish dynamic indications, a snub circuit, which closes at the proper time when the blade is descending, is provided to stop the mechanism gently. The signal is held clear by a clutch arrangement instead of holding coils. The normal indication of the approach signal is given by an electric lock located on the top of the home signal lever and locking it at the normal indication point, battery being furnished at the approach signal. The circuit is closed by a contact on the approach signal, which in turn is closed at or below the 45 deg. position. In all respects, except giving this normal indication, the approach signal is the same as any other automatic signal.

The return indication lock is also used for approach locking, current being withheld from the lock until the train has passed the home signal, by having the circuit open when the track between the approach and home signal is occupied. A release is provided to restore the lock in case it is desired to change a route after the signal has been given. The lights on the signal levers are selected through switch levers and relay points to indicate as follows: "No light," when there is no route lined up; a "green light," when there is a route lined up unoccupied; a "red light," when there is a route lined up that is occupied.

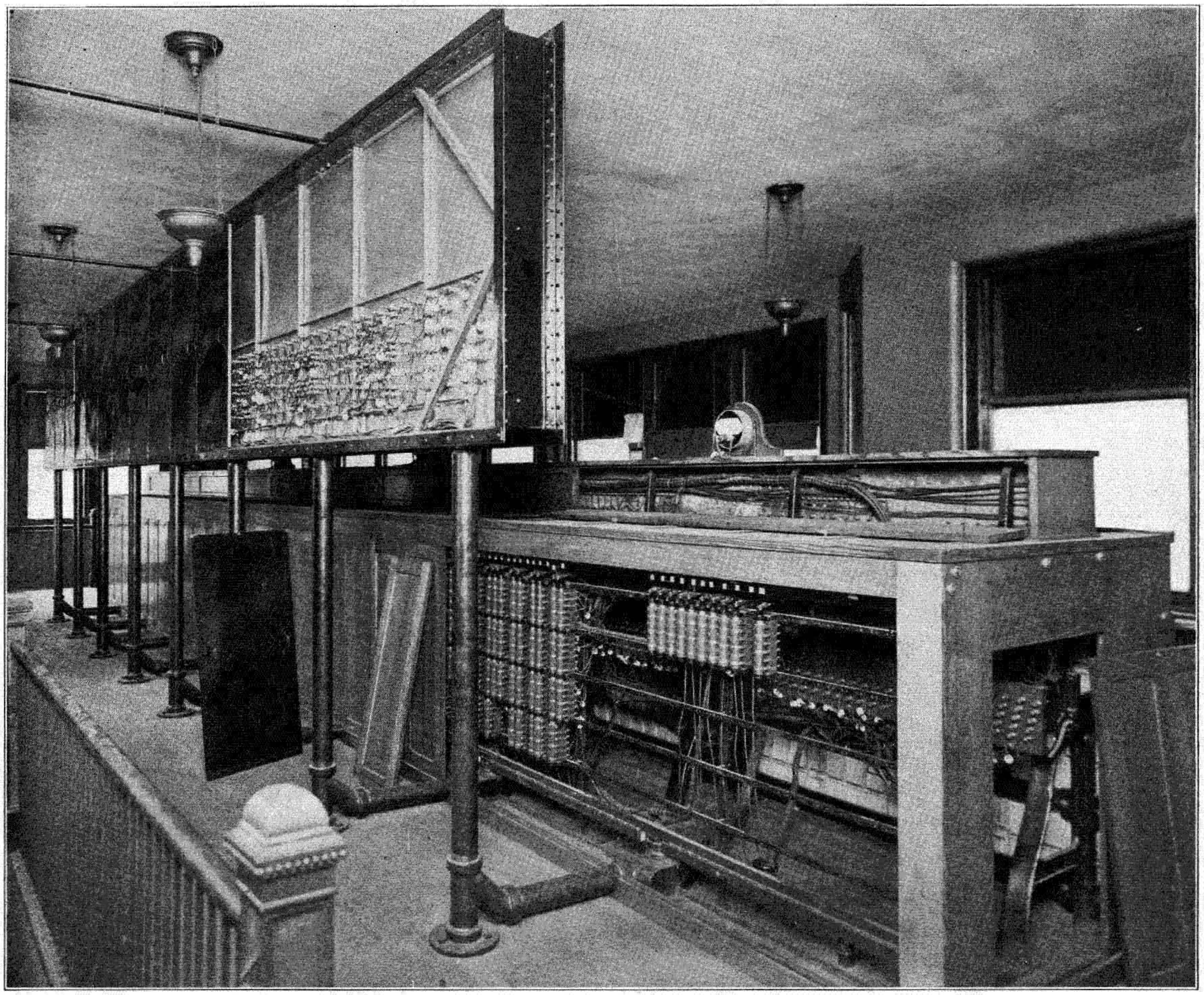
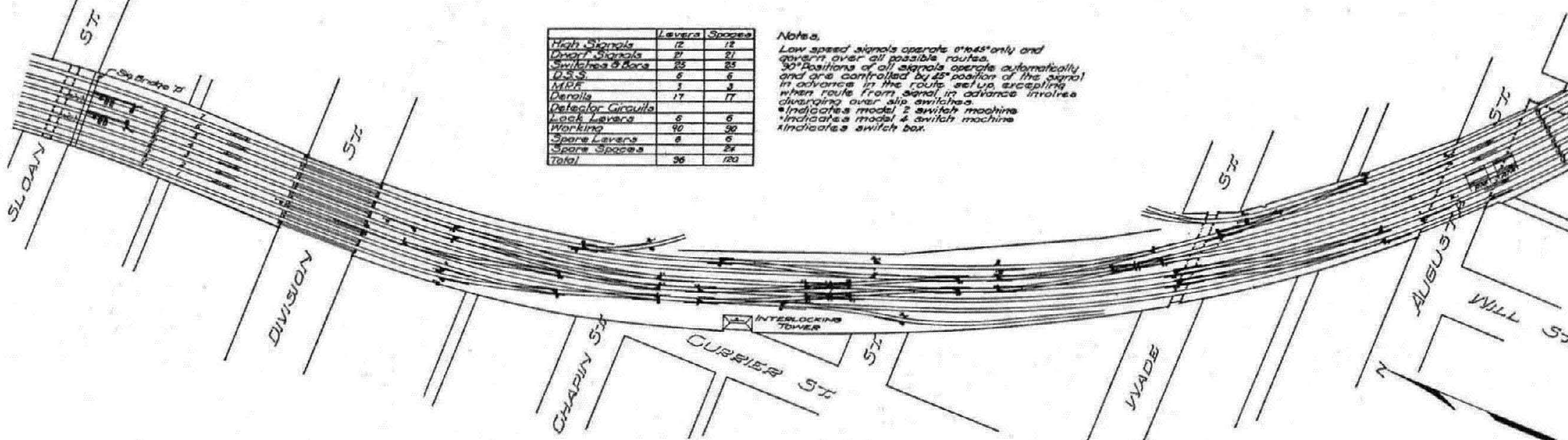


Fig. 7. Rear View of Machine and Illuminated Track Diagram in Lake Street Tower.

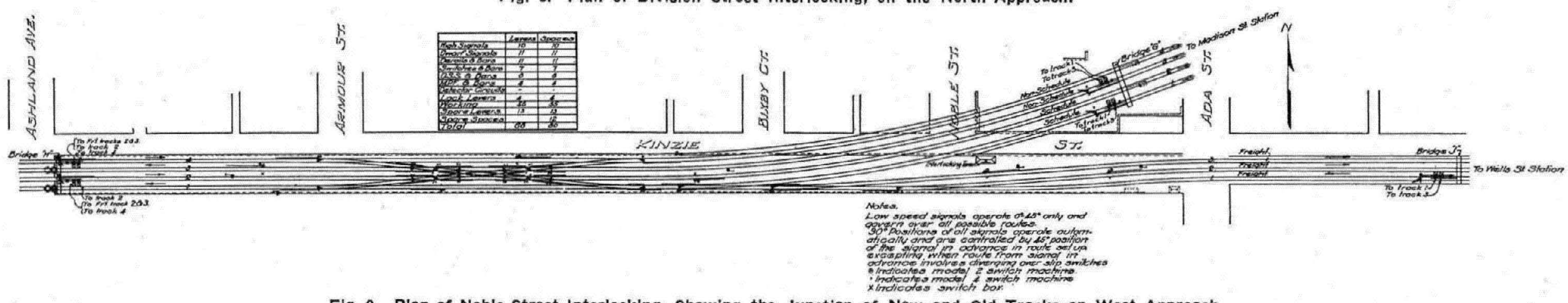
TRACK CIRCUIT FEED.

The track circuits for the interlocking plants are fed by loops as shown in Fig. 11, from the 20-volt storage batteries in the towers. The wires of the same polarity are joined at the end, forming the loops and giving the current from the switch bar two paths to any point on the loop. Thus the wires can break at any place and all points will still receive current. Two positive and two negative wires are run through a low-voltage distributing board to junction boxes in the plant to be fed. Ammeter jacks for each wire and for the main feed wires after the loop wires are joined, are placed on the switchboard, and a regulating rheostat is inserted in the positive lead for cutting the battery down to 12 volts, at which it is generally maintained. The track sections are fed through the various points on the loop through resistance units of the enclosed fuse type and averaging 37½ ohms. The ammeter jacks are used to determine when there is a break in any of the loop wires. As long as the circuits are perfect the readings are the same, while if there is a break the readings on wires 1 and 3 will be different from those on wires 2 and 4. In calculating the sizes of wire for the loops one side of each was considered cut off at the switchboard with every track circuit occupied



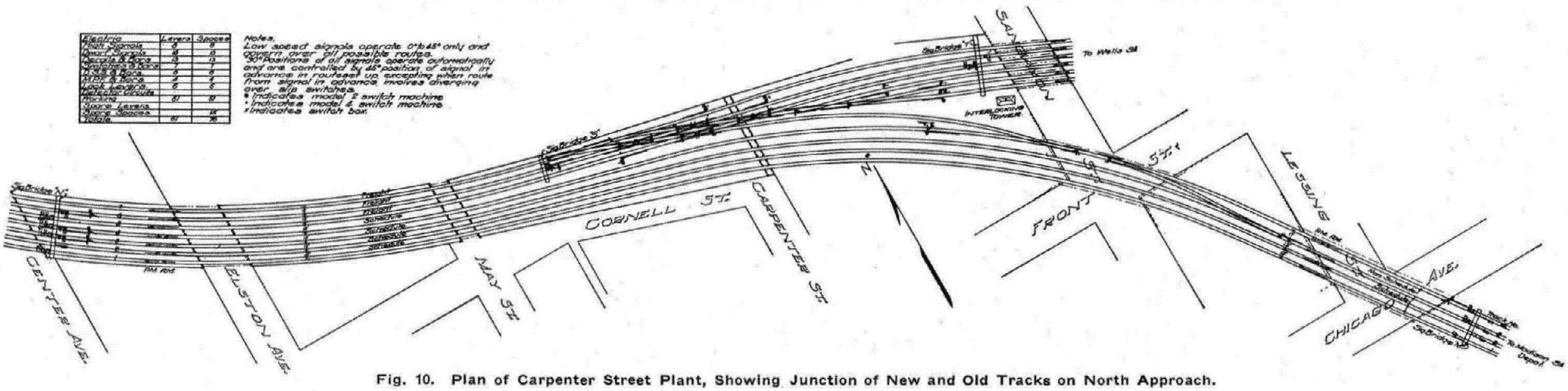
	Levers	Spaces
High Signals	12	12
Dwarf Signals	21	21
Switches & Bars	25	25
D.S.S.	6	6
M.P.F.	3	3
Derails	17	17
Detector Circuits		
Lock Levers	6	6
Working	90	90
Spare Levers	6	6
Spare Spaces		24
Total	96	120

Fig. 8. Plan of Division Street Interlocking, on the North Approach.



	Levers	Spaces
High Signals	10	10
Dwarf Signals	11	11
Derails & Bars	11	11
Switches & Bars	7	7
D.S.S. & Bars	6	6
M.P.F. & Bars	4	4
Detector Circuits	-	-
Lock Levers	4	4
Working	35	35
Spare Levers	13	13
Spare Spaces		[illegible]
Total	68	[illegible]

Fig. 9. Plan of Noble Street Interlocking, Showing the Junction of New and Old Tracks on West Approach.



Electric	Levers	Spaces
High Signals	8	8
Dwarf Signals	16	15
Derails & Bars	13	13
Switches & Bars	7	7
D.S.S. & Bars	6	6
M.P.F. & Bars	4	4
Lock Levers	6	6
Detector Circuits		
Working	61	61
Spare Levers		
Spare Spaces		15
Totals	61	76

Fig. 10. Plan of Carpenter Street Plant, Showing Junction of New and Old Tracks on North Approach.

except the one nearest the cut off end. The limit to the number of circuits that could be fed from the loop was found to be 20. Relays of 12 ohms resistance are used on all of these circuits, and a 12-ohm resistance unit is placed in series with the relay to obtain a quicker drop away of the armature on account of the detector locking. The time of the drop was reduced 50 per cent by this resistance.

Where the track sections are adjacent to the towers track trolled by electric locks located on top of the lever, the circuit being held normally open by a contact operated by a lever latch. A white light in multiple with the lock and latch contact shows whether or not the lock can be energized. Each lock is controlled directly by the track relay of the section in which the switch is located, providing absolute detector locking and making it impossible to throw a switch when the section in which that switch is located is occupied.

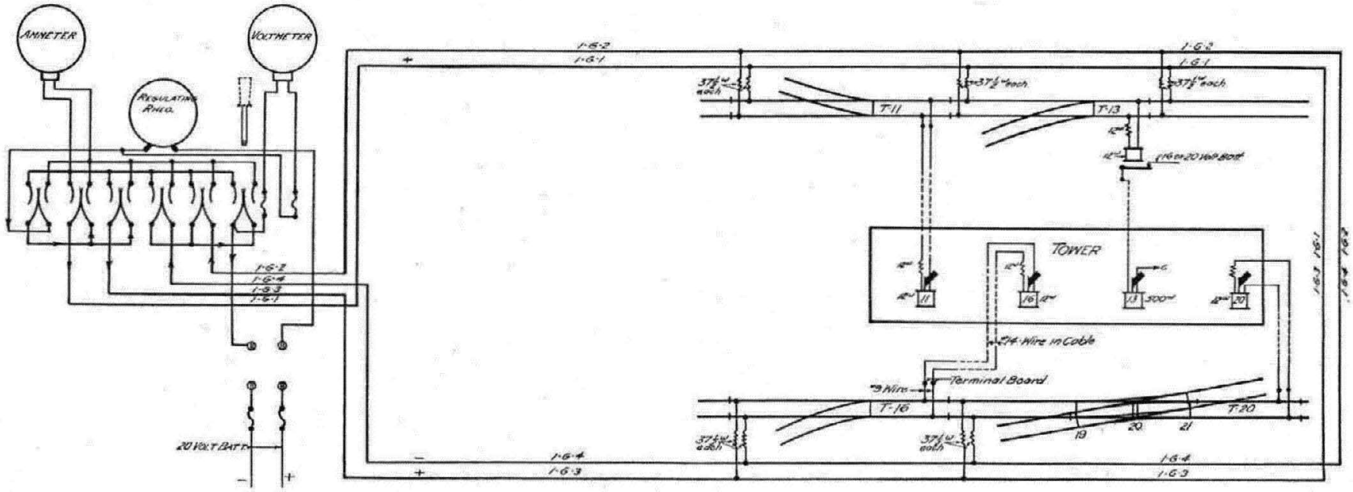


Fig. 11. Diagram of Typical Track Circuit Feed Arrangement for Interlocking Plant.

sections. Motor generator sets, run from the depot lighting system, running successively in six-hour periods, feed direct to the trainshed track circuits, no storage batteries being used.

At the signal bridges at which power houses are located the track circuits are fed from a single cell of 120-ampere hour capacity storage battery with an eight-ohm resistance in series. relays are placed therein. In other cases repeater relays in the towers are controlled by track relays set adjacent to their

The mechanical locking was specially designed for sufficient flexibility to permit effective releasing while remaining rigid enough to give protection. In the Lake street plant signal locking only is employed. The signal levers lock their routes, and the switch levers do no locking except in a few special cases.

In the Division and Clinton street plants the derail levers lock the routes and the system of locking allows very nearly the complete release effected by the electric locking and still

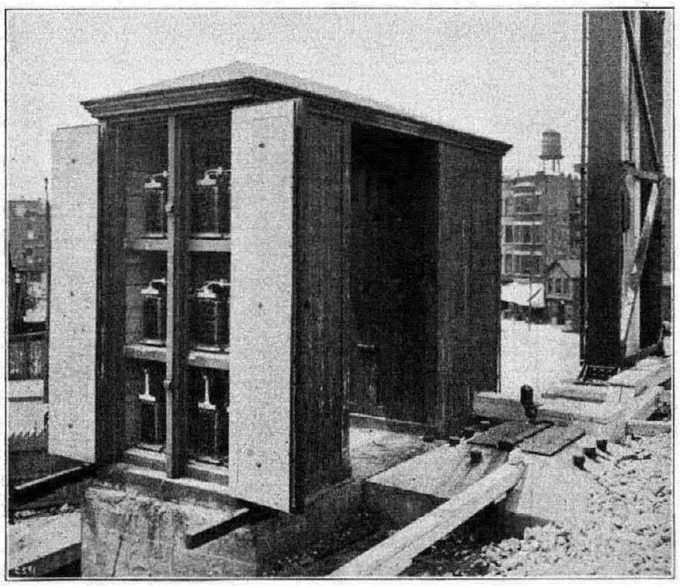


Fig. 12. Storage Battery, Generator, and Relay House at Automatic Signal Bridge.

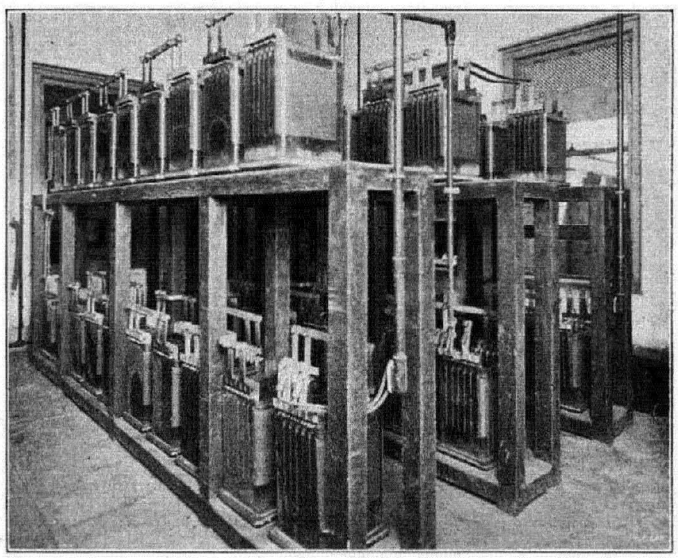


Fig. 13. Storage Batteries in Lake Street Tower.

Four-ohm relays are used where the track circuit is fed from these individual cells.

RELEASE ROUTE LOCKING.

Release route locking circuits are employed at Lake, Clinton, and Division streets only. In operation, a train locks up all switches, derails, and movable frogs in the route, and as the wheels leave each track section the switches, derails, and movable point frogs in that section are released so that they may be moved for the setting up of a new route. The levers are con-

retains the derail protection. All facing derails lock the trailing derails and facing point switches in their routes.

At Clinton street, where two derails are used in some cases, the slow-speed derails do all the mechanical locking, and the circuits of conflicting high signals are controlled by the derails. At the Carpenter and Noble street plants the route ahead of a high-speed train is locked, and on all slow-speed movements detector locking only is installed. In these plants the mechanical locking is as follows: Derails lock all switches in the route;

high-speed derails lock back-up derails; lower number locks the higher number in derails of the same class; mechanical locking is transferred from derails to signals to allow necessary freedom when the special release feature is required.

INSTALLATION OF WIRING.

On account of the great mass of wires required it was necessary to furnish detailed plans showing exactly how each piece of work was to be accomplished; and the workmen were required to follow this plan without any knowledge of the complete circuits involved. Plans for the terminal boards in junction boxes, and manholes on the ground, and on the signal bridges, and also for the terminal boards in the tower were made to show which wires were to be spliced through, the wires to be connected to terminals, and the locations of terminals and resistance units. Plans of the conduits were made to show the location and size of each, and tables were furnished giving the number and size of the wire in each duct, the total length of each wire, its number, destination, and the number of feet to be left out at each end. In addition plans were furnished showing the backs of relay racks, combination boards, interlocking machines, releases, etc., giving the details for connecting the wires, using the tag numbers to identify them. The circuit sheets were written instead of drawn, and by description gave each connection to be made and each cable or conduit through which wires were run. This work in the drafting room saved an immense amount of labor in the field.

Where storage batteries are located at the signal bridges they are in duplicate with a motor generator set for charging. A three-phase 220-volt relay operated in parallel with the motor controlling the charging circuits provides for the possibility of the alternating current failing or a fuse opening in the motor end. Whenever either of these happens this relay opens the charging circuit, preventing the discharge of the battery. If the power returns after failing, the relay restores the charging circuit.

POWER DISTRIBUTING SYSTEM.

Power for all uses except the operation of the Lake street plant is taken from the power house at 6,600 volts, three phase, and distributed through a conduit system. The current is transformed to 220 volts, three phase for power purposes, and to 220 volts—110 volts single phase for lighting purposes. Transformers located near each tower supply current for the towers, and also for the nearby signal bridges. The remaining transformers are so located as to supply two or more outlying signal bridges. The lighting transformers are arranged in pairs, with secondaries in multiple so that there are two sources of power for each circuit, either transformer being able to carry the total load. Induction-motor generation sets are provided in duplicate for each battery located in the towers. The generators are shunt wound with wide variation of voltage. A motor generator is running continuously in multiple with each battery, taking most of the load, the battery helping out on the peaks. Automatic underload circuit breakers are provided for opening the generator circuits in case of failure of the alternating current supply. All motor generators are of the same type, the votage range being from four to 40. The generators are capable of charging from one to 16 cells of battery.

Current for the lever locks of the interlocking machines is supplied from a 220 to 55 volt transformer and the illuminated track

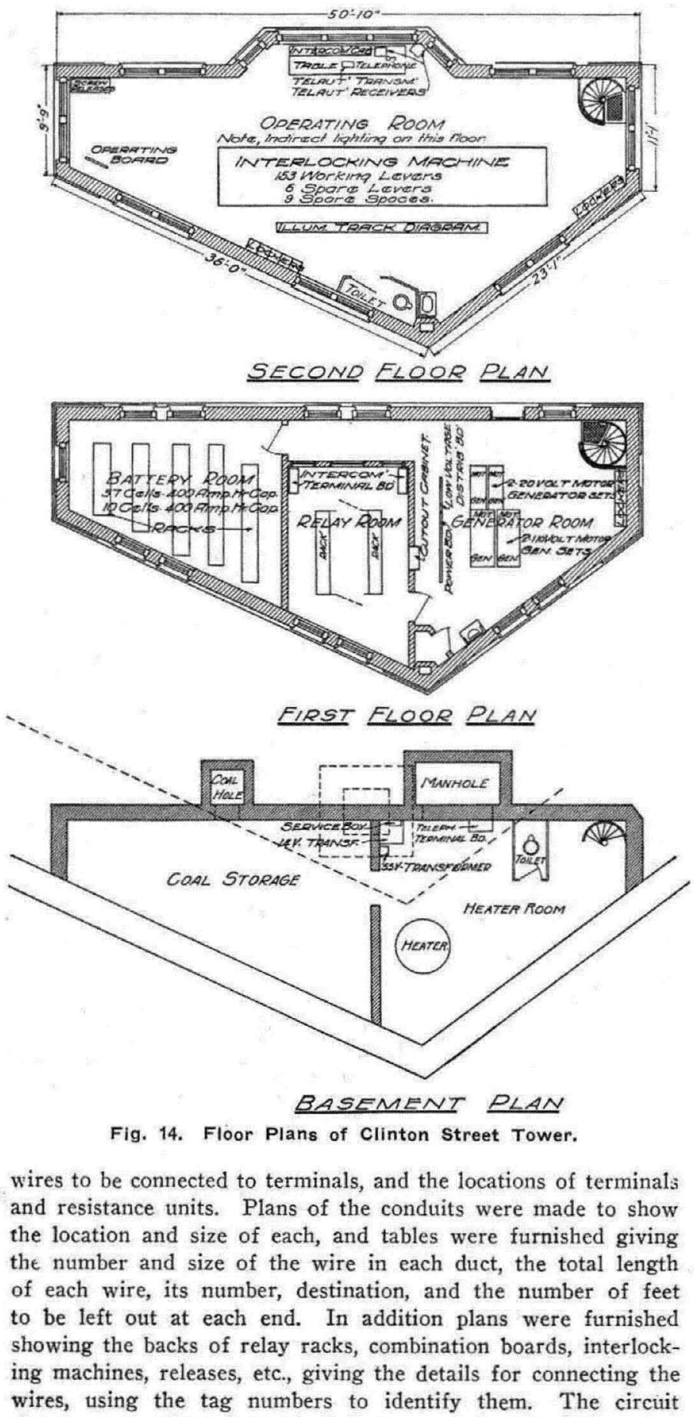


Fig. 14. Floor Plans of Clinton Street Tower.

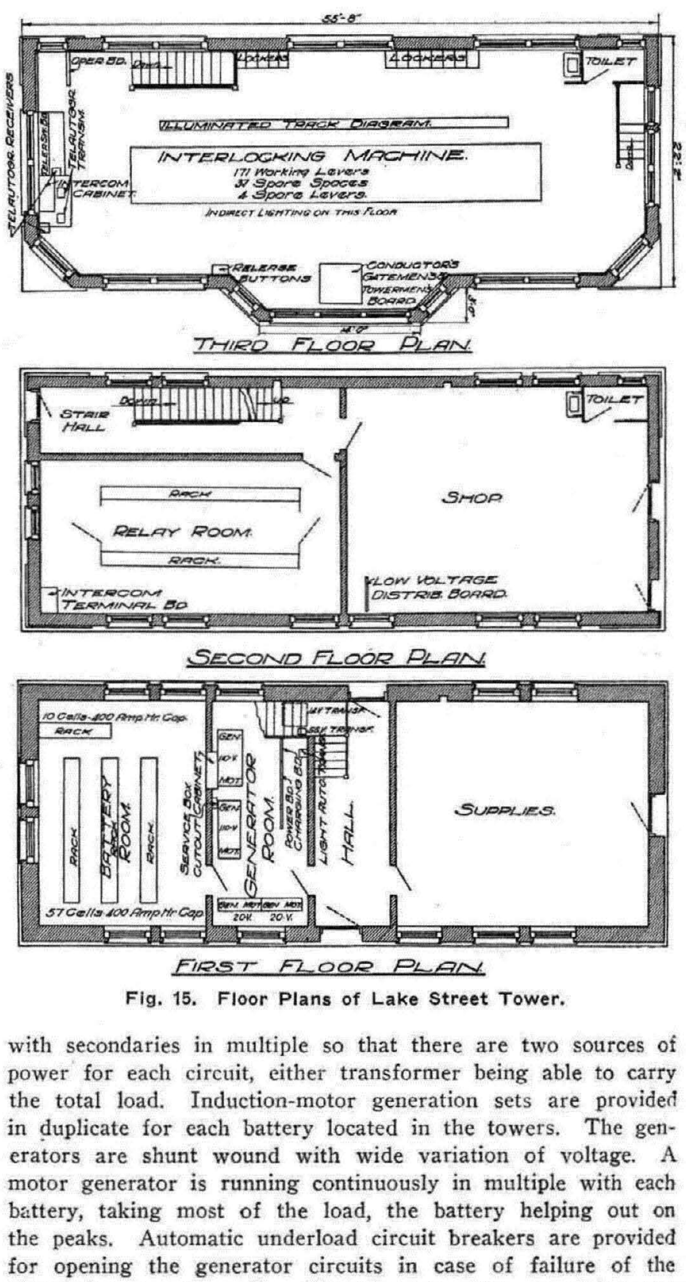


Fig. 15. Floor Plans of Lake Street Tower.

diagram is fed from a 220 to 14, 12, and 10 volt transformer. If the alternating current fails an emergency switch will connect up the locks, and the plants are then operated without the diagrams.

The Lake street plant receives power from three single-phase transformers delta connected, located in the power house and furnishing 320 volts. The electric lighting is normally on direct current from the power house but may be put on alternating current, and provision is made for charging the batteries from the d. c. mains in case of failure of the alternating current.

The range of voltages used is shown in the following list:

(8) 110-volt direct current for interlocking machine and telautographs;

(9) 20-volt direct current for auxiliary circuits, emergency lever, locks, and telephones and intercommunication systems;

(10) 16-volt direct current for automatic signal operation;

(11) 12-volt direct current for track circuit lights;

(12) One-volt direct current for individual track circuits.

INSTALLATION.

For the present needs and future requiremei.ts of power distribution for the signal, telephone, and telegraph systems an

STATISTICS OF MATERIALS AND UNITS ON THE NORTH-WESTERN TERMINAL.

	Lake Street Interlocking	Clinton Street Interlocking	Carpenter Street Interlocking	Division Street Interlocking	Noble Street Interlocking	Wisconsin Division Automatic	Galena Division Automatic	Station	Totals
Signal motors, 1-6 h.p.	67	62	23	31	21	16	15	....	235
Switch motors, 1 h.p.	98	77	32	51	30	....	....	....	288
Motor generators, 110 v. d.c.	2-12.5 h.p.	2-12.5 h.p.	2-5 h.p.	2-7.5 h.p.	2-5 h.p.	....	....	2-½ h.p.	10
Motor generators, 20 v. d.c.	2-12. 5 h.p.	2- 2.5 h.p.	2-1 h.p.	2-1.5 h.p.	2-1 h.p.	4-2 h.p.	....	2-½ h.p.	12
Motor generators, 4 v. 40 v. d.c.	....	....	....	....	....	4-2 h.p.	4-2 h.p.	....	8
									553 motors 30 generators
Storage battery, 110 v.	57 cells400 a.h.	57-400	57-160	57-240	57-160	....	....	....	285
Storage battery, 20 v.	10 cells400 a.h.	10-400	10-160	10-240	10-160	....	....	....	50
Storage battery, 16 v.	....	....	....	....	....	8 sets-8 cells 120 a.h.	8 sets-8 cells 120 a.h.	....	128
Storage battery, 2 v.	....	....	....	....	....	38-120 a.h.	30-128 a.h.	....	68
									531 cells storage battery
Lamps—									
On signals, 2 c.p. 110 v.	134	68	30	46	27	32	30	....	367
On levers, 1 c.p. 55 v.	196	183	72	114	70	....	....	....	635
On illuminated track diagram, 4-watt. 14 v.	924	419	....	....	....	....	....	....	1343
On intercommunicating diagram, 20 v. tel.	22	158	54	45	11	....	....	....	290
On telephone switch board, 20 v. tel.	51	....	....	....	....	....	....	....	51
On conductor, towerman, gateman, 20 v.	96	....	....	....	....	....	....	....	96
On conductor, towerman, gateman, 2 c.p. 20 v.	....	....	....	....	....	....	....	274	274
On tower lighting	....	....	....	....	....	....	....	....	....
									3056 lamps
Relays and indicators	255	160	46	92	32	31	29	32	677
Relays, intercommunicating	22	158	54	45	11	....	....	....	290
Relays, telephone	57	....	....	....	....	....	....	....	57
									1024 relay
Transformers—									
Power, single phase, 220 v.	3-10 k.w.	....	....	....	....	....	....	....	3
Power, three phase, 220 v.	....	1-20 k.w.	1-7.5 k.w.	1-7.5 k.w.	1-7.5 k.w.	1-2 k.w.	1-2 k.w.	....	6
Light, single phase, 220 v.	1-2.5 k.w. auto.	2-3 k.w.	1-3 k.w.	1-3 k.w.	1-3 k.w.	2-3 k.w.	2-3 k.w.	....	10
Lever light, 55 v.	1-1 k.w.	11-1 k.w.	1-½ k.w.	1-½ k.w.	1-½ k.w.	....	....	....	5
Illuminated track diagram, 14 v.	1-5 k.w.	-5 k.w.	.....	....	....	....	....	....	2
									26 transformers

48,710 feet rubber lead cable 1,214,500 feet of wire.
13,890 feet paper lead cable 910,650 feet of wire.
90,500 feet linen lead cable 122,500 feet of wire.
578,835 feet loose wire rubber covered.

153,100 feet lead covered cable 2,826,485 feet of wire.

	Lake Street Interlocking	Clinton Street Interlocking	Carpenter Street Interlocking	Division Street Interlocking	Noble Street Interlocking	Wisconsin Division Automatic	Galena Division Automatic	Station	Totals
Levers—									
High signals	....	29	8	12	10	....	....	....	59
Dwarf signals	67	33	15	21	11	....	....	....	147
Switches	29	26	7	25	7	....	....	....	94
Double slip switches (ends)	46	12	8	6	8	....	....	....	80
Movable point frogs	23	6	4	3	4	....	....	....	40
Derails	....	33	13	17	11	....	....	....	74
Traffic locks	6	14	6	6	4	....	....	....	36

									553 motors 30 generators
Storage battery, 110 v.	57 cells400 a.h.	57-400	57-160	57-240	57-160	....	....	....	285
Storage battery, 20 v.	10 cells400 a.h.	10-400	10-160	10-240	10-160	....	....	....	50
Storage battery, 16 v.	....	....	....	....	....	8 sets-8 cells 120 a.h.	8 sets-8 cells 120 a.h.	....	128
Storage battery, 2 v.	....	....	....	....	....	38-120 a.h.	30-128 a.h.	....	68
									531 cells storage battery
Lamps—									
On signals, 2 c.p. 110 v.	134	68	30	46	27	32	30	....	367
On levers, 1 c.p. 55 v.	196	183	72	114	70	....	....	....	635
On illuminated track diagram, 4-watt. 14 v.	924	419	....	....	....	....	....	....	1343
On intercommunicating diagram, 20 v. tel.	22	158	54	45	11	....	....	....	290
On telephone switch board, 20 v. tel.	51	....	....	....	....	....	....	....	51
On conductor, towerman, gateman, 20 v.	96	....	....	....	....	....	....	....	96
On conductor, towerman, gateman, 2 c.p. 20 v.	....	....	....	....	....	....	....	274	274
On tower lighting	....	....	....	....	....	....	....	....	....
									3056 lamps
Relays and indicators	255	160	46	92	32	31	29	32	677
Relays, intercommunicating	22	158	54	45	11	....	....	....	290
Relays, telephone	57	....	....	....	....	....	....	....	57
									1024 relay
Transformers—									
Power, single phase, 220 v.	3-10 k.w.	....	....	....	....	....	....	....	3
Power, three phase, 220 v.	....	1-20 k.w.	1-7.5 k.w.	1-7.5 k.w.	1-7.5 k.w.	1-2 k.w.	1-2 k.w.	....	6
Light, single phase, 220 v.	1-2.5 k.w. auto.	2-3 k.w.	1-3 k.w.	1-3 k.w.	1-3 k.w.	2-3 k.w.	2-3 k.w.	....	10
Lever light, 55 v.	1-1 k.w.	11-1 k.w.	1-½ k.w.	1-½ k.w.	1-½ k.w.	....	....	....	5
Illuminated track diagram, 14 v.	1-5 k.w.	-5 k.w.	.....	....	....	....	....	....	2

other two. Three-inch bituminized fiber conduit laid in concrete was used throughout. Across the subway approaches and extending 10 ft. on either side a four-inch iron pipe was run for each duct, and the fiber put through it. The manholes are built of brick, with iron covers. Branch systems of conduits were installed for interlocking wires, following the same general type of construction as for the main line except that concrete junction boxes were built instead of manholes. Two-inch iron conduit is used for short runs. As a great many of the switches are on structural steel work the ducts were often laid in the concrete protection of the floors, the concrete junction boxes built as a part of the floor, and the waterproofing made continuous up to and around them. Loricated tubing was used exclusively for wires and cables in the towers and standard bushings and condulets were employed for branches and at ends. Three-inch and four-inch yellow pine trunking was used where connections were made with loose wires, as between junction

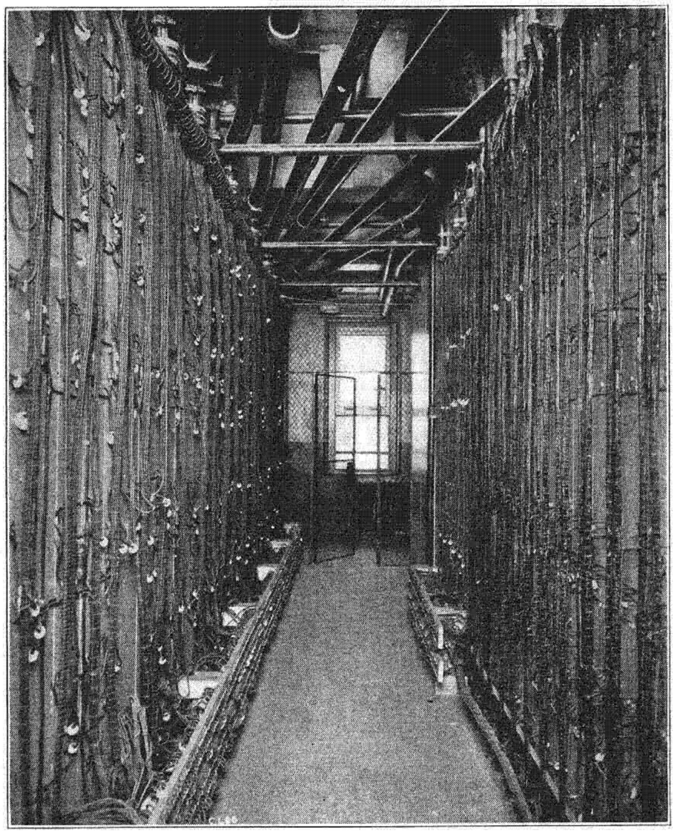


Fig. 16. Wiring on the Backs of the Relay Racks in Lake Street Tower.

boxes and manholes and switches and signals. Where more than six wires were run in one duct cables covered with a lead sheath were employed. For the intercommunicating system paper insulated wire in cables of the telephone type were used and for the power distribution the cables were made up of three No. 4 B. & S. copper conductors insulated with linen and covered with lead.

BUILDINGS.

The towers are of brick, three stories high. The floor plan of the Lake street tower is shown in Fig. 15.

The Clinton street tower is mounted on top of a peculiarly shaped bridge abutment, which accounts for its shape as shown in Fig. 14.

All of the towers are heated by steam, the Lake street tower direct from the power house, while the others have individual heating units. The inverted lighting system is shown in Fig. 7.

There are eight bridge power houses. In one section of each house are the storage batteries in duplicate sets for signal and track purposes. The other section is divided into two parts. One contains the motor generator and switchboard while the other contains the relays. The doors of these houses are specially constructed for protection against dust and dirt.

MAINTAINING AUTOMATIC SIGNALS WITH SECTION FORCES.

For the past year the Union Pacific has been maintaining automatic block signals on double track with the regular section forces on that part of the Nebraska division between Kearney, Neb., and North Platte, a distance of 95 miles. Previous to this time the signals in this territory were maintained by a separate corps of men working under a district maintainer and independent of the track department, as on other parts of the system. The sections on this district are nine miles long, and each section foreman has an assistant and from 10 to 15 men. At the time the maintenance was turned over to the track department the district maintainer was made an assistant roadmaster, and the maintainers were made assistant foremen, except in one or two cases where maintainers with track experience were made foremen. The pay of the foremen was raised at the same time from $65 to $75 per month. While the former maintainers have practically all left by this time, the section foremen have rapidly learned the work.

Previous to taking up the signal work nearly all the foremen had enrolled in the correspondence courses of signaling provided by the educational bureau of the Union Pacific. These lessons were of much help to the men in handling their new duties. As was to be expected, the number of signal failures increased at first, but they came down to about the average number within a short time. Signal maintenance has largely been regarded as a work requiring mechanical and electrical knowledge and skill beyond those of the average foreman, but they have mastered it readily.

This method of maintaining signals with the track forces has several points of merit. In the first place, it eliminates the double daily inspection, as the foreman can inspect the signals at the same time that he is making his track inspection. Again, under the old system it was necessary for the maintainer to call on the section forces for help whenever he had any heavy work to do, and in such cases much time was lost by the men in waiting for one another. The presence of the men from the two departments also frequently led to trouble. Its economy is the result of doing away with the "lack of co-operation" often existing between section and signal forces.

The increase in salary offered an incentive to the better class of foremen to study the operation of signals and increased their efficiency as a class. This plan has worked out even better than was expected by the local officers, and is regarded by them as a success. It has been carried out under the direct supervision of Thomas Scott, roadmaster.

"Up in this part of the country, where they do some mighty good railroading, is a big-hearted general officer, who once, during a blizzard, directed his superintendents to order train and engine crews to disregard block signals forced out of commission by the elements. A section foreman went out to change a rail with the traditional one man who could not flag both ways. So the section foreman, with the rail out, relied upon the (automatic) block signal for protection. Along came the train with orders to disregard the signal—and the engine landed in the ditch. There was some official talk of discharging the section foreman. The big general officer faced the music and said, in effect, that if any enforced vacancies were to occur he himself must be the man. 'Furthermore,' he added, 'we have learned something; if we are ever again tempted to disregard block signals, we will first notify everybody on the railway, including the section foreman. Such manliness is the rule rather than the exception among railway officers. It is a practical kind of honesty which counts in the great art of handling men."—*D. A. D., in "Letters From an Old Railway Official to His Son, A General Manager," copyrighted by Railroad Gazette (Inc.).*