Design of an Interlocking System for the Illinois Central Yards at Champaign, Illinois

Introduction

Champaign, Illinois is a division point of the Illinois Central Railroad. Here are located the sidings and freight yards, round house, machine shops, and train dispatchers office. As originally laid out, all the yard room was around the depot in the heart of the city, but the increase of traffic necessitated the removal of the freight yards to a point about three-fourths of a mile south of the depot where more room could be obtained. At these yards most of the freight switching is done, though there is still a considerable amount of work done in the depot yards. The depot yards, however, are now used as storage room for trains awaiting transit.

Twelve hundred feet north of the depot is the grade crossing of the Illinois Central with the Wabash and the
Chicago, Cleveland, Cincinnati and St. Louis Railroads, the tracks
of the tracks of the two latter roads being parallel and about
90 feet apart. Fifteen hundred feet north of the crossing is
the junction of the main line with the Havana Branch of
the Illinois Central Railroad.

The peculiar situation of the depot yards in the city
unders any increase in the number of tracks or sidings almost
impossible; so that as traffic grows, it will be more and more
and more difficult to safely and speedily handle this traffic
in the cramped yard room. In time the traffic will become
so great that with present methods all movements in the
depot yards will be seriously retarded. To obviate this diffi-
culty, by promoting the safe and speedy handling of the
traffic, is the object of the Interlocking Plant and it is
the province of this Thesis to select a system and make
a design best suited to the case in hand.

In setting out to make the design, two assumptions
have been made: 1. That the main line instead of being a single track, as at present, has been changed to a double track. 2. That the depot yards have become so congested that the traffic can not be safely and speedily handled by the ordinary methods of switching. In this case it becomes necessary to substitute some more efficient method. Having reached this conclusion, we will now enter into the consideration of the problem.

**Advantages of Interlocking**

The reasons for adopting interlocking as the solution of the difficulty are best set forth by an enumeration of the advantages of interlocking; but before entering into a discussion of the advantages, it may be well to describe briefly the principles and methods of interlocking. In an interlocking plant the levers controlling the movements of the switches and the levers operating the signals indicating the different routes are assembled in a compact
and convenient shape in an elevated tower where the operators, or operators, may control and direct all the movements of traffic over the tracks. The normal position of all signals is at danger, i.e., signal blade horizontal, the normal position of the switches are such as best suit the convenience of the particular place. The levers which control the movements of switches and signals are so interlocked that no route can be signaled till the switches are set for that route, and a certain route being signaled, no conflicting route may be signaled till the first one is cleared. Further than this, the switch levers are locked so that no movement of the switches can take place after the route has been indicated. This locking of conflicting levers is the distinctive feature which has given it the name interlocking plant; and no small part of the design of a system or plant consists in regulating the train movements and perfecting the interlocking.
We will now consider the advantages claimed for Interlocking; they may be classed under two heads.

1. Increased safety.

2. Increased facility in handling the traffic at busy points.

1. Increased safety. Increased safety is assured by working each system of switches and signals from a central point, the mechanism of such system being so arranged that so long as the apparatus is kept in good condition, movements taking place under the sanction of the operator, as expressed by lowering the signal or signals—and no other movement can take place without such sanction—are secure against collision from conflicting directions and from disturbance of the switches traversed by such authorized movements. In busy yards and terminal stations where all movements of the switches are made by the switchmen on the ground, collisions and derailments often occur by reason of wrong signals or wrong setting of switches.
2. Increased facility. This depends upon a good lay-out of tracks as well as of signals. With these conditions, much more rapid handling of trains can be obtained with safety by one man who handles all switches and signals from an elevated point, where he can see each movement and anticipate each requirement, than by a number of men on the ground who have to run from switch to switch to throw them.

That these two advantages have great merit is proved by the number of Railroad Companies that have, within the past few years, equipped their busy yards, drawbridges, crossings, and terminal stations with interlocking plants. Notable among these are the Grand Central Station, New York; the Boston Yard of the Boston and Albany Railroad; and the Jersey City Terminals of the New York Lake Erie and Western Railroad. In busy places, interlocking plants have become a necessity.
Selection of a System

There are in use at the present time what we may conveniently term two systems of interlocking: 1. Pneumatic System, 2. Mechanical System.

In the first, the motive power which actuates all switches and signals is compressed air; the compressed air being led from a main reservoir, where the supply is generated, through the entire length of the system by a main supply pipe. Branching from this main, wherever convenient, are smaller pipes conveying the pressure to the various switch and signal movements. At each movement is located a second reservoir (known as the auxiliary reservoir) and a cylinder and piston for actuating the switch or signal. The movement of the switches is controlled by means of a slide valve which admits the air to the cylinder, the movement of the slide valve being controlled either by compressed air or by an electric circuit. The signal movements are
controlled by means of an electric circuit, the arrangement being such that the signal shows "clear" only when the circuit is closed, going to danger automatically when for any reason the circuit is broken. Each signal is interlocked with its corresponding switch and can show "clear" only when the switch is in the proper position; when the signal is put to "clear", the switch is locked and can not be moved till the signal is again put to "danger."

In the mechanical system, the movements of all switches and signals are made by means of levers located at a central point. The levers are connected to the various switches and signals by means of pipe or wire. The levers which control the various movements are so interlocked that it is impossible to signal conflicting routes or routes for which the switches are not set.

These two systems are the ones most in use today, but some modifications of the two are in use, but these may...
always be classed under the one head or the other. It is seen, then, that the choice lies between the Pneumatic and the Mechanical interlocking. To make this choice we must study the advantages and disadvantages of each.

Advantages of Pneumatic System

1. Switches and signals may be operated at any desired distance from the cabin and any number of either or both may be operated at the same time, and any number of either from the one lever.

2. Switches are required to be not only moved and securely locked in the proper position before a signal governing traffic over them can be cleared, but are also required to indicate to the operator at the machine that they have been moved and locked, before the clearing of the signal can be effected.

3. Each signal, when clear, automatically locks the lever operating it and prevents its being used to release conflicting switches or signals until the first signal has again been
placed completely at danger. This insures that two conflicting signals shall never be clear at one time.

4. The locking of the machine being between switches and signal levers only, is of great simplicity and permits a construction insuring great durability.

5. The correct positions of switches and signals are insured at all times from the fact that the moving parts of the operating mechanism are attached directly to the ties or to the parts on which they are located, and that lost motion and the effect of expansion and contraction in the moving parts is consequently inappreciable.

6. The machine being provided with a miniature model of the tracks operated, the operator can at a glance see the condition of them at any time (This however might be equally as well applied to the mechanical machine.)

7. Any number of blades on a post may be provided with any desired number of indicators without encumbering the post
with cranks, balance levers, and connections; all of which would be required under other systems.

7. The machine occupies less than one-fourth the space required for a manual machine of the same capacity, and weighing correspondingly less, cabins of smaller and lighter design may be used.

8. Connections between the machine and the switches being of small diameter and immovable, no heavy foundations or expensive anti-friction devices are necessary.

10. The operation of the machine requiring so little exertion, trusted employees crippled in service, and thus rendered incapable of performing former duties, may again be made useful or female operators may be employed.

Disadvantages of Pneumatic System.

1. All pipes, valves, cylinders, etc., must be carefully made and fitted and erected so that the cost of the plant and the erection are considerably greater than that of the mechanical system.
2. In addition to the switches, signals, and interlocking
machine, an engine and boiler is required for furnishing the
compressed air, causing additional expense.

3. Because of the greater delicacy of the working parts,
repairs and renewals must be made more frequently, thereby
increasing the cost of maintenance; the expense incident to run-
ning the compressed air plant still further adds to this cost.

4. The effect of changes of temperature in the pipe supply-
ing the compressed air is such that expansion joints must
be used in the lines of pipe.

5. Owing to the condensation of moisture from the compressed
air, there is liability during severe weather of the pipes and
cylinders freezing up.

6. Any leak in the valves or connections may throw a
switch without the movement of the corresponding lever in
the cabin, thereby making serious accidents possible.

7. The maintenance of the plant requires the services of
an electrician, as well as a skilled mechanic; while in the mechanical system, a mechanic of ordinary ability can make all necessary repairs.

8. The arrangement of the machine is such that special locking can not be so readily furnished as in the mechanical machine; a thing often very desirable in intricate yards.

Advantages of the Mechanical System.

1. By reason of the greater simplicity of working parts, the original cost of the plant and cost of erection is less than in the pneumatic.

2. The simplicity of the plant enables an ordinary mechanic to repair and keep it in good order with the minimum of labor.

3. All movements of switches and signals are positive and a failure of any part is immediately manifested to the operator by the different action of the levers.

4. The locking and releasing of the levers is automatic.
and the interlocking is such that no signal can be given until the route is clear; and further, no signals for conflicting routes may be given at the same time, nor the position of the switches changed after the route is signaled.

5. The arrangement of the machine is such that any special locking desired may be provided.

Disadvantages of the Mechanical System

1. The manual machine being larger and heavier than the pneumatic, a larger cabin is required and better foundations.

2. The connections between the switches and signals and the machine being moveable, good foundations and anti-friction devices are necessary.

3. There is a limit to the distance at which switches and signals can be successfully worked; for the former the limit is about 1000 ft. for the latter 3000 ft.

4. The effect of expansion and contraction on connecting parts is such that for all lines of pipe 100 ft or over a
compensating device must be used. For wire connections no compensator is used up to 2000 ft, and with some com-
panies, notably the Union Switch and Signal Company, no com-
ensators are used in wire connections.

Summarizing the advantages and disadvantages of each, we see that the mechanical plant is cheaper in first cost, erection and maintenance, but has the disadva-
tagge of having a heavier and larger machine requiring more
space and better foundations; also that the connections must
have good foundations and expansion and contraction requires the
use of compensators on the connecting points. We see that
the pneumatic plant is lighter in its parts and more easily
worked; that a smaller and lighter cabin is necessary but
that the first cost and cost of maintenance is greater. A prom-
inent representative of the mechanical system gives the cost
of the pneumatic as fifty per cent greater than the
mechanical. This estimate must be taken with some res-
eration since the person giving it may not be free from personal bias.

In regard to some of the good features of mechanical interlocking, the Report of the Roadmasters Association of America says of the Johnson Interlocking machine, a prominent representation of the mechanical system. The Johnson interlocking machine of the Johnson Railway Signal Company has preliminary locking. It has a simple and durable patent rocking movement, and the extreme simplicity of its special locking as performed by the patent sliding section of the tapper is to be commended. Any part of the locking mechanism may be readily removed for alteration or examination without disturbing the locking, having no relation thereto. All its ordinary and special locking is in the same plane. All its parts are made interchangeable. The machine is to be admired for the features it presents of economy of maintenance and adaptability to any arrangement of tracks at

* Railroad Gazette, Vol. XXIII, p. 648
yards, crossings, drawbridges, or tunnels."

The same report also says of Pneumatic Interlocking:

"The Westinghouse system of pneumatic interlocking of the Union Switch and Signal Company is an elaborate apparatus in which compressed air and electricity are the actuating agents. The plant required for the purpose consists of a steam generating boiler, air compressor and condensing tank."

It seems probable that under favorable conditions the cost of equipping and maintaining in either case will not differ widely. Whatever difference there is will be found to be in favor of the mechanical; this difference sometimes amounting to as much as fifty per cent in first cost. For a large and compact yard or a number of yards where it will require all the time of an electrician and master mechanic to superintend the repairs and maintenance of the plant or plants, and especially for points where space must be economized, the pneumatic interlocking is best suited. For small or isolated plants, where
it would not be economical to employ a superintendent of
the qualifications mentioned above, and especially where low-
first cost combined with ease and cheapness of maintenance
is desired, the mechanical interlocking is best suited.

The Illinois Central Yards conform more nearly to
the latter conditions than to the former; and the evidence points
to the mechanical interlocking as being best suited to the case
because of its cheapness, simplicity, durability, and ease of
maintenance, and because of the fact that a machine is needed
that will give a large number of special lockings. A machine
widely known and used is the Johnson machine made by the
Johnson Railway Signal Company, Rahway N.J. This machine
has been used with success in a large number of yards,
terminal stations, and grade crossings, and has been commended
by the Roadmasters Association of America (see p. 16). Because of
its undoubted excellency, and further that it is one of the
leading machines of the mechanical system, and for the ad-
ditional reason that the writer is better acquainted with this
machine than with any other, the Johnson machine is selec-
ted for the design.

Design of the System.

One of the objects to be attained in the interlocking,
is the protection of the grade crossing of the Illinois Central
with the Chicago, Cleveland, Cincinnati, and St. Louis, and the
Wabash Railways. In order to do this, the tower must be so
located as to give a clear view of all these roads. The best
point to locate the tower is between the tracks of the two lines
last mentioned and just west of the Illinois Central tracks. In
this location the tower commands the view of not only the Chicago
Cleveland, Cincinnati, and St. Louis, and the Wabash tracks, but also
the tracks and sidings of the Illinois Central as far south as
University Avenue and as far north as is needed for the pro-
tection of the crossing. This location, then, being the most ad-
vantageous is the one chosen. (See map of north end of yards.) For the
interlocking at the south end of the yards a second tower must
be placed. The position best suited to command the view both
north and south is west of track D and north of the point where
track F joins D. (See map of south end of yards.)

Having decided upon the location of the towers the next
steps are to determine what part of the train movements are to
be controlled by interlocking, to decide on the most advantageous
position of switches and signals, and to so design the interlocking
that it will be impossible to give signals for conflicting routes.

Extends of Interlocking

As has been said, the road is to be operated as a
double track all main track running to be right hand (except
in case of blockade) In the yards the trains may run either
right or left hand, right hand running being given the preference
and used whenever possible.

The traffic is to be divided up among the tracks as
follows: Track A, arrival and departure of passenger trains either north or south bound. Track B, arrival and departure of either passenger or freight. Tracks C and D, used for freight exclusively. Track K, north end used for storage track for cabooses for north bound freight. Tracks E and F, movements of engines to and from round house. Track S, storage track for cabooses for south bound freight. Track A between crossovers R and Q, storage track; south of crossover R, track to the south yards when freight is made up. Track T, main track.

The scope of the interlocking is to include: 1. All main tracks including the four parallel tracks in front of the depot. 2. All crossovers on main tracks and all switches and turnouts leading out from the main tracks. 3. The grade crossing of the Illinois Central with the Chicago, Cleveland, Cincinnati and St Louis and the Wabash. 4. The Big Four "Y." Owing to its great distance the Havana Branch will not be included. With this brief summary we will take up the in-
Interlocking controlled by each tower.

Tower 1 will control the interlocking for the grade crossing; and for all Y's, switches, turnouts, and crossovers as far on each side of the tower as the safe working of switches will permit. The distance to which a switch may be safely worked is about 1000 feet. We see from this that it will not be practicable to include the Havana Branch of the Illinois Central since its distance is about 1600 feet. However, if it is found necessary to protect train movements at this point, a four-level ground machine may be put in at this place and the distant signal slotted from this machine and tower 1 so that it will require the concurrence of both operators to give the clear signal.

The interlocking for tower 2 will begin at switch No. 11, near University Avenue, and extend south as far as switch 20, which is as far as switches can be safely worked. For the present, the freight yards, still further south, will
not be interlocked, unless it be thought best to put in a
ground machine to protect the switches leading into the yards.
The design is so arranged, however, that at any time it is
decided necessary, a third tower may be placed at the yards
and the yards interlocked without in any way interfering
with the present system.

**Arrangement of Switches and Signals**

But few rules can be laid down for the arrangement
of switches and signals for the interlocking of yards, it
being necessary in each case to adapt the arrangement to
the particular problem. In the case of grade crossings
the practice is more uniform, a set of rules for interlock-
ing having been formulated by the Illinois Board of
Railroad and Warehouse Commissioners. On this account
we will first take up the arrangement for the grade
Crossing, the design to be according to the rules above
mentioned.
Grade Crossing Switches and Signals

The rules above cited provide that derailing switches for high-speed tracks shall be placed not less than three hundred feet from the crossing; in case a train is liable to back up over the crossing after having passed over, back-up derails must be provided, the derails being placed one hundred and fifty feet from the crossing. Fifty feet beyond the derail switch is placed the home signal and twelve hundred feet beyond the home signal is placed the distant signal. On slow speed tracks the distant signal may be omitted. In this particular case, it is evident that no distant signal is needed south of the crossing on the Illinois Central or west of the crossing on either the Chicago, Cleveland, Cincinnati and St. Louis or the Wabash, the depots in both cases being about twelve hundred feet distant. North of the crossing and also to the east, the usual distant signals will be placed.
By referring to the map of the north end of the yards, shown opposite page 28, a clearer understanding of the arrangement will be gained. Switches numbered 20, 25, and 26 are derail switches for high speed tracks; switches numbered 21 are back-up derail switches. Signals numbered 5, 8, 12, 9, 13 and 39 are home signals; signals numbered 1, 10, and 14 are distant signals. The signals used are of the ordinary semaphore pattern described in the specifications page 71. See also Fig. 6.

We will now take up the arrangement of switches and signals for yard interlocking. This part of the design will be divided into two heads: 1. Arrangement of switches. 2. Arrangement of signals.

Arrangement of Switches.

One of the rules observed in practice is to eliminate, as far as possible, all facing point switches. Accordingly, in the design, turnouts and crossovers have been altered so as to make as few facing point switches as consistent with rapid movements of traffic. To secure greater safety, all facing point
switches are locked in either position by a bolt worked by a separate lever in the tower. For trailing point switches the switch and lock movement described on page 54 is used. In order to protect the main track, all sidings have a derail switch to prevent cars running out upon the main track. This derail switch is worked by the same lever that works the siding switch. In order to prevent a switch being thrown while a train is upon it, a long thin bar of iron called a detector bar is hinged vertically alongside the outside of the rail, the length of the bar being greater than the distance between any set of wheels. When the switch is thrown, the first motion of the crank raises the detector bar so that if car or standing on the track, the wheels prevent the detector bar being thrown over, thus preventing the throwing of the switch. Fig 37 page 49 shows a cross-section of rail and detector bar, Fig 38 shows the detail of the hinge and support.
Arrangement of Signals

The best practice at present is to place the signal which controls the movement on the right hand side of the track looking in the direction of the movement. The signal used is of the semaphore pattern, high signals being used for main track running, dwarf signals for switching and derailing movements. The signals are placed about fifty feet from the switch which they control. The practice with the Illinois Central is to use but one arm for the dwarf signal regardless of the number of routes. For the high signal, not more than two arms are used, the top arm indicating the main track.

The method of connecting a signal to the lever of the machine is by means of two wires, a back and a front wire. The distance to which a signal may be worked is about 3000 feet. When signals are worked at such a great distance, an electric circuit is run from the signal to the tower and indicates on a miniature model the position of the signal.
an more than 2000 feet away, the wire connections should be compensated. Figs 576 show the standard high signal with connections; Figs 748 show the standard dwarf signal.

A reference to the map of the yards opposite page 23 will serve to show the arrangement of switches and signals for the yard interlocking. In the numbering of switches and signals, the number given corresponds to the number of the switch in the tower which operates said switch or signal. With this explanation as to the numbering we are ready to proceed with the design of the interlocking.

**Design of Interlocking**

In order to show the method employed in the design, we will take up and go through in detail the design of the interlocking for tower 1. In what follows, it is to be understood that the normal position of all signals is at danger; that the normal position of derail switches is the switch open; that the normal position of all other switches is with the
main line or lines clear; and that the normal position of
the levers of the interlocking machine is shown for levers
3, 4, 5, 6, 7 and 8, Fig. 1. Interlocking is the term applied to
the locking of the levers of the machine among themselves.
A detailed description of the machine is given on page 44.
In order to make the design of the interlocking clearer, we will
here repeat some of the description in regard to locking. One
lever is said to lock another, when the moving of the first from
the normal position prevents the moving of the second from the
normal position. One lever is said to release another, when
the first must be completely moved from its normal position
before the second can be moved from its normal position.
Locking is said to be conditional or special when the po-
position of one lever determines whether two other levers shall
lock each other or release each other. With this much in
explanation we will now proceed with the design.
One of the requirements of a good design is that
the interlocking shall be so arranged that conflicting signals shall not be given. The position and number of switches and signals having been determined the details of the design will be taken up beginning with lever 1.

Lever No. 1 controls distant signal and can not be set to clear till No. 2 is set to clear releasing No. 1. No. 1, then, locks No. 2 in the reversed position.

Lever No. 2, controls home signal with two blades; by means of a selector, the selector being worked by No. 19. No. 2 then must lock No. 19 in either position; this is effected by locking the facing point lock lever No. 17. The conflicting signals are 3 and 4 which are also locked by No. 2. Also, when the main track is clear, No. 5 must be reversed before No. 2 is released; hence No 2 lock No. 5 in the reversed position when No. 19 is home.

Further than this No. 2 in the reversed position releases No. 1 the distant signal.

Lever No. 3 controls signals for left-hand running for
trains going out on the Havana Branch. The conflicting signals are Nos. 2 and 4 which are locked by No. 3. In case crossover 22 is thrown, No. 3 should be reversed before No. 7 can be cleared; or 3 releases 7 when 22 is reversed. In order to prevent crossover 22 being thrown after the signal is given, 3 locks 22 in either position. 3 must also lock 19.

Levers 4 controls the movements from the "Y" to track B. The conflicting signals are 2 and 3 which are locked when 4 is reversed. Since No. 19 must be thrown before 4 is released, 4 locks 19 in the reversed position.

Levers 5 controls home signal for derail switches 20 and 21. When crossover 22 is thrown, 1 is a conflicting signal; hence 5 locks 7 when 22 is reversed. Since the derails 20 and 21 must be closed before 5 can be cleared, 5 locks 20 and 21 in the reversed position. When the switches are set for main track, 5 must be cleared before 2 can be cleared; or 5 releases 2 when 19 is thrown. 5 also locks F.P.L. lever No. 16. Bolt locks switch 20, see Fig 3.
Lever 6 controls the movements from H to A. The conflicting signal is 7, which is locked by 6. In movements from H to A, crossover 22 must be open; hence 6 locks 22. Since 23 releases 6, 6 locks 23 in the reversed position; also 21.

Lever 7 controls the movements on main track A, from A to B, or from A to H. The two blades of the signal are rotated by means of a selector worked by either 22 or 23. To prevent movement of the switches after the signal is given, 7 locks the F.P.T. (Facing point lock) lever No. 16. When 23 is reversed, 6 is a conflicting signal; hence 7 locks 6. When 22 is reversed 5 is a conflicting signal; hence 7 locks 5 when 22 is reversed. Since 7 is released by 3 when 22 is reversed, 7 locks 3 in the reversed position when 22 is reversed. 7 having been released by 20 and 21 locks 20 and 21 in the reversed position. 7 released 39.

Lever 8 controls the home signal for eastbound trains on the Chicago, Cleveland, Cincinnati and St. Louis (Big Four). No. 9 is a conflicting signal and 24 an conflicting switch, both being locked.
by 8. Since the detrain switch 25 must be set for main before 8 is released, 8 locks 25 in the reversed position. No 8 also bolt locks switch 25 as illustrated by Fig. 3.

Lever 9 controls home signal for west bound Big Four trains, the two blades of the signal being worked by a selector controlled by 24. No 9 locks the conflicting signals 8 and 11 and the F.P. lever 18. Since 25 releases 9, 9 locks 25 in the reversed position.

No 9 releases distant signal 10 and bolt locks 25 in the same manner.

Lever 10 controls distant signal for west bound Big Four trains. Since 9 releases 10, 10 locks 9 in the reversed position.

Lever 11 controls siding signal. It locks the conflicting signal 9 and since it is released by 24, locks 24 in the reversed position.

Lever 12 controls home signal for east bound Wabash. It locks the conflicting signal 13 and the detrain switch lever 26 in the reversed position. It also bolt locks switch 26. (see Fig 3)

Lever 13 controls home signal for west bound Wabash. It locks the conflicting signal 12 and the detrain switch lever 26. It also bolt locks switch 26. (see Fig 3)
Lever 14 controls distant signal for west bound Wabash, since
13 releases 14, 14 locks 13 in the reversed position.

Lever 15 - spare lever.

Lever 16 controls facing point lock which locks switches 22
and 23. In order to prevent signal being given when facing
points are not locked, 16 locks 5 and 7.

Lever 17 controls facing point lock for switch 19. In order to
prevent clear signal being given with facing point not locked, 17 locks 2.

Lever 18 controls facing point lock for switch 24. In order to pre-
vent clear signal being given with facing point not locked, 18 locks 9.

Lever 19 controls switch and derail for "Y", locks conflicting
signal 3 and works the selector which controls the movement of
the two blades on signal 2. Releases 4.

Lever 20 controls the two derail switches, for right hand tracks
In order to prevent clear being given on the Wabash or Big Four
when the Illinois Central is clear, 20 locks 24, 25 and 26 with
detail points open. No 20 releases 5, 74, 37 and 41.
Lever 21 controls the two back-up derrails. Locking and releasing same as 20 except that 21 also releases 6.

Lever 22 controls the two crossover switches in crossover L between tracks A and B. It makes the selectors for signals 5 and 7, and locks 6.

Lever 23 controls siding switch and derail; makes the selector for the two blades on signal 7; releases signal 6.

Lever 24 controls siding switch and derail on Big Four; locks 20 and 21 which control derail switches on Illinois Central; locks 27 and the conflicting signal 8. Releases signal 11. Also locks 27.

Lever 25 controls derail switches on Big Four. In order to prevent clear being given on the Illinois Central at the same time, 25 locks 20, 21 and 27. Releases home signals 8 and 9.

Lever 26 controls derail switches on the Wabash. In order to prevent clear being given on the Illinois Central at the same time, 26 locks 20, 21 and 27. Releases home signals 12 and 13.

Lever 27 controls siding switch and derail for track E. Locks 24, 25 and 26; locks 41 when 33 is home. Since movements may vary...
to be made into siding E without throwing signal 40, 27 releases 36 when 40 is home. 27 also releases signal 37.

Lever 28 controls crossover G from B to A. It locks the conflicting signals 40, 43 and 48. It also locks 41 when 39 is home in order to prevent clear being given on 41 till 39 is set at clear.

Lever 29 controls switch and derail for sidings C, D and F. It locks the conflicting signal 44 and works the selector which controls the movement of signal blades on 40. It releases switches 31 and 32. *signal 46*

Lever 30 controls siding switch and derail for track K. Locks the conflicting signal 48; releases siding signal 43.

Lever 31 controls siding switch for track C. Locks signal lever 46 and switch lever 32 and releases siding signal 47. Since 31 is released by 29, 31 locks 29 in the reversed position.

Lever 32 controls siding switch for track D; locks 31 and 46 since 29 releases 32, 32 locks 29 in the reversed position. Releases 45.

Lever 33 controls facing point lock for switch 29. In order to prevent clear signal being given with 29 not locked, 33 locks 40.
Lever 34 and 35 spare levers

Lever 36 controls two-bladed home signal by means of a selector worked by 27. When 27 is home, 40 must be cleared before 36 is released; hence 36 locks 40 in the reversed position when 27 is home.

When 22 is home, 36 releases 5. To prevent switch being thrown after signal is set, 36 locks 27 in either position. Also 36 locks signal 37.

Lever 37 controls siding signal; looks the conflicting signal 36. Since 37 is released by 27, 37 locks 27 in the reversed position.

Lever 38 controls signal for left hand running track A; looks conflicting signal 39; locks 41 when 28 is reversed and 28 in either position. Having been released by 42, 38 locks 42 in the reversed position. Also, 38 releases 5 when 22 is reversed.

Lever 39 controls home signal for derail switch track A; locks conflicting signal 38. Having been released by 7, 39 locks 7 in reversed position. 39 releases 41 when 28 is reversed; releases 43 and 48.

Lever 40 controls home signal with two blades by means of a selector worked by 29. 34 locks 28 and 41, also 29 in either
position. Releases 36 when 27 is home.

Lever 41 controls signal for left hand running track B. It
locks 38 when 28 is reversed. Locks conflicting signal 40. It releases
signals 44, 45, 46 and 47, locks 39 reversed when 28 is reversed.

Lever 42 controls siding signal. It locks 43 and 48, releases 38
when 28 is home, locks 31 in either position.

Lever 43 controls siding signal. It locks 42 and 48 home, and
30 and 39 reversed.

Lever 44 controls signal for left hand running track B. Locks
29 home and 41 reversed.

Lever 45 controls signal for track D. It locks 32 and 41 reversed.

Lever 46 controls signal for track F. Locks 31 and 32 home, 29 and 41 reversed.

Lever 47 controls signal for track C, having been released by
31 and 41. 47 locks 31 and 41 in the reversed position.

Lever 48 controls high signal for track A. Locks the conflicting
switches 25 and 30 and the conflicting signal 42. Having been re-
leased by 39, 48 locks 39 in the reversed position.
In the same manner the interlocking for tower 2 is
designed. It is not necessary to go through the details, that
already given being sufficient to show the method. We will now
give a summary of the interlocking for both towers 1 and 2.
In order to make the summary brief and compact a few words
of explanation are necessary.
In the first column is given the number of the lever;
in the second, the locking; in the third, the releasing; and in the
fourth, the switch signal or lock which the lever operates. The
locking and releasing is that which occurs when the lever
given in column one is moved from its normal position or,
in other words, reversed. A number placed in a circle in
column two indicates that the lever in question is locked in
the reversed position; written in the ordinary way indicates
that the lever is locked in the home or normal position.
With this explanation the summary of the interlocking
is appended.
# Table of Interlocking

## Tower 1

<table>
<thead>
<tr>
<th>Lever</th>
<th>Locks</th>
<th>Releases</th>
<th>Operates</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>1</td>
<td>Distant Signal.</td>
</tr>
<tr>
<td>2</td>
<td>3, 4, 5 when 19 is Home, 17.</td>
<td>7 when 22 is reversed</td>
<td>Home Signal, 2 Blades.</td>
</tr>
<tr>
<td>3</td>
<td>2, 4, 19, 22, 23</td>
<td>1</td>
<td>Home Signal.</td>
</tr>
<tr>
<td>4</td>
<td>2, 3, 19</td>
<td>19</td>
<td>&quot;Y&quot; Signal.</td>
</tr>
<tr>
<td>5</td>
<td>39 when 22 is Home, 7 when 22 is reversed, 22 reversed, 19</td>
<td>2 when 19 is Home.</td>
<td>Home Signal, 2 Blades.</td>
</tr>
<tr>
<td>6</td>
<td>7, 20, 21, 22, 23</td>
<td>39</td>
<td>Siding Signal</td>
</tr>
<tr>
<td>7</td>
<td>39 when 22 is reversed, 6, 16, 20, 21</td>
<td>39</td>
<td>Home Signal, 2 Blades.</td>
</tr>
<tr>
<td>8</td>
<td>9, 24, 25</td>
<td>10</td>
<td>Home Signal.</td>
</tr>
<tr>
<td>9</td>
<td>8, 11, 18, 24, 24, 25</td>
<td>10</td>
<td>Home Signal, 2 Blades.</td>
</tr>
<tr>
<td>10</td>
<td>9</td>
<td>14</td>
<td>Distant Signal</td>
</tr>
<tr>
<td>11</td>
<td>9, 24</td>
<td>14</td>
<td>Siding Signal</td>
</tr>
<tr>
<td>12</td>
<td>13, 26</td>
<td>14</td>
<td>Home Signal</td>
</tr>
<tr>
<td>13</td>
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<tr>
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<td>13</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>5, 7</td>
<td>22, 23</td>
<td>Facing Point Lock.</td>
</tr>
<tr>
<td>17</td>
<td>2</td>
<td>19</td>
<td>Facing Point Lock</td>
</tr>
<tr>
<td>18</td>
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<td>24</td>
<td>Facing Point Lock</td>
</tr>
<tr>
<td>19</td>
<td>3</td>
<td>4</td>
<td>FACING POINT LOCK</td>
</tr>
<tr>
<td>20</td>
<td>24, 25, 26</td>
<td>5, 7, 39</td>
<td>2 Derail Switches, 2 Locks, and 2 Detector Bars.</td>
</tr>
<tr>
<td>21</td>
<td>24, 25, 26</td>
<td>5, 6, 7, 39</td>
<td>Same as 20.</td>
</tr>
<tr>
<td>22</td>
<td>6</td>
<td>2</td>
<td>Switch, Derail, and 2 Detector Bars</td>
</tr>
<tr>
<td>23</td>
<td>6</td>
<td>2</td>
<td>Switch, Derail, and 2 Detector Bars</td>
</tr>
<tr>
<td>24</td>
<td>8, 20, 21, 27</td>
<td>11</td>
<td>Switch and Derail</td>
</tr>
</tbody>
</table>
# Table of Interlocking

## Tower 1

<table>
<thead>
<tr>
<th>Lever</th>
<th>Locks</th>
<th>Releases</th>
<th>Operates</th>
</tr>
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<tbody>
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<td>Same as Lever 25</td>
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<tr>
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<td>24 , 26 , 26 , 41 when 28 is Home</td>
<td>36 when 40 is Home, 37.</td>
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</tr>
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<tr>
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<td>44</td>
<td>31 , 32 , 46</td>
<td>Switch and Derail</td>
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<tr>
<td>30</td>
<td>48</td>
<td>43</td>
<td>Switch, Derail, 2 Locks, and 2 Detector Bars.</td>
</tr>
<tr>
<td>31</td>
<td>29 , 32 , 46</td>
<td>47</td>
<td>Switch, Lock, and Detector Bar.</td>
</tr>
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<td>32</td>
<td>29 , 31 , 46</td>
<td>45</td>
<td>Same as Lever 31</td>
</tr>
<tr>
<td>33</td>
<td>40</td>
<td>29</td>
<td>Facing Point Lock</td>
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<tr>
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<td></td>
<td></td>
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<td>35</td>
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<td>36</td>
<td>40 when 27 is Home, 27 , 27 , 37</td>
<td>5 when 22 is Home</td>
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</tr>
<tr>
<td>37</td>
<td>27 , 36</td>
<td></td>
<td>Siding Signal.</td>
</tr>
<tr>
<td>38</td>
<td>28 , 29 , 39 , 41 when 28 is Reversed</td>
<td>5 when 22 is Reversed</td>
<td>Signal for Left-Hand Running</td>
</tr>
<tr>
<td>39</td>
<td>7 , 38</td>
<td></td>
<td>Home Signal.</td>
</tr>
<tr>
<td>40</td>
<td>28 , 29 , 29 , 33 , 41</td>
<td>36 when 27 is Home</td>
<td>Home Signal, 2 Blades</td>
</tr>
<tr>
<td>41</td>
<td>38 when 28 is Reversed , 40</td>
<td>44, 46, 46, 47</td>
<td>Dwarf Signal.</td>
</tr>
<tr>
<td>42</td>
<td>30 , 50 , 43 , 48</td>
<td></td>
<td>Siding Signal.</td>
</tr>
<tr>
<td>43</td>
<td>50 , 59 , 42</td>
<td></td>
<td>Siding Signal.</td>
</tr>
<tr>
<td>44</td>
<td>29 , 41</td>
<td></td>
<td>Signal for Left-Hand Running.</td>
</tr>
<tr>
<td>45</td>
<td>39 , 41</td>
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<td>Dwarf Signal.</td>
</tr>
<tr>
<td>46</td>
<td>29 , 31 , 32 , 41</td>
<td></td>
<td>Siding Signal.</td>
</tr>
<tr>
<td>47</td>
<td>31 , 41</td>
<td></td>
<td>High Signal.</td>
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<tr>
<td>48</td>
<td>28 , 30 , 39 , 42</td>
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<td>Main Track Signal.</td>
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</table>
## Table of Interlocking

### Tower 2.

<table>
<thead>
<tr>
<th>LEVER</th>
<th>LOCKS</th>
<th>RELEASES</th>
<th>OPERATES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3, 8</td>
<td>WHEN 10 IS REVERSED, 11</td>
<td>SIDING SIGNAL</td>
</tr>
<tr>
<td>2</td>
<td>3, 8</td>
<td>WHEN 10 IS REVERSED, 11, 17</td>
<td>DwarF Signal</td>
</tr>
<tr>
<td>3</td>
<td>1, 2, 10, 17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>9, 10, 14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>9, 13</td>
<td></td>
<td></td>
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<tr>
<td>6</td>
<td>9, 12, 13, 14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>9, 12, 13, 14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>19, 2</td>
<td>WHEN 10 IS REVERSED, 9, 17</td>
<td>Home SIGNAL, 2 Blades</td>
</tr>
<tr>
<td>9</td>
<td>6, 16, 23</td>
<td>WHEN 15 IS REVERSED</td>
<td>2 WHEN 10 IS REVERSED</td>
</tr>
<tr>
<td>10</td>
<td>3, 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>7, 13, 14</td>
<td></td>
<td></td>
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<tr>
<td>13</td>
<td>7, 12, 14</td>
<td></td>
<td></td>
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<tr>
<td>14</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>18, 26, 27</td>
<td>WHEN 19 IS HOME</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>9, 23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>2, 3, 8</td>
<td></td>
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<td>22</td>
<td>15, 23</td>
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<td></td>
</tr>
<tr>
<td>23</td>
<td>9, 15</td>
<td>WHEN 15 IS REVERSED, 16, 22</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>19, 21, 26, 27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>19, 21, 26, 27</td>
<td></td>
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</tr>
<tr>
<td>26</td>
<td>18, 20, 21, 24, 25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>15 WHEN 19 IS HOME, 20, 21, 24, 25</td>
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<td></td>
</tr>
<tr>
<td>28</td>
<td>15 WHEN 19 IS HOME, 20, 21, 24, 25</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
- Switch, DeraIl, 1 Lock, and 2 Detector Bars
- Switch, Lock, and 2 Detector Bars
- Same as 12
- Switch, DeraIl, 1 Lock, and 2 Detector Bars
- 2 Crossing Switches
- 3 Facing Point Locks and 2 Detector Bars
- Same as 16
- Switch, DeraIl, 2 Locks, and 2 Detector Bars
- Switch, DeraIl, 1 Lock, and 2 Detector Bars
- 1 Switch
- 2 Facing Point Locks 1 Detector Bar
- Siding Signal
- Home Signal
- Siding Signal
- Home Signal, 2 Blades
- Distant Signal
Minor Details of the Design.

In order to make the design complete, two more points must be provided for which have not yet been mentioned. 1 Some method of communication between the two towers so that conflict of train movements will not occur on the tracks between the two towers. 2 Method to be employed to warn the tower men of the approach of a train on the main track.

1. Communication will be made between the towers by means of electric bells, each tower man warning the other when he has signaled a train for a certain route giving the route signaled.

2. To warn the tower man of the approach of a train, an electric circuit will be made with a section of the track distant about 5000 ft. from the tower. When a train passes over this section, the circuit will be closed causing a bell in the tower to ring. Electric circuits will also be made between the depot and towers so that the tower man may be signaled when a train is ready to depart.
Details of Mechanism and Construction

The design having been completed, then remains to be considered the details of the mechanism of the system and the construction of the more important parts. These will now be taken up in order.

The Johnson Interlocking Machine

Fig. 1 represents an eight lever interlocking machine. These machines are made in sizes varying from 4 to 200 levers.

The engraving shows a perspective view of the back elevation of an eight lever machine, and Fig 2 a detail of the interlocking of said machine. A plan of the switches which the machine is arranged to operate is shown below the diagram.

1, 2, 3, 4, 5, 6, 7, and 8, Fig 1, are wrought iron levers centered on a girder B attached to stands C C. The stroke of these levers is limited by portions of the segments W which form, in connection with the spring latches D, the well-known means...
for holding the levers in the back and front positions. These segments also answer the purpose of spacing and guiding the levers. The segments are carried by the front girder B and the back girder B which are supported at their ends by the stands CC. The machine is supported by the beam E, and steadied and braced by being bolted to the floor trimmer G.

The girders B and B are made for spans of four and eight levers. Connections leading to switch are shown attached to lever No 6, and connection leading to signal is shown attached to lever No 1. The locking is in one vertical beneath the floor and is easy of access, as are also all its parts for oiling, cleaning, and repairs. Its position protects it from dust; it is easy to alter in case of change of arrangement of switches, and complete new locking, can, when desired, be substituted for the old one in a very short space of time and at moderate cost, all the parts being interchangeable.

The vertical and radial movements of the latch
D are communicated to the locking tappet by means of the connecting link \( H^1 \) and rocker \( H^2 \) centred at \( H^3 \) to the bracket \( H^4 \), one of which is secured to each lever. The locking tappets \( H \) are connected to the reversing rocker \( H^2 \) by a friction roller which fits the radial slot in the rocker and is centred in the tappet jaw \( H^5 \).

One lever, as No. 1, is said to lock another, as No. 4, when the moving of No. 1 from its normal position prevents the moving of No. 4 from its normal position. One lever, as No. 2, is said to release another, as No. 1, when No. 2 must be completely moved from its normal position before No. 1 can be moved from its normal position. Generally the following is understood, viz; that when 1 locks 4, 4 also locks 1, and when 2 releases 1, 1 back locks 2.

Locking is said to be conditional or special when the position of lever, as No. 4, determines whether two other levers, say 2 and 7, shall lock each other or shall release each other.
Figure 2 shows an elevation of the locking plate. The locking is effected by means of locking dogs L, M, M', M'', N, P, etc., with transverse connections, carried in planed grooves in the locking plate L. The dogs fit into notches cut at an angle of 45° in the tappets and are free to slide horizontally in the grooves of the locking plate. The tappets are made of steel, as also are all other parts of the locking, and are free to slide vertically in planed recesses of the locking plate and retained by wrought iron strips. The joining of one locking dog to another is effected by means of a cold-rolled connecting bar 3/8 inch by 3/8 inch section, each dog being secured to the bar by two steel machine screws. A cover plate prevents any tendency these screws may have to withdraw.

In case a tappet is free, the intention of moving a main lever as expressed by grasping the handle and raising the latch, will raise the tappet and effect all the
locking of other lever latches necessary to the safe movement of the lever in question. This movement also brings the rocker $H^2$ in such position that the radial slot therein becomes radial to the center of the main lever, so that there is no movement of the tappet during the movement of the lever. When the lever is reversed, the dropping of the latch communicates a further upward movement of the tappet $H$ whereby the releasing is effected.

The action of ordinary locking and releasing is illustrated in Fig 2. This shows all levers in the normal position except 7 which is reversed. As will be seen, the vertical movements of the tappet cause the dogs to slide in their grooves locking those tappets which must be locked to insure safety. At the same time, it releases other tappets by bringing the notches in tappet 7 opposite the dogs which lock the tappets that are to be released. This is illustrated by locking dog “A” which releases lever 8.
The special locking is on the same principle as
the ordinary locking but will need a fuller explanation in
order to be made clear. Let it be understood in the fol-
lowing description that “tapper down” means that the lever to
which such tapper is connected stands in the back or normal
position, and when such lever is intended to operate a signal,
such signal stands normally at danger; when such lever is
intended to operate a switch, the switch lies in that of its
two positions as has been determined is the best or most
convenient. “Tapper up” means the reverse of the foregoing.

Referring to Fig. 2 the third space from the top con-
tains the following special locking. 7 looks 2 when 4 is home,
but not when 4 is reversed; the tappers having the same
number as their respective levers. The tapper spaces are
lettered A K and extend from one end of the machine to the
other. Tappers 2 and 4 are shown “down”, and tapper 7 “up”
M, M', M", and N are four locking dogs, M being connected to M'
and M" to N. T is a transverse sliding section of tappet 4, being
rabbeted into that tappet which has a gap corresponding
to the depth of the piece T. The two parts of the main
tappet 4 are connected together by a back strap riveted there,
as shown in the dotted lines. The dog M" is shown entered into
the notch in tappet 2 which is down. Dog N abuts against
the edge of the sliding piece T in tappet 4 which is also
down. The other edge of sliding piece T is notched below the
locking dog M', so that tappet 4 must be raised up before dog
M' can enter said notch. Dog M stands below the notch in
tappet 7 which is up, so that tappet 7 must be dropped down
before the dog can enter the tappet. As shown in the figure,
No 7 being tappet 7 up and No 4 being tappet 4 down the dog M
is moved transversely to the right moving the sliding piece T
which abuts against N causing the locking of tappet 2 by
dog M". Change No 7 to tappet 7 down, and No 2 becomes free; or
change No. 4 to tappet 4 up, and the dog M' can then enter into
the notch in sliding piece $T$ leaving No. 2 free. Or leave No. 4 and No. 7 tappet down, and change No. 2 to tappet up, and $T$ is locked by the movement of dog M" transmitted through the sliding piece $T$ to the dog M. It is therefore seen that with No. 4 tappet down, $T$ locks 2 and 2 locks $T$; that with No. 4 tappet up, $T$ and 2 are free of each other. By means of this mechanism any form of special locking desired may be had.

Mechanism of the Switch

For facing point switches, except the detail switches, the switch is locked by a separate lever from that which operates the switch. It differs from the switch and lock movement in that the escapement crank is replaced by a bell crank and the lock and detector bar operated by a separate connection.

Figure 3, page 54, shows the switch and lock movement to be used on trailing point switches. The ordinary point switch is the kind used and the arrangement of the mechanism is such that one lever operates switch, lock, and detector bar. An essential
requirement for this movement is that the detector bar shall be completely raised and the switch unlocked before any movement of the switch bar takes place. This is effected in the following manner. When the lever in the town is moved, the pipe connection A is moved in the direction indicated. This imparts a movement to the T crank CA which in turn actuates the crank CT which raises the detector bar BQ and draws the plunger CB. The plunger CB consists of a round bar with a portion of the center cut away thus, and works in a flat bar in which are two holes connected by a slot thus, this locking rod CD being connected with the switch. The rounded portion of the bolt being withdrawn from the hole in CD, it leaves the locking bar free to move. By this time the T crank CA has moved far enough to engage the escapement crank 324 which shifts the switch. The final movement of the T crank drops the detector bar beside the rail and engages the plunger with the lock-
CONNECTIONS FOR CROSSOVER

PIPE CONNECTIONS

NOTE:—CROSSOVER CURVE MADE SHARPER THAN IN ACTUAL PRACTICE IN ORDER TO GET IT ALL UPON THE DRAWING

FIG. 4.
ing bar, locking the switch in the reverse position.

When the switch is between the tower and its signal, as is the case with the derail switches, a locking arrangement termed a bolt lock, similar to the bolt and bar used for the switch, is placed on the wire connections to the home signal so that the signal can not be set till the switch is thrown fully to either position, thus preventing the possibility of a clear signal being given with the switch half open. This bolt lock is used on the six main track derail switches. See CF and CG Fig. 3.

In the case of a crossover, the switches at each end are worked by the same lever, the connections being so made that the movements of the switches are simultaneous. Fig. 4 illustrates the method of making connections. For siding switches and derails, the switch and derail are also worked by the same lever. The method of making connections is a slight modification of that shown in Fig. 4.
SEMAPHORE SIGNAL

Fig. 5

Fig. 6
ONE ARM DWARF SIGNAL

WIRE CONNECTED

Fig. 7.

Fig. 8.
The detector bar used in connection with each switch is 45 feet long and has eleven supports. Fig 37 shows a cross-section of rail and detector bar. Fig 38, page 67, shows the details of one of the supports.

**Mechanism of Signals**

Figs 54, page 58 shows the ordinary form of semaphore signal to be used on high speed tracks. The diagram shows an unbladed signal and connections. A is the front wire and B the back wire. W is a counterweight to bring the signal back to danger in case the connections should break.

Figures 7 and 8 show the details of the approved form of dwarf signal and connections. A is the front wire, B the back wire, and W the counterweight.

In Fig 6 the clear position of the signal blade is shown by the dotted lines.

For night signaling a white light is placed behind the red glass C on the blade. When signal is set to clear, the white light is exposed.
DETAILS OF SELECTOR

Fig. 9.

Fig. 10.

Fig. 11.
Mechanism of Selector

When it is desired to operate two blades on one signal post with one lever, a device known as a selector is used. Figures 9, 10 and 11, page 61, give details of selector used with wire connected signals. D is the connection leading to the tower, E and F the wires leading to the two blades on the signal post, G the pipe connection which determines whether the wire E or F shall be operated when D is operated. The pipe G is connected to the pipe leading to the switch. When the switch is in one position, the crank A is in such position that cam C raises the hook H, while cam B allows hook K to drop, causing D to operate wire F. When the switch is reversed, G throws crank A so that cam B raises hook K, while cam C allows hook H to drop, causing D to operate wire E. In this manner the different signal blades indicate the different routes.

The selector is located in the lead out as near the tower as possible. D is the front wire, the back wire is not shown. Selector foundation is shown on page 69.
LEAD OUT AND FRAMING FOR 48 LEVER MACHINE

SCALE: 5 FEET = 1 INCH.

ONLY HALF THE FRAMING SHOWN IN THE ELEVATION AND PLAN
Dimensions of Towers

The dimensions of the tower for the 28 lever machine are: 20 feet 1 1/2 inches long, 12 feet wide, 13 feet from rail level to upper floor, and 16 feet high from floor to ceiling. For the 48 lever machine, the dimensions are the same as for the 28 lever machine except the length, which is 28 feet 5 inches. The upper stories are made almost entirely of glass in order to give the operator a clear view.

Lead Out and Framing for Machines

On page 63 is shown the framing for a 48 lever machine. The framing for a 28 lever machine does not differ from this except in length. No explanation is necessary. Fig 12 shows the lead out for wire connections. The lead out for pipe connections where the pipe runs perpendicular to the length of the tower is by means of a down rod from the tail piece of the lever and a bell crank on the lead out supports. When the pipe runs parallel to the length of the tower, rocking shafts
WIRE CARRIERS

ANTI-FRICTION PIPE CARRIER.

Fig. 15.  
Fig. 16.  
Fig. 17.  
Fig. 18.  
Fig. 19.  
Fig. 20.  
Fig. 21.
CHAIN WHEELS

Fig. 22.

Fig. 23.

Fig. 24.

HORIZONTAL WHEELS

Fig. 25.

Fig. 26.

Fig. 27.

Fig. 28.

VERTICAL WHEELS

Fig. 29.
MISCELLANEOUS DETAILS

ROCKING SHAFTS

PLAN

SIDE ELEV.

ELEVATION

Fig 30

Fig 31

Fig 32

Fig 33

Fig 34

Fig 35

P.P.P. LEAD OUT PIPES

ELEVATION

LAZY JACK COMPENSATOR

Fig 36,

DETECTOR BAR AND SUPPORT.

Fig 37.

Fig 38.
are employed. The shafts are placed in a horizontal position the down rods from the levers being attached at A, the lead out pipes P, P, being connected as shown. See Figs. 30-35 page 67

Pipe Connections

The connections between the tower and the switches and locks are made by one-inch steel pipes carried on anti-friction rollers 24 inches in diameter, spaced 7 feet apart and 21 See Figs. 20, page 65. When it is desired to change the direction of a line of pipe a bell crank is inserted. All lines of pipe have a turn buckle to make alterations in the length. For lines of pipe over 50 feet in length a compensator of the lazy jack pattern is used. See Fig. 36 page 67

Wire Connections

Connections between tower and signals are made by means of two strands of No. 9 galvanized steel wire carried on wire carriers placed not more than 25 feet apart.

Whenever a line of wire changes direction the wire is cut and

* See Page 15 to 19 page 65
TIMBER FOUNDATIONS

SCALE: 2 FEET = 1 INCH

MATERIAL - OAK

COMPENSATOR

10 WAY PIPE CARRIER

SELECTOR

BELL CRANK

CHAIN WHEEL
a short piece of chain inserted where it passes around the chain wheel. Chain wheels are not less than 10 inches in diameter (see page 66). Hinges are provided with turnbuckles to alter the length. Lines of wire exceeding 2000 ft. are compensated.

Timber Foundations.

The drawings on page 69 give details of timber foundations for compensator, bell crank, etc. These are constructed of oak dovetailed and bolted together. Bell crank and compensator foundations are laid in concrete; the rest are tamped firmly in the earth, the top of the foundation being flush with the surface of the ground.

This finishes the more important part of the details; for a fuller treatment see the appended specifications for construction.
Specifications for Construction of Interlocking System

The Railroad Company will do all track work, and have all switches, crossties, movable frogs, etc., ready to be connected; will do all preliminary grading and prepare surface of ground where connections are to be run; will do all blasting; will provide proper drainage; will furnish broken stone, sand and cement for concrete-cement, compensator and wheel foundations (when necessary); will provide boxing for pipe and wire lines across streets, through station platforms, and across tracks, if desired; and will furnish free transportation over its own lines for men, tools, and materials, both going and returning.

The town, including all upon which frame for supporting machine rests, will be furnished by the Railroad Company. The machine shall be of some approved pattern, with interchangeable parts. The locos must be of single throw, and the locking must be positive and not dependent on
gravity or the use of springs. The locking must also be preliminary, and any movement of the latch rod of a lever must lock all conflicting levers.

The levers shall be numbered from left to right. Switch levers and lock levers shall be placed in the center. Spur spaces, if any, outside of lock levers. Home signal levers next to and outside of the spur spaces, and on the extremities of the machine the distant signal levers shall be located.

All parts of the machine, except the visible parts of the levers and the interlocking mechanism, shall be painted with two coats of a good black color. The visible parts of the levers, except the finished parts, shall be painted as follows:

Switch Levers: --- Black
Lock Levers: ---- Blue
Switch and Lock Levers: ---- Black and Blue,
Home Signal Levers: ---- Red
Distant Signal Levers: ---- Green
Interlocking for grade crossing must conform to the rules laid down by the Illinois Board of Railroad and Warehouse Commissioners.

The leadout as far as practicable, shall be by wrought iron rocking shafts, which must not be less than 2 1/4 inches in diameter, varying in length as the situation requires. Bearings shall be turned.

Pipe lines must not be nearer than three feet six inches from gauge side of rail. They must be straight whenever possible. Pipe lines must be made of steel pipe one inch inside diameter and laid 2 3/4 inches between centers. The top of foundations for carriers shall be placed 3 1/2 inches below base of rail, and they must be located not more than seven feet between centers. Pipe carriers must have sheaves not less than 2 1/4 inches in least diameter. Couplings must not be placed closer than eight inches to a pipe carrier where the beam is on the center.
All pipe connections shall be made with coupling 2½ inches long, plugs 6 inches long, with square nuts, and with All switch, lock, and selector connections shall be made of one-inch pipe.

Bends will not be allowed in pipes, but must be placed, where necessary, in cranks or in solid metal, and they must not exceed 3 inches at any one point. Bell cranks shall be made of wrought iron, mounted on a substantial cast iron stand, and with pin supports above and below crank, and provided with two bolts and two lag screws for fastening them down. Not more than three bell cranks shall be mounted on the same center.

Crank pins shall be 1¼ inches in diameter. All jaws shall be of wrought iron, except when used for adjustment, when malleable iron jaws may be used. Jaw pins shall be ¾ inches in diameter. Chain wheels shall be of cast iron 10 inches in diam-
The wire carrier shall be made in racks of two and four. The wheels shall be of cast iron, not less than 2 inches in diameter, mounted in malleable iron frames and fastened in their supports with four screws.

Means of adjustment shall be provided for each line of pipe or wire and for each switch, lock, detector bar and selector. Wire and pipe adjusting screws shall be of wrought iron and open.

Compensators shall be of the lazy jack pattern, and of wrought iron, mounted on a substantial cast iron stand. A separate compensator shall be provided for each line of pipe exceeding fifty feet in length. An additional compensator, however, must be provided whenever a line of pipe exceeds seven hundred feet in length.

Detector bars, forty-five feet in length must be pro-
vided at each facing point switch to work in connection with the facing point lock. They must be placed on the outside of the rail, fitting closely to the rail head, and work in a plane inclined slightly from the vertical and towards the center of the track. At half stroke the top of the bar must stand not less than one inch above top of rail. Not less than eleven supports shall be used to each bar, each support to be clamped to bottom of rail. Detector bars must be provided for all switches but may be worked in connection with the switch and lock movement on trailing points.

Facing point locks must be placed on the outside of the track and the lock casting must be bolted to an iron plate 3/8 inches x 6 inches x 7 feet on top of the tie.

Plunger must clear lock rod not more than 1 1/2 inches when with drawn, and shall have 8 inches stroke.

Connection from plunger to detector bar through slotted crank must not be jointed.
All facing point slip switches and movable point frogs shall be locked by a separate line of connections from the one used to move the switch or frog.

All front rods must project beyond the point of the switch and must be jointed.

Connection to switches must be made by threaded rod with four nuts passing through spring carrier of switch. Pipe line operating switch must have not less than one inch stroke than the switch.

All holes must be drilled to a template, and all pins must be machine turned and provided with cotters. Pins must be a neat fit.

Only split cotters must be used, no half cotters or wires allowed. All parts to be Pennsylvania Railroad standard unless otherwise specified.

Pipe carrier foundations shall be constructed of 2 1/2 inches x 8 inches white oak or 3 inches x 8 inches yellow pine dove
tailed and bolted together with a total depth of 2.4 inches. One way pipe carriers shall be twelve inches long and for each additional way they shall be increased 2\frac{3}{4} inches.

Bell crank foundations shall be constructed of 4 inches x 10 inches white oak or 5 inches x 12 inches yellow pine, 12 inches x 24 inches on top with a depth of not less than 3 feet 6 inches. They shall be dovetailed, bolted and braced with two 6 inches x 14 inch braces.

Compensator foundations shall be constructed of 4 inches x 10 inches white oak or 5 inches x 12 inches yellow pine, 12 inches x 3 feet 6 inches on top with a depth of not less than 3 feet 6 inches. They shall be dovetailed, bolted and braced with two 6 inches x 14 inch braces.

Chain wheel foundations shall be constructed of 2\frac{3}{4} inches x 10 inches white oak or 3 inches x 10 inches yellow pine, 10 inches x 24 inches on top, with a depth of three feet or more. They shall be dovetailed, bolted and braced.
Selector foundations shall be constructed of 2 1/2 inches x 8 inches white oak or 3 inches x 8 inches yellow pine, 12 inches x six feet on top, with a depth of not less than 2 feet 6 inches. They shall be dovetailed and bolted together.

Stakes for support of wire shall be 3 inches x 4 inches white oak or yellow pine, four feet long.

All foundations and stakes shall be creosoted.

Bell crank and compensator foundations shall be laid in concrete.

Each signal or indicator shall be operated by two lines of No. 9 steel galvanized wire having a tensile strength of 1200 pounds and an elongation of four per cent, the back wire having in all cases 1 1/2 inches more stroke than the front wire (or selector) and attached to tail piece of lever.

All wires to be supported on wire carriers placed at a maximum distance apart of twenty-five feet. When run contiguous to a line of pipe, wire carriers may be placed on the pipe carrier foundations.
All signal posts shall be of the best white or yellow pine, 10 inches square at the base and 7 inches square at top. They shall be placed on a framed and well-braced foundation. They shall clear track by seven feet.

All portions of the posts, including bracing, etc., below the surface of the ground shall be thoroughly painted with two coats of preserved or creosote paint before being erected.

Bracket posts shall be formed of a main post 12 inches x 12 inches of white or yellow pine supporting a cross piece and uprights. The cross piece shall be located not less than 20 feet above the top of the rail and shall be made of two pieces 3 inches x 12 inches yellow pine, framed and braced to the main post. The uprights shall be formed of 7 inches x 7 inches white pine framed and braced to the cross piece. The uprights shall be placed 7 feet 6 inches center to center, lowest
arm shall be 6 feet 6 inches above cross arms.

Semaphore signal arms shall be formed of clear, well-seasoned ash, and shall be 5 feet 6 inches from center of casting to outer end. They shall be 11 inches wide and ½ inch thick at the outer end and 7 inches wide and ¾ inch thick at the arm grip.

On all main track posts, the lowest semaphore arm shall be placed not less than 25 feet above top of rail. The distance between arms on the same post shall be 6 feet 6 inches center to center. Top arm to govern main route.

For switching and drills, movements, dwarf signals of the approved pattern shall be used.

Speckle and back light castings shall incline downward at an angle of 30 degrees to center line of arm and shall be counterweighted so as to carry signal to danger in case any of the connections between operating lever and signal blade should be broken.
All signals not facing the tower shall be provided with a back light of blue glass.

A counterbalance lever shall be provided for each signal arm.

Chain to be % inch proof. Split links must have the points well hammered down.

Lamps shall have a front lens properly focused and a two-inch bulls eye in the back. Dressel square lamps to be used for large signals and round lamps for away.

All pipe connections outside of the tower (except across tracks) shall be boxed with good yellow pine lumber, surfaced one side; 15 inches x 6 inches stuff for the top; 2 inches x 7 inches stuff for the sides. Loose covers must be left over all wheels, cranks, compensators, headouts and selectors.

All iron work and boxing, except otherwise specified, shall be painted two coats of Indian red oil color. Signal posts shall be painted one coat of priming and two coats of white with black trimmings at base of pole for a height of 5 feet.
all iron work on signal posts shall be painted with good black asphaltum. Home signal arms shall be painted two coats of the best vermilion with white stripes 8 inches wide at 14 inches from outer end. Distant signals shall be painted two coats of green with white stripes 8 inches wide and 14 inches from outer end.

THE END