Design of an Electrically Operated Interlocking Switch And Signal Plant at McCook, Ill.

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1907

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Design of an electrically operated interlocking
DESIGN OF AN
ELECTRICALLY OPERATED INTERLOCKING
SWITCH AND SIGNAL PLANT
AT MCCOOK, ILL.

A THESIS
PRESENTED BY

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TO THE
PRESIDENT AND FACULTY
OF
ARMOUR INSTITUTE OF TECHNOLOGY
FOR THE DEGREE OF
BACHELOR OF SCIENCE IN ELECTRICAL ENGINEERING
HAVING COMPLETED THE PRESCRIBED COURSE OF STUDY IN
ELECTRICAL ENGINEERING

JUNE 1st 1907

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SECTION 1.

DEVELOPMENT OF INTERLOCKING.
EDITOR

REPORT OF EARTHQUAKES
When railways were first operated in England and afterwards in this country, it was customary for the engineman to bring his train to a standstill before crossing an intersecting railway line. Such is yet the practice in sparsely settled districts of our country, in places where the railway management considers it more economical to bring the few trains traversing a line in a day, to a stop, than to hire a towerman to operate and maintain an interlocking plant. Where traffic is more dense and the time consumed by trains in making the stop before crossing an intersecting line amounts to considerable it becomes necessary to provide some means for their safe passage over the crossing without stopping.

The first interlocking was preceded by a concentration of switch levers. As early as 1846 it became common practice in England to concentrate in one cabin the levers of a number of switches and of the signals governing the movement of trains towards these signals and switches, where all were located together, thus requiring fewer attendants for the operation of the switches and signals and greatly facilitating the celerity of train movements. Before long however, trouble arose on account of the fact that the attendant could give conflicting clear indications simultaneously and thus cause disaster by allowing two trains to enter the same section of track at the same time. For this reason the interlocking of signals and switches became imperative and here- in England we find the first
interlocking switch and signal plant.

As to the economy of substituting an interlocking plant for no interlocking with the necessity of trains coming to a stop before proceeding over the crossing in the latter case, the following figures given by Mr. J.A. Peabody, Signal Engineer of the C.& N.W. Ry., may be of interest.

The cost of stopping an eight-car passenger train, weight about 530 tons, from and to fifty miles per hour is:

- Coal to stop train (air pump) .................. 30#
- Coal to accelerate train ....................... 275#
- Total coal = 305#, @ $2.15 per ton = .............. $0.33
- Brake shoe and tire wear ....................... 03
- Brake and draft rigging wear ................. 06
- Total .............................................. $0.42
- Time lost = 145 seconds (exclusive of time standing)

The cost of stopping and starting a 2000 ton, eighty-car freight train from and to a speed of thirty-five miles per hour is:

- Coal ............................................. $0.56
- Brake shoe wear ................................ 15
- Other items, as above, ......................... 29
- Total ................................................ $1.00

The above figures are based on actual tests.

Data obtained from another railway shows the cost of stopping and starting a six-car passenger train as $0.35 and for a 1500 ton freight train as $0.56, counting in each case coal and brake wear only, the passenger train from and to forty-five miles per hour and the freight train from and to fifteen miles
per hour.

Calculating from the other side we find that for an interlocking plant at the intersection of two double track railways the first cost (complete) is about $9,000.

Interest on cost @ 4% = $360.00
Depreciation per year @ 7% = $630.00
Cost of maintenance = $480.00
Cost of operation = $1440.00
Total cost per year = $2910.00

Allowing for eighty trains per day using the interlocking, the cost per year for stopping and starting trains will be $13,140. Total cost of interlocking per year as itemized above = $2,910. Net saving by using interlocking is $10,230.

An interlocking system has been defined by the American Railway Association as, "An arrangement of switch, lock, and signal appliances so interconnected or interlocked that one movement must succeed another in a pre-determined order."

The definition applies alike to the mechanical, the pneumatic, the electro-pneumatic, and the purely electric systems. Interlocked signals and switches are worked from a cabin, called the tower, in all systems, the system used determining the means by which the movement is effected.

The arrangement of interlocked switches and signals is the same whether the yard be simple or complex. The principle of this interlocking may be explained by referring to Plate 1. The plan of tracks shows a main line with a switch leading to a siding. The "Locking sheet" for this lay-out is as follows:
Locking Sheet.

1 locks upper arm of 2 reversed;
2, upper arm, locks 3 normal, 4 normal;
2, lower arm, locks 3 reversed, 4 normal, 1 normal;
3 locks --------
4 locks 2 normal, 3 reversed.

As a train approaches the switch 3 from the direction such that it must pass signals 1 and 2, first signal 2 must be moved, that is, the signal arm must be dropped through an angle of 60° to 75°. If Switch 3 is normal, that is, set for the main line, the upper arm of 2 will clear and then distant Signal 1 can also be cleared. If Switch 3 is set for the siding the lower arm of Signal 2 will clear and Signal 1 cannot be cleared, since the lower arm of 2 locks 1 normal. For a train coming from the siding onto the main line 3 must be reversed before 4 can be cleared, and 4 locks 2 normal, so 2 cannot be cleared when 4 is clear. The foregoing will illustrate the method used in interlocking switches and signals.

There are four systems of interlocking in common use today: the mechanical, the pneumatic, the electro-pneumatic, and the all-electric. I shall describe each of these briefly, giving their advantages and disadvantages.

Mechanical interlocking has been in use longer than any of the other varieties and consequently has had a longer time to become perfected. It is simple and does not require any power
system for its operation. We might argue that as long as a man must remain in a tower to operate any system he might as well use his energy in furnishing the power for the operation, as he does in a mechanical plant. All pipe and wire lines can be left open and so are easily accessible in case of trouble. No motors or other delicate apparatus is situated outside the tower. Some of the disadvantages of this system are: 1. Changes in temperature cause wire lines to sag and thus cause drooping signals. 2. Pipe lines cannot be run for any great distance on account of the limited power available in the tower for their operation. 3. Both pipe and wire lines are located where any derailment of trains will cause great trouble by breaking them. 4. Any heavy object falling on a wire line and breaking one wire can cause a false indication to be given. 5. At busy points several men are required to operate a mechanical interlocking plant where a power plant would require only one man. 6. It is a proven fact that the movement of mechanically operated switches and signals requires several times as long a period of time as in case of a power operated plant. This fact alone prohibits a mechanical plant from being used at a crossing where there are many trains passing in a day.

Interlocking apparatus operated by compressed air at low pressure (15#/ per sq. in.) and with no electric features is in general use. The New York Central alone operates several of these plants on its lines. The interlocking between the levers of this machine is mechanical, the parts being very small and occupying but very little space as compared with the similar parts of a mechanical system. The interlocking
Hi!
machine itself requires less than one-quarter of the space occupied by a mechanical machine for operating the same number of switches, locks, signals, etc. The operation of the most distant signals requires not more than two seconds and so is much quicker than the mechanical system. The pipes are underground and thus where they will not be broken easily in case of derailment of trains. The levers require but very little energy in their operation and thus even at the most congested crossings the number of levermen will be less than in case of a mechanical plant. Some of the disadvantages of the pneumatic system are: 1. Leakage from the pipes. The pipes, being underground, rapidly deteriorate and begin to leak. This of course necessitates a frequent change in pipe lines, the part of the system concerned being thrown out of service during this time. 2. An air compressor must be kept working a large portion of the time or else extra large storage tanks provided for the storing of the compressed air. 3. The means used for the indication of movements of signals or switches requires an auxiliary piping system, a very expensive feature. 4. The pressure at distant signals is liable to considerable drop, so the pressure at the tower must be kept higher than is required for operation of signals near the tower. This drop is caused by leakage at joints, etc. 5. The apparatus used for the operation of signals and switches requires frequent attention in the replacing of washers, etc., thus requiring more attendance than some other power systems of interlocking.

The electro-pneumatic system has the same advantages as outlined for the low-pressure pneumatic, with the additional
advantage that indications of movement of signals and switches are made electrically, thus avoiding the great expense of an additional pipe line for indication. One of the disadvantages of this system is that both electric and pneumatic power must be supplied, thus entailing a waste of power. The electro-pneumatic system is used very extensively in this country. A good example is the St. Louis terminal of the Terminal Railroad Association of St. Louis, Mo. The machine operated in this plant contains two hundred and fifteen levers, the operation of which would be impossible in a mechanical plant. This system possesses the same disadvantages as the low pressure pneumatic system, the greatest trouble being in the leakage of air from the pipe lines. The power required to operate is much greater than in case of an all-electric system.

A system which has come into very extensive use recently and is rapidly supplanting the above systems on many lines of railway is the all-electric. One of the largest installations of interlocking ever made in or near Chicago is now being put in all-electric. An electric plant has been in operation at Sixteenth and Clark Streets for over ten years and has given and is giving perfect satisfaction. Some of the advantages of this system over the mechanical system of interlocking are as follows:

1. The electric system is absolutely unaffected by changes in temperature while in the mechanical systems a sudden change in temperature makes imperative an immediate adjustment of signal connections or else drooping signals will result.

2. The breaking of any of the essential connections in the
electric system can mean only a failure to clear a signal; never a false indication. In a mechanical plant a break can mean a false indication, as before explained.

3. In a mechanical system no derail, switch, movable point frog, or bars at a distance of nine hundred feet or over from the tower should be operated. The English Board of Trade regulation in this matter limits the distance at which trailing point switches can be operated to nine hundred feet and in the case of facing points this distance is restricted to five hundred and forty feet. Even at these distances the dangers incident to breakage of pipe have led the London and Northwestern and a number of other English railways to adopt an expensive steel channel section instead of pipe. In case of an electric system any derail, switch, movable point frog, or bar can be as quickly and as safely operated at a distance of a mile as at a distance of a foot from the tower. In consequence, at many places where two or more mechanical plants would be required, a single electric plant can be installed, thus effecting a great saving in the cost of operation.

4. At busy points where from three to six men working eight hours per day would be required for the operation of a mechanical plant, two men working twelve hours a day will be sufficient for the operation of an electric plant.

5. At many points, such as stations, the space occupied by the pipe and wire lines leading from the tower is a great disadvantage and in some cases cannot be tolerated at all. For an electric plant the wires from a tower having the equivalent of two hundred mechanical levers can be contained in a
condiiit having a crosssection of 6"x6" against a width of approximately eighty three feet for a similar mechanical plant.

6. Where a mechanical plant is employed any considerable change in alignment or grade of tracks practically necessitates the rebuilding of the plant at great cost, whereas similar changes made in an electric plant will require practically no expenditure to make the interlocking suit the new conditions. I know of a case where on account of raising one of the tracks six inches half the mechanical plant in operation had to be rebuilt, and this happened only six months after the plant was first installed.

7. Where mechanical signals are used it is always difficult to work them in conjunction with an automatic electric block system, whereas an electric system can be made to act as a continuation of the electric blocking without additional cost.

8. Owing to the fact that in an electric system there are no movable parts between the tower and switches and signals and owing to the fact that the wires are all well insulated and carried either on poles or in conduit above the ground, the cost of maintenance as compared with a mechanical plant will be very small.

9. The size of the tower required for an electric interlocking machine is less than one-half the size that would be required for a mechanical machine, considering a fifty lever installation.

Some of the advantages of the electric system over other power systems of interlocking are as follows:

1. The electric system can have a perfect method of
indication, this indication being given instantaneously with the locking of a switch after its movement or after the movement of a signal, and cannot be given under any circumstances before a switch is locked or before a signal has completed its movement. Even though the movement is made a mile from the tower the indication comes in a fraction of a second.

2. The electric system, by using a storage battery, can be operated economically for a plant no matter how large or how small. It is as economical as a mechanical plant where as few as six levers are operated, and no combination of junctions, crossings, drawbridges, or tunnels is too complicated for perfect operation.

3. The cost of producing power for the electric system will rarely, if ever, exceed two or three percent of the cost in any other power system. For example: in a system using compressed air for operating signals and switches the cost of coal and services of men employed in running the power plant is $400.00 monthly. The total cost in producing the power for an electric plant doing the same work will not exceed four dollars monthly. Many times more electric current is consumed in certain power plants for valve control and indication purposes than is used for both operation and indication in an all-electric plant.

4. The cost for maintenance and renewals for an electric plant is much lower than for other power plants. This can be well understood from the fact that more feet of electric conductor are required for indication in some electro-pneumatic installations than are required in an all-electric plant for both indication and control, in addition to the piping required for the pneumatic
part of the plant, in the former case. This underground piping deteriorates very rapidly in the soil found near railways. Repairs on these pipe lines are very expensive because the pipes are buried several feet. The wires, in case of an electric plant, are above the surface and consequently more easily accessible in case of trouble.

5. Some power systems experience trouble on account of valves sticking in cold weather; this is avoided in electric interlocking.

Whether power is cheaper than mechanical plants depends upon the number of levers, frequency of trains, etc. Power plants are from 300 to 500% faster than mechanical plants, with the additional advantage that levers can be moved practically without effort on the part of the towerman, while with a mechanical plant the work would naturally lag, it being arduous.

After a careful consideration of the various systems of interlocking, the advantages and the disadvantages of which are given above, I have decided that an all-electric plant is the best suited and the most economical for the installation at McCook.

McCook is the name given the junction of the A.T.& S.F., C.T.T., and C.& I.W. Rys., about twelve miles southwest of Chicago near the Des Plaines river and the Drainage Canal. About two-hundred trains pass through this interlocking daily and switching movements double the switch and signal changes required.

Of the all-electric plants now in operation in this country the Taylor Signal Co.'s interlocking is giving the best satisfaction and after carefully studying this system I have decided to adopt it as best suited to the conditions at McCook. Following will be found a description of this system.
SECTION 2.

THE TAYLOR INTERLOCKING SYSTEM.
A Taylor interlocking system embraces all the mechanical and electrical apparatus used in operating an interlocking plant. The essential parts of the system are: (a) a storage battery; (b) an interlocking machine in which the circuit controllers of various switches and signals are connected with mechanically interlocked levers, this machine being provided with electromagnetic indication arrangements; (c) insulated wires for conducting current to various motors, on switches and signals, from the circuit controllers of (b); (d) switch and signal motors or other electro-magnetic devices provided with means for operating the circuit immediately after the switch and signal devices have performed their proper movement and are located in position. These are provided with the necessary means for closing the indication circuit at the same time; (e) the switches and signals to be operated.

In Figure 1, shown as Plate 1, the various connections of the battery, interlocking machine, signals, and switch mechanisms are shown. By means of the manipulation of the levers in the machine all the various devices are required to fulfill their functions. Each lever of the machine, four being shown in Plate 1, is provided with a cam slot controlling the movement of a tappet bar extending downward. The shape of the slot determines the position of the bar. These tappet bars are used for interlocking between the various levers, and unless they are in the correct positions it is impossible to move any of them. These locks on the movement of the levers act in such a way that
if the levers should be moved in the order 1-2-3-4, 4 cannot be moved until 1-2-3 are moved, and in the proper order. Although the cross locking necessary is somewhat complicated this method positively prevents a wrong signal or switch indication being given. The circuit controllers, indicated on Plate 1, consist of metallic steps, which are carried on movable blocks of insulating material, connected to the levers, which make contact with the brushes supported on fixed blocks.

Referring to Plate 2 we see that during the first quarter of the stroke of a lever the tappet bar will be raised one-half its stroke by means of the cam slot. This movement makes no change in the connections on the circuit controller, the contact pieces merely sliding along the same brushes. This part of the movement however, causes a preliminary locking of the controller routes which stop any further movement of the lever until they are opened. At half and three-quarter positions of the lever the contact pieces move to the brushes at the opposite end of the controller, while the tappet bar remains stationary, since it is moving along the longitudinal section of the slot. The latch L stops the movement of the bar, or lever, beyond three-quarter stroke until released by the indication magnet I. After released but a slight pull is necessary to move the lever the remaining one-quarter stroke. During this final quarter stroke the electrical connections are unchanged, remaining as at three-quarter stroke. The tappet bar is raised upward through this last one-quarter stroke and releases the other levers whose further motion was waiting for this lever to complete its movement.
The switch movement is controlled by means of two wires in addition to the main common wire, and the indication currents which are generated by the switch motor itself, are transmitted through the same wires and an indication common. In one position of the lever one of the wires is the control wire, and in the other position it is the indication wire. When the lever is moved to the opposite position the functions of the two wires are reversed. In case of the switch circuit controller each of the two wires mentioned last is connected to two brushes of the circuit controller, one brush at each end. The controller, by movement of the lever, reverses the connections of these wires so that in one position of the lever one is connected to the positive end of the battery in series with the safety magnet S, and to the operating bus bar; while the other end is connected to the common indication wires through the indication magnet I, and to the indication bus bar. In the other position these connections are reversed. Pole changing switch P, located in the switch itself controls the movement of the switch.

The pole changer is automatically shifted by means of the switch lock bolt during the latter part of its movement and after the latter has passed entirely through the lock rod, connection be being made between the movable part of the pole changer and the mechanism represented at the rod. This pole changer has two movable contacts and eight fixed contacts. The switch motor armature is shown at A3, connections to the points being as shown. The terminals on one end of the field coil F3 are arranged so as to receive current at either 12 or 14, the direction of the flow through this coil being always the same. The other end of the
field coil is connected to the main common wire.

It is seen at once that these connections are made in such a way that in one position of the pole changer $P$ current will flow through the armature from one of the control wires and the field coils, while in the other position the current will flow through the armature in the opposite direction, and from the other control wire, the current through the field coil in series with the armature remaining in the same direction. The diagram (Plate 1) represents the connections as they normally are. The switch normal control wire in this position is connected to the battery, no current flowing, because at the pole changing switch there is a disconnection.

If lever 3 is reversed current will flow from the + side of the battery to $K$, the operating bus bar, fuse $f_3$, safety magnet $S$, contacts 6 and 8, reverse control wire, pole changer contacts 16 and 15, switch motor armature $A_3$, contacts 11 and 12, motor field $F_3$, then to main common wire and back to battery. This battery is comprised of chloride accumulators and will be described later. Current continues to flow until the switch has completed its movement and has been locked in its position. Before this locking occurs however, magnet $S$ still remaining in circuit, the lock rod shifts the pole changer from contacts 15 and 16 to contacts 13 and 14; also from contacts 11 and 12 to contacts 9 and 10; thus reversing the connections on the armature of the switch motor. Just here a very important function is performed.

An electric motor when driven by a current tends to develop an E.M.F. in opposition to the driving E.M.F. so when the driving E.M.F. is cut off the momentum gained by the motor
armature keeps it revolving and it becomes a generator. The current thus generated is used as will be explained later. The last connections made by the pole changer are such that the counter current leaves the armature at the terminal a, and since its direction is the same as that formerly sent through the field coils, the flux continues to be in the same direction, and the current flows out to the indication common through the main common and through the following circuit: indication common, magnetic cut out H, switch J, indication bus bar, indication magnet I₃, the circuit controller contacts 4 and 2, reverse indication wire, pole-changer contacts 10 and 9, to terminal b of the armature, thus causing indication magnet I₃ to become energized, which releases the locking of lever 3.

Lever 3 is released as follows: (note Plate 2)
When magnet I₃ is not energized lever L₃ is held in a horizontal position by a spring and dog P₃. While in this position a projection on its right end will engage a similar projection on lever 3 and prevent the last one-quarter stroke. When magnet I₃ is energized it picks up armature T₃ and strikes dog P₃, which allows lever L₃ to drop and thus allows lever 3 to be pulled through the last one-quarter stroke. It is evident that in order that the indication current may flow through magnet I₃ it is necessary that the driving current must be cut off; that the indication wire must be put in connection with the armature and also that the connections between the armature and fields of the motor be reversed. The first of these conditions could be caused by a broken wire, the second by a cross between the indication wire and the armature wire, and the third by breaks and crosses
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in the armature and field wires. However these three conditions would require a state of affairs which it might be said would be impossible of accidental creation.

While the switch is being moved a cross between the normal and the reverse wires would send a current from the battery back through the indication magnet, but a false indication is prevented in the following manner: A safety magnet S is placed directly beneath the indication magnet I₃, the indication armature resting normally on the poles of this magnet. This magnet is in series with the battery and the control wires at all times therefore all battery current must be sent through this safety magnet. Were the normal and reverse control wires crossed the entire current, both that flowing through the switch motor and also that passing to the indication magnet, must pass through the safety magnet, so that if the entire current returned by way of the indication magnet the current in this magnet would not be greater than that in the safety magnet, and as the armature rests on the safety magnet it cannot be lifted from that position by the indication magnet. If any of these wires were broken, even in the safety coils, it would be cut off from all current, since these coils are in series with the battery.

By moving lever 3 back to its normal position the normal control wire is connected through safety magnet S to the battery. Thus a current is sent through the switch motor, and passes from terminal b to terminal a through the armature in a reverse direction from that for moving the switch before. The field coils being energized by current flowing in the same direction in both cases, the direction of rotation of the armature will be reversed
and the switch will be moved back to the position it assumed at first. When the switch movement is completed the pole changer P moves back to the position shown on Plate 1, the indication current being generated as above shown. This current passes from terminal b to terminal a through the normal indication wire, the latter being formerly the reverse control wire. P is operated automatically by the lock rod of the switch in the latter part of its movement and is also under the control of the lever by means of the magnets M and M'. Both of these magnets have one terminal connected to the main common wire; the former has its other terminal connected to the normal control wire and the latter its other terminal connected to the reverse control wire.

When the normal control wire is connected to the battery a current will flow through the magnet M while where the reverse control wire is connected to the battery current will flow through coil M'. These currents are strong enough to shift the pole changer whenever it is free from the bolt lock, which is during the entire switch movement and all the bolt lock movement except the first and last three-quarter inches.

If the lever 3 is reversed to reverse the switch, current is sent out through the reverse control, through the switch motor in the proper direction to reverse the switch and through the magnet M'. The current through the magnet M' tends to hold the pole changer in position to maintain the current in the motor. If for any reason it is desired to put the switch back normal before it has completed its reverse movement as, for instance, when the rails are blocked with snow, it is only necessary to put the lever back normal when a current is sent
through the normal control wire and the magnet M. The magnet M being energized shifts the pole changer to the other side and into position to send the current from the normal control wire through the motor in the direction to put the rail switch normal, at the end of which movement the pole changer is shifted back to the position shown and the indication current is developed as before.

No current is sent through the indication magnet I when the magnet M shifts the pole changer, for the reason that the controller connected to the lever is in the wrong position with reference to the pole changer and none is developed should the magnet fail to work for the reason that the connections between the armature and the field coils are wrong to develop it. They would have to be reversed for this to occur. A simple circuit breaker, not shown in the diagram, operated automatically by the switch movement is provided for cutting off current from magnets M and M' when the switch is home and locked in either position.

The home signal having two arms is represented as operated by one operating machine through a switch box connected to the switch as a selector, this being accomplished by the operation of one lever. Each of the signal arms is counterweighted by means of a weight at the end of a lever, to each end of which the end of a chain is attached. This chain passes around a chain sheave which is connected to and operated by the above machine. This chain sheave is provided with webs to hold the chains in their proper position, and also to grip the chain. When the motor armature is operated in one direction one of the levers will be moved, while if the armature is operated in the
other direction the other lever will be moved. The direction of rotation of the armature is controlled by the position of the reversing switch, which changes the contacts as required. Each of the signal arms controls, through a short rod, a circuit breaker.

The circuit breaker operated by the home, or upper arm, has four contacts; one pair for controlling its motor circuit and the other pair for controlling the circuit of the distant arm, this being the case when the home arm is at the clear position. The lower arm circuit breaker has only two contacts, and these only for controlling its own motor, since the distant arm has no further control over any other signal arm. The signal controller, connected to the lever mechanism in the interlocking machine, has two pairs of stationary contacts, one for normal connections and the other for reverse connections, this being accomplished by a sliding contact piece which is connected to the lever and moved by motion of the latter. One of the reverse contacts is connected with the plus end of the battery, one of the normal contacts being connected to the common indication wire, the other two remaining contacts being connected with one end of the indication magnet, the other end of this indication magnet being connected to the signal control wire, one wire only being necessary for either single-arm or double-arm signal, for both control and indication positions.

After lever 2 has been reversed the control wires are connected to the battery through the indication magnet I₂ and also through the sliding contact of the circuit controller. This current flows through indication magnet I₂, signal control wire, circuitbreakers G2 and G in series, motor fields F₂,
switch box contacts, armature $A_2$, and again through the switch box to main common. If the switch is thrown for the main line the switch box will be normal and armature $A_2$ of the signal motor will rotate in such a direction as to move the home arm to clear. When this occurs circuit breaker $G_2$ opens the circuit and at the same time closes the circuit of the main common for the distant signal. The brake magnet $B_2$ is shunted across the circuit breakers, but this magnet receives only a small current, being of very high resistance.

This brake magnet retards a disc carried on the shaft of the armature and thus brings the armature quickly to rest. This holds the signal clear as long as lever 2 remains in the reverse position to which it has been thrown. Since the current which has been used to clear the signal passes through indication magnet $I_2$, the lever 2 is released by latch $L_2$, and thus permitted to be pulled to the end of the stroke. This does not indicate, however, that the signal has reached the clear position but this is not necessary since the indication of a clear position of the signal would be of little use, as no locking is released by the final connections made during the last part of the stroke of the lever, except that between the home and the distant signal, and this is already provided for by the circuit breaker $G_2$, which is controlled by the home signal.

When lever 2 is in the normal position the circuit to the brake magnet is opened at the controller, and the control wire put in connection with the indication common through the indication magnet. This releases the brake and permits the signal arm to return to normal position by the action of the counterweight.
The falling counterweight drives the motor armature backward, making a generator of the motor, and when the signal arm is nearly normal circuit breaker G₂ is replaced in its normal position, thus closing a circuit for the current generated by the motor. This current leaves the armature at b₂, passes through the switch box and main common to the indication common, through the indication common, the coil H, the indication bus bar, the indication magnet, the control wire, the circuit breaker, the fields F₂, the switch box, and back to armature at a₂. This current energizes the indication magnet I₂ and effects the release of the lever as described in the case of lever 3, permitting the final movement of the lever to be made. It also serves to check the rotation of the armature and acts as a cushion for the falling counterweight.

If the switch box is reversed when lever 2 is reversed, the current after it passes through the switch box and field coils enters the armature at b₂ and leaves at a₂. This rotates the armature in the proper direction to clear the lower arm. In this case the brake magnet is cut into the circuit by the lower circuit breaker G. When the lower arm is put normal the indication current is developed in the same manner as that described for the upper arm. It flows in the same direction and in the same wires except as to direction in the armature and the two wires connecting it with the switch box.

Lever 4 operates the dwarf signal shown at 4. This signal is operated by a solenoid which has two windings, one of very low resistance and the other of very high resistance. The low resistance winding is shown at W in Plate 1 and is known as
the working coil. The purpose of the other winding, $R$, is to retain the armature of the solenoid in the position given it by the working coil. This solenoid also operates two circuit breakers which are controlled directly by the dwarf signal arm, one of these circuit breakers controlling the indication circuit and being closed only when the signal is in normal position, and the other controlling the working circuit and opening each time the signal is reversed. The circuit controller for the dwarf signal connected to lever 4 is provided with eight fixed contact pieces and two movable contact strips. Two of these contacts at each end of the controller are much longer than the others, that is, they connect with the movable strip during the preliminary and the final movement of the lever. The other two at each end are short so they make contact with the other movable strip only when the lever is stopped by the latch $L_4$. The indication current for the dwarf signal comes direct from the battery instead of from a motor running as a generator, as in case of the switch and other signal indications.

One pole of the indication magnet is connected always to the positive pole of the battery through the operating bus bar and the connections of the dwarf circuit controller are such that when the lever is at normal indication point the control wire is connected to the indication bus bar and the free terminal of the indication magnet is connected to the indication wire. In the reverse indication position the control wire is connected to the plus pole of the battery the other pole or terminal of the indication magnet being connected to the negative pole through a circuit including the indication common and main common wires.
In the full normal and reverse positions the control wire has the same connections that it acquires at the same indication points, the indication magnet being cut off to prevent a needless flow of current through the coils. If lever 4 is reversed the control wire becomes connected to the battery, while the current flows through the working coil W and the circuit breaker G4 to the main common wire. This causes the signal arm to be moved to the clear position and also opens the circuit breaker, which puts in circuit the retaining coil, which latter is in shunt with the circuit breaker. The current in the retaining coil holds the signal arm in the clear position. The indication magnet is at the same time connected to battery at the point of indication and allows the release of the lever so it can make its final movement to the reverse position. This arrangement is used so as to have a standard set of connections for both signal and switch levers.

When lever 4 is pushed back to normal the circuit through the retaining coils is broken and the signal falls back to normal. When it reaches the normal position the circuit breaker D connects the indication wire with the main common at the signal; and as the movement of the lever to normal has put the free terminal of the indication magnet I4 in connection with the indication wire, a current flows through the indication magnet and effects the release of the lever from the latch L4, permitting it to be pushed back into full normal position.

It is evident from the number and location of the wires used in this machine that if crosses between certain wires should become of accidental creation the various devices would be
extremely liable to cause false indications, thus introducing
dangerous factors into the system. To protect against any such
accidents the following scheme is used; Noting Plate 1, J and K
are two electrically independent switches held normally closed by
the current in coil C. The switch K, when open, cuts off the
battery from all functions. The switch J, when open, cuts off
all wires from the indication common. Current energizing coil
C flows from the positive side of the battery through the coil,
the indication common and the main common back to battery.
Another coil of low resistance H is on the same core with C.
Coil H is in series with and forms a part of the indication common
wire. All indication currents from switch and signal motors
flow through the indication common in the direction indicated by
the arrow and the winding of coil H is such that a current in this
direction aids the coil C in holding the switches closed. It is
at once seen that since the indication common is connected at its
outer end to the main common and this to the negative pole of the
battery that any current which might flow from the battery through
coil H would flow in the direction opposed to the arrow. This
would neutralize the effect of coil C and throw the cut-out open.

An inspection of Plate 1 shows that all wires which would
next be operative are connected at the interlocking machine to the
negative pole of the battery through the indication bus bar, the
switch J, the coil H, the indication common, and the main common
so that current reaching any of these wires on account of being
crossed with a live wire will flow back through coil H in a
direction to open the cut-out and thus cut off the current which
might otherwise effect a movement not wanted.
The resistance of the return path through coil \( H \) is made less than that through the motor and main common, so that the greater part of the current, due to a cross, must flow back through coil \( H \). The windings of coils \( H \) and \( C \) are so proportioned that any current, due to a cross, strong enough to move a motor will throw the cut-out open and cut off all current from the crossed wires before it has time to move the motor.

The indication common is led out a distance from the tower where it is joined to the main common. This is done to avoid the effects of the drop in potential in the main common due to the working of a switch or a number of switches. If the indication common were connected directly at the battery this fall of potential would tend to send a current back through the indication wires of the other functions not being operated and would in some cases open the cut-out unnecessarily and cause annoyance. By joining the indication common to the main common at a distance from the battery this fall in potential is entirely avoided and is just as safe since a break in either would open the cut-out.

Referring again to Plate 2; lever \( D \) slides in its guide \( E \) and is held in place by the caps \( F \) and the adjacent lever guide. The dotted circles (1 to 5) in Figure 1 show the position of the tappet bar which corresponds with like numbered positions of \( Z \). The lever is connected to \( Z \) by rod \( W \). In passing from position 1 to 2 the tappet bar \( V \) is raised, thus locking all conflicting levers and the projection \( M \) on lever \( D \) coming in contact with projection \( K \) on latch \( L \) causes the latch to assume the position shown in Figure 2, thus bringing projection \( J \) into the path of tooth \( Q \) as shown in Figure 2.
In moving from the position 2 to 3 the tooth Q coming into contact with a similar projection on cam N, causes it to revolve into the horizontal position (shown dotted in Figure 2) thus forcing dog P into the position of Figure 2 and locking L in a horizontal position. In moving from 3 to 4 the cam N is revolved into the position shown in full lines in Figure 2 and the lever is stopped at position 4 by the tooth Q coming against projection J. Having come into contact with brushes X-X, bar Z completes the battery circuit to the motor and causes the switch to be thrown and locked in position, the indication current lifting armature T and causing plunger R to strike dog P and throw it out from under latch L. This permits the lever to move from position 4 to 5 and thus complete its stroke.

Plates 3 and 4 show the front and back views of the Taylor Interlocker. This is a six lever machine, with simple locking, but the principle of operation is the same as in case of a fifty or a hundred lever machine.
SECTION 3.

INTERLOCKING FOR THE CROSSING AT MC COOK.
INTERLOCKING FOR THE CROSSING AT McCOOK.

As stated before Mc Cook is the station name for the crossing of the A.T.& S.F., the C.T.T., and the C.& I.W. railways about twelve miles southwest of Chicago. The location of the various tracks will be seen by referring to Plate 5. The A.T.& S.F. Ry. is double-tracked through the plant, with leadouts for sidings each side of the crossing. The C.T.T. Ry. is also double tracked but has no sidings interlocked. The C.& I.W. Ry. is a single track road, with switches leading to the crossings interlocked.

Since the crossovers leading from the C.T.T. Ry. to the A.T.& S.F. cross the C.& I.W. line, derails and dwarf signals must be placed so as to protect the said crossings. These crossings are protected on the C.& I.W. Ry. by the regular derails and signals. On the A.T.& S.F. the upper arm of the home signal governs the main line; the lower arm the leadout for the siding at the other side of the crossing. Dwarf signals govern all back-up or switching movements. On the C.& I.W. the upper arm of the home signal governs the main line, while the lower arm governs the route leading through the crossover to the C.T.T. tracks.

The country at and near McCook is level, with but very little foliage, so trains can be seen at least one-half mile in any of the four directions. Thus the location of the tower depends more on the most economical location in regard to electrical circuits than in regard to vision. The location selected is as shown on Plate 5. The location of the derails and signals is
governed by the rulings of the state railway commissioners and state laws, which will be given under "Specifications". The signals, switches, and derails are all numbered to correspond with the numbers on the levers of the interlocker in the tower. These numbers are also used in the diagram of connections as shown in Plate 6.

This diagram of connections is drawn similar to that shown on Plate 1 and by a study of the latter any operation affected by the movement of a lever in the former can be followed out. As stated previously, these levers are so interlocked that movements must be made in a pre-determined order. One variation from the connections shown in Plate 1 is the location of track circuit relays so as to govern certain circuits. The reason for this is to avoid the use of detector bars. It is a well known fact among Signal Engineers that the detector bar does not give the protection required and cannot be depended upon even though working perfectly. The bar comes disconnected easily and is frequently bent out of shape. A track circuit in place of a detector bar was first put in service in 1904, and has given satisfaction wherever substituted for the bar since that time. Where automatic signal circuits are to be continued through the plant these track circuits are utilized by simply adding another point to the track circuit relay.

The principle of the track circuit control will be better understood by reference to Plate 9. On this plate all track circuits are shown, these occupying the places where detector bars are usually located, and in certain cases extending further than a detector bar would have done. Consider a train approaching
the double-arm signal to the left of the crossing on the A.T. & S.F tracks, bound towards the crossing. Before the signal is cleared the derail ahead of it must be closed. Then as soon as the front trucks of the engine pass the insulated joints opposite the double arm signal relay R, located across the track adjacent to the tower, will be shorted and the current from the battery near the double-arm signal will pass through the wheels of the train instead of through the relay. This will permit the relay armature to drop and thus break the control circuit leading to the derail. This control circuit will remain broken until the last car of the train passes over the insulated joints in front of the tower and until then the derail cannot be operated, that is; opened. In this way the track circuits control all derails and facing point switches. The relay numbers on Plate 6 correspond to those shown on Plate 9.

The reason for making the track circuits longer in certain cases is to give better protection to trains and to form a continuous link in the automatic signal system on the A.T. & S.F. Ry. It is sometimes considered a good policy to run all track circuits up to the crossing, but it was thought unnecessary in this plant.

Lever 13 governs both switches for the crossover on the A.T. & S.F. In Plate 6 the two switch mechanisms are shown as connected in multiple but this is not as good a scheme as the one in which a stub lever connection is provided, as shown in Figure 1, Plate 7. In the former case an indication might be given by one switch while some obstruction kept the other from closing and a derailment result. In the connections as shown on Plate 7 an indication cannot be given until both switches are closed.
The wires leading from the tower to the various switches, derails, and signals are shown on Plates 8 and 9. Plate 8 shows the power wires and by reference to this plate and to Plate 9 the number of wires to be put in cables leading various ways can be ascertained. The lighting circuits are shown on Plate 9, in addition to the track circuits already described. The lighting as well as the power is at 110 volts.

Before starting the design of the tower it is necessary to find the size of the interlocker to be installed. The machine is to have 47 levers, of which 12 will be signal levers, 18 derails, 5 switches, and 12 dwarfs. One of the switch levers (13) controls two switches. The width of the case is less than three feet. The over-all length in inches is found by multiplying the total number of levers, or lever spaces, by two and adding nine inches extra for the case. This makes it eight feet seven inches long. A standard width of towers is twelve feet, and a length sufficient to accommodate the interlocking machine and an office for the operator (C.T.T. Ry.) was determined to be twenty-one feet. The upper floor is given over to the operator and the interlocking machine, while the lower floor is occupied by the battery, gasoline engine, generator for charging, and the switch board. The design of this tower is shown as Plate 10. The engine and the generator are to be mounted on concrete foundations, and the battery placed in a convenient cupboard provided with ventilating pipes. The locking sheet is shown under "Plates" just preceding Plate 1.

The calculation for the battery was made as follows: From a Taylor plant in operation the data given was taken.

One switch movement takes five amperes.
One high signal movement takes three amperes.
One dwarf signal movement takes one-quarter of an ampere.
Brake magnets (high signal) take .1 ampere.
Eighteen signal and switch(dwarf) lights 2 cp each take 1.13 am.
Five tower lights 16 cp each take 2.5 amperes.
All of these calculations are for a 110 volt system. Twenty-three lights burn a maximum of fourteen hours per day.

\[3.63 \times 14 = 50.82 \text{ ampere-hours required per day for lighting.}\]

As a high value the following number of trains are considered as using the interlocking per day:

- C.& I.W. .......... 40 trains.
- Total ................ 200 trains.

Time required to clear signal ........... 2 seconds.
Time required to throw switch ........... 2 seconds.

One signal operation requires:
For movement .................... 001668 ampere-hour.
Holding ......................... 0083 " ".
Total ......................... 009968 or .01 ampere-hour.

One switch movement requires .0028 ampere-hour.
One dwarf signal requires .0083 ampere-hour, including .1 ampere for five minutes holding.

An A.T.& S.F. train movement requires the movement of two signals = .02 ampere-hour, five switches = .014 ampere-hour, one dwarf = .0083 ampere-hour. Total for one train = 2.115 ah.

A C.& I.W. train movement requires the movement of two signals = .02 ampere-hour, six switches = .0168 ampere-hour, three
dwarfs = .0249 ampere-hour. Total for one train = .0617 amp.-hr.

A C.T.T. train movement requires the movement of two signals= .02 ampere-hour, three switches= .0084 ampere-hour, two dwarfs= .0166 ampere-hour. Total for one train= .0450 amp.-hr. The above figures are calculated as an average. Fifty trains per day on the A.T.& S.F. = 2.115 ampere-hours; Forty trains per day on the C.& I.W. = 2.468 ampere-hours; One hundred and ten trains per day on the C.T.T. = 4.95 ampere-hours. Total for the three roads = 9.553 ampere-hours per day, but switching movements through the interlocking plant, this being a junction point for the interchange of cars, doubles the switch and signal movements, requiring therefore 19.066 ampere-hours per day.

For lights 50.82 ampere-hours per day are required. 50.82 + 19.066 = 69.89 or 70. ampere-hours total required per day. Two days = 140 ampere-hours. Considering the efficiency of chloride accumulators as 80% the capacity of battery needed is 175 ampere-hours. This is figured on the basis of having the battery charged every other day. From a table given by the manufacturers of the chloride accumulators I have chosen type E, 13 plates, 7-3/4x7-3/4". Normal charge rate= 26 amperes. Fifty-five cells are to be used, giving a voltage when charged of 110. A 3 K.W. generator is required for charging, with a five H.P. gasoline engine to furnish the power for the generator.

In figuring the amount of shelf room necessary to accommodate the storage battery care was taken to allow room enough between shelves to let the plates be removed without moving the glass jars from the shelves. Plate 11 shows the construction of the shelves, spacing of cells, etc.
Plate 12 shows the switch-board and connections for charging and discharging the battery. This switchboard is attached to the wall of the tower on the lower floor as shown in Plate 10, and is located so its top is six feet above the floor of the tower. The ammeter shown on the switchboard in Figure 1, Plate 12, reads both ways, that is, it reads amperes for current flowing in either direction so that the charging as well as the discharging current can be observed. To charge the battery, the generator is brought up to a speed giving a voltage a little higher than that across the battery, the voltage being read by opening the battery switch, closing the generator switch, and putting the voltmeter switch on point c. When the voltage is as stated the battery switch is closed and the battery will be charged. In case the gasoline engine should drop below the proper speed and the generator voltage drop below that of the battery there will be a tendency for the generator to become a motor, current flowing from the battery in an opposite direction from charging. To prevent this an underload circuitbreaker is provided as shown in Figure 1.

Figure 2 shows the wiring on the back of the board, and Figure 3 shows the method of attaching the switchboard to the wall of the tower. Figure 4 is the wiring diagram of the charging system. It may be well to add here that an ammeter indicates, to a large extent, the working condition of the various switches and signals, and in doing this is most valuable and should be in full view of the leverman. To provide for this an auxiliary ammeter can be put in series with the switchboard instrument, and located above the interlocker on the upper floor of the tower.
It is also well to have a voltmeter in parallel with the switch-board instrument, and this also located on the upper floor.

The type of derails used are the Wharton and the Hays. Wharton derails are of the type shown in Plate 13. The Hays derail is used only on slow speed tracks. It is thrown over the rail and will not prevent excessive damage to the derailed cars as the Wharton derail does. Noting Plate 5; Derails 9, 10, 19, 21, 27, 28, 29, 30 are Wharton derails. Derails 11, 14, 15, 16, 17, 18, 23, 24, 25, 26, are Hays derails. The Taylor motor used in operating both derails and switches is of the type shown in Plate 13.

A two arm signal of the type used is shown in Plate 14. This is of the enclosed type, thus affording better protection for the signal motor and other apparatus. The one-arm signal is similar to the two-arm except that the upper arm and that part of the mast adjacent to it is missing.

Referring again to Plate 5 we note that a system of letters A, B, C, etc. are used to denote certain tracks. The route of a train through the plant can be designated as from A to B, etc. The levers to be pulled to clear the switches and signals for the various high speed and low speed routes are given in the manipulation chart, shown as Plate 15.

While a well recognized fact that the signal standards of all roads should be the same, both for the safety of the public and to simplify signalling for the trainmen, it is as well known that such a standardization has not as yet been effected. Therefore, to make clear the signal indications of the railways using the interlocking Plates 16 and 17 have been inserted.
The system used on the A.T.& S.F. Ry. is recognized as being the safest of the three, as a false indication for clear (green) cannot be given as easily as a false white (for clear) indication. The only difference between the indications for the C.T.T. Ry. and the C.& I.W. Ry. is that the former uses a drop of 60° of the signal arm for clear, while the latter uses a drop of 90° for a clear indication.

I do not consider it necessary to give the rules of the railway companies concerning the use of the interlocking plant, signal government, etc. Suffice to say that I have carefully studied these and the location of the signals and their indications are made to conform with the separate companies rules as well as the state laws in regard to the matter.
SECTION 4.

SPECIFICATIONS.
SPECIFICATIONS.

In giving specifications I will limit myself to those affecting the design only of the plant. In the matter of construction I assume standard specifications such as compiled by the American Railway Engineering & Maintenance of Way Association to be followed.

STATE OF ILLINOIS

STATUTORY PROVISIONS.

Act relating to crossings on the same level; approved June 3, 1887, in force July 1, 1887. An act in regard to dangers incident to railroad crossings on the same level.

Section 1. That when in case of two or more railroads crossing each other at a common grade,...... a plan of such interlocking and signals, works and fixtures, for such a crossing, designating the plan of the crossing, shall have been filed with such Railroad and Warehouse Commissioners, then, in that case, it is hereby lawful for the engines and trains of any such railroad or railroads to pass over such crossing or bridge without stopping.

RULES GOVERNING THE INSTALLATION OF INTERLOCKING DEVICES.

RULINGS OF THE RAILROAD AND WAREHOUSE COMMISSION,

STATE OF ILLINOIS.

Prior to the commencement of the erection of an interlocking system there should be filed with the secretary of the commission, for approval or amendment by the consulting engineer, a complete plan, in duplicate, showing the location of all
main tracks, sidings, switches, cross-overs, spur-tracks, buildings, and other obstructions to the view at or in the vicinity of the crossing or junction to be protected; also showing the proposed location of all switch points, signals, locks, detector bars, towers, etc.—the same to be fixed by measurements indicated by plain figures, or by a plan drawn to a scale of not less than 50 feet nor more than 100 feet, to one inch.

The grade of each track per 100 feet must be shown on the said plan, also the direction in which trains are moved thereon. All tracks must be marked "main", "side", "transfer," etc., according to use.(This provision is not enforced except in case of heavy grades or complicated yards).

At each switch, derail, signal, detector bar, lock, etc., shown on the said plan there must be marked the number of the lever to operate the same.

III. A complete diagram of locking must be furnished with petition for inspection of any interlocking system. This diagram must correspond with the arrangement of locking dogs as finally located and fixed.

IV. A manipulation sheet showing the combination necessary to be set up for each of the several routes governed by signals must be furnished with petition for inspection.

VI. It being desirable that a uniform system of signals shall be used at all interlocking plants, it is recommended that all signals shall be of the semaphore type......All signals must be provided with a lamp,........

VII. The home signal should, when practicable, be
located on the engineman's side of the track it governs, and should not be less than fifty (50) feet nor more than two hundred feet in advance of the point it governs, except when special conditions exist. The signal must point to the right of the track it governs, and should have a square end. When the derail or facing point or crossing is set against the train movements governed by the home signal, the signal must be locked in a horizontal position, showing red, or danger color by night, indicating "danger-stop." When the track it governs is clear and safe for the passage of trains the signal may be inclined at an angle of about sixty (60) degrees or more from the horizontal, showing a white light or clear light by night to an approaching train, indicating "clear track-advance." In case two signal arms are used on the home signal post the top signal should in all cases govern main or high speed routes, and the lower signal the diverging route or routes........

VIII. The distant signals should be located not less than twelve hundred (1200) feet in advance of the home signal with which it operates, on the same side of the track, with the arm pointing in the same direction. The distant signal should be distinguished by a notch cut in the end of the semaphore arm. It must be so arranged and connected with the home signal that it will be held in a horizontal position, showing green or caution signal light by night to approaching train when the home signal indicates danger.

X. Dwarf signals, having a small arm and suitably adapted as to height, should be similar in design and location to the home signal. They should be used only to govern
movements on secondary tracks or movements against the current of traffic on main tracks when such reverse movements become necessary, and when necessary in yards.

XII. The signalman in the tower should be able to see the arms and back lights of all signals; the back lights of the lamps to be made as small as practicable, having regard to efficiency. When the front lights are visible to the signalman in the tower no back lights will be required. If for any unavoidable reason the arm or light of any signal can not be seen by the signalman, a repeater or indicator should be provided in the signal tower.

XIII. The fixed lights in the signal tower should be screened off so as not to be mistaken for the signals exhibited to control the running of trains.

XIV. Where the grade is practically level, the derailing points on high speed tracks shall be located not less than five hundred (500) feet in advance of crossing or fouling point which it is intended to protect; but in case of a descending grade toward the crossing or fouling point, the derailing point must be located at such a distance from the crossing or fouling point as to give the same measure of protection that is required for level approach.

XV. On secondary tracks, such as switching, drilling, storage, and low speed tracks, the derail point should be located so as to give the same measure of safety required for high speed tracks.

XVI. When the crossing is made by a switching, drilling, storage or low speed track with a high speed track on which
trains are moved in both directions the derail on the high speed track should be located on each side of the crossing, and at a distance therefrom indicated in article XIV. A derail should be located on the secondary tracks on each side of the crossing, according to the requirements of article XV.

XVII. In case two or more secondary low speed tracks cross each other at grade, each track should be provided with a derail on each side of the crossing. The distance of the derail in advance of the crossing should be governed by the kind of traffic upon such tracks, provided that the same measure of safety is secured at such crossings as is required for the protection at crossings of high speed tracks.

XIX. In case of double track crossings where trains are moved on each track, as a rule, in one direction, a derail should be provided for the back-up movements, and for the further purpose of insuring clearance of crossing before clearance signal can be given on opposing route. The back-up derail should be placed not less than one hundred and fifty (150) feet nor more than three hundred (300) feet from the crossing.

XXVI. The locking should be actuated by the action of the latch rod, or by a device performing similar service in advance of the first movement of any lever. The first act in reversing a lever must lock the levers of all conflicting routes.

XXVIII. Signal towers should be so placed and of such a height as to afford the best possible view of the signals and other parts of the interlocking system.
SECTION 5.

AUTOMATIC SIGNALS THROUGH THE INTERLOCKING PLANT.
AUTOMATIC SIGNALS THROUGH THE INTERLOCKING PLANT.

No attempt will be made here to go into detail in describing the automatic electric signal system designed for the A.T.& S.F. Ry. tracks extending through the plant. The only purpose in giving this design is to show how any such system can be made to operate in conjunction with an electrically operated interlocking. A wiring diagram of the signals is shown as Plate 18. The home signals are located one mile apart, with a distant signal one-half mile in advance of each home. Each home signal protects the entire mile block to the next home signal, the control being through the track circuits. Each distant signal shows only the indication of the home signal one-half mile in advance, and does not show caution when a train is between it and the next home signal unless the home signal is at danger, as before stated.

The track circuit for the automatic signals is made to work through the relays used for the electric locking in the interlocking plant, an extra point being provided for this service. On Plate 18 the relays marked $R_1, R_2$, etc. are the locking circuit relays, while those not marked are used for the automatic signals exclusively. The principle of the operation of these signals is similar to that of the electric locking in their relation to track circuit control so needs no further explanation. All line relays are of 500 ohms resistance, and track relays of 4 ohms resistance.
SECTION 6.

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BIBLIOGRAPHY.

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   Railway & Engineering Review, 44:978, 986.

Electric Journal,
   Feb. March, April, 1907.

Special Notes taken by the author.
SECTION 7.

PLATES.
LOCKING SHEET.

1 locks 2 reversed.
2 (upper arm) locks 9 reversed, 13 normal, 14 R, 12 N, 35 N,
2 (lower arm) locks 9R, 13N, 14R, 12R, 15R, 36N.
3 locks 4R.
4 (upper arm) locks 10R, 13N, 31N, 11R, 32N,
4 (lower arm) locks 10R, 13N, 31R, 16R, 33N.
5 locks 6R.
6 (upper arm) locks 19R, 20N, 21R, 22N.
6 (lower arm) locks 19R, 20R, 26R.
7 locks 8R.
8 (upper arm) locks 21R, 22N, 19R, 20N,
8 (lower arm) locks 21R, 22R, 24R, 41N.
9 locks 27N, 28N, 29N, 30N.
10 locks 27N, 28N, 29N, 30N.
11 locks 27N, 28N, 29N, 30N.
12 locks 35N.
13 locks 2N, 4N.
14 locks 27N, 28N, 29N, 30N.
15 locks ********
16 locks 31R, 27N, 28N, 29N, 30N.
17 locks 19N, 21N.
18 locks 19N, 21N.
19 locks 27N, 28N, 29N, 30N.
20 locks ********
21 locks 27N, 28N, 29N, 30N.
22 locks ********
23 locks 19N, 21N.
24 locks 22R.
25 locks 19N, 21N.
26 locks 20R.
27 locks 9N, 10N, 11N, 14N, 16N, 19N, 21N.
28 locks 9N, 10N, 11N, 14N, 16N, 19N, 21N.
29 locks 9N, 10N, 11N, 14N, 16N, 19N, 21N.
30 locks 9N, 10N, 11N, 14N, 16N, 19N, 21N.
31 locks 32N.
32 locks 11R, 31N.
33 locks 16R, 31R.
34 locks 18R.
35 locks 12N, 14R, 13 N&R.
36 locks 15R, 12R, 14R, 13N&R.
37 locks 17R, 23R.
38 locks 26R, 20R, 19R.
39 locks 25R, 16R.
40 locks 23R, 17R.
41 locks 24R, 22R, 21R.
42 locks 28R.
43 locks 27R.
44 locks 45R.
45 locks 29R, 27R, 43N.
46 locks 47R.
47 locks 30R, 26R, 42N.
PLATE 1.

Diagram of Connections:
TAYLOR INTERLOCKING
PLATE 2.

LEVER MECHANISM
TAYLOR INTERLOCKER
PLATE 3.
TAYLOR INTERLOCKER, FRONT VIEW.
PLATE 8

TAYLOR INTERLOCUTER, FRONT VIEW
PLATE 4.

TAYLOR INTERLOCKER, REAR VIEW.
PLATE 4

TAYLOR INTERLOCUTER: REAR VIEW
PLATE 6

ELECTRIC INTERLOCKING
FOR
McCOOK
DIAGRAM OF CONNECTIONS
FOR OPERATION.
PLATE 7

Fig 1
CHANGES IN CONNECTIONS FOR LEVER 13

Fig 2
LEG FOR TAYLOR INTERLOCKER
ELECTRIC INTERLOCKING

FOR

McCOOK

LIGHTING AND TRACK CIRCUITS.

Scale 1" = 100'

PLATE 9
ELECTRIC INTERLOCKING FOR
MCCOOK SIGNAL TOWER
Scale 1"=1'
SWITCHBOARD & CONNECTIONS
Figs. 1 & 3  Scale 1"=1
PLATE 13.

WHARTON DERRAIL, OPERATED BY TAYLOR MOTOR.
PLATE 16

WATER DRAIN OPERATED BY TAYLOR MOTOR
TWO ARM ENCLOSED SIGNAL
# MANIPULATION CHART

## HIGH SPEED THROUGH ROUTES

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<th>TO</th>
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<td>9 14 2 1</td>
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<tr>
<td>C</td>
<td>D</td>
<td>10 11 4 3</td>
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<tr>
<td>H</td>
<td>J</td>
<td>19 21 6 5</td>
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<tr>
<td>K</td>
<td>M</td>
<td>29 27 45 44</td>
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<tr>
<td>N</td>
<td>L</td>
<td>30 28 47 46</td>
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## SLOW SPEED OR SWITCH MOVEMENTS

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<tr>
<td>L</td>
</tr>
<tr>
<td>M</td>
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PLATE 16

"HOME" SIGNAL

"DISTANT" SIGNAL

STOP

CLEAR

CAUTION

CLEAR

DOUBLE ARM "HOME" OR "ROUTE" SIGNAL - DwarF Sig.

STOP

CLEAR

FOR SUPERIOR ROUTE

FOR INFERIOR ROUTE

SIGNAL INDICATIONS USED BY THE A.T & S.F.RY.
PLATE 17

"HOME" SIGNAL

STOP

"DISTANT" SIGNAL

CLEAR

CAUTION

CLEAR

DOUBLE ARM "HOME" OR "ROUTE" SIGNAL. DWARF SIG.

STOP

FOR SUPERIOR ROUTE

CLEAR

FOR INFERIOR ROUTE

CLEAR

Signal indications used by the C.T.T. Ry.

AND THE C&I.W.RY-EXCEPT THAT SIGNAL CLEAR 90°