Traffic Safety and Economy

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The perfection of traffic safety and economy must always be kept in view by railway managers. This aim is realized by the following means.

1. *The use of electric interlocking plants, permitting greater interlocking ranges and consequently reductions in staff and maintenance costs.*
2. *The introduction of dwarf signals requiring less shunters and permitting the shunting work to be performed with greater speed and precision.*
3. *The arrangement of track circuits in such manner that the trains will do the signalling themselves and thus make human labour superfluous. The traffic work can further be performed more quickly and the traffic density be increased.*
4. *The mounting of an illuminated track diagram in the station master's office, representing the track circuits of the adjoining lines. The trains will thus report themselves as soon as they leave the preceding station, and reporting by telegraph and telephone can be dispensed with.*

The perfection of safety devices, and economic handling of the traffic are the two aims that railway companies managers must always keep in view.

Everything must, of course, be done to make the movement of trains perfectly safe. It is not only great material values that are exposed to danger, but in the first place the human lives must be considered. Every moment great numbers of people are under the protection of the railways: both employees, and passengers who confidently use the railways for long or short journeys.

On the other hand, the economic position of the railways is at present very difficult, and, consequently, the possibilities of reducing costs are given more attention than ever before. The demands for simplification and rationalization have steadily increased. In order to meet the present demands and stand up under the heavy competition from other means of transportation, the railways have been forced to take various economy measures. In railways operation, as in other lines of business, wages are now one of the greatest items of costs. If expenses are to be reduced, the wagebill must in the first place be cut, *i. e.,* the number of employees must be kept as low as possible.

In dealing with such activities as the safety service of the railways, where the highest possible degree of perfection must always be endeavoured it may appear inconsistent to demand a reduction of the staff. But here we are in the happy situation that these two points of view can and must coincide. The safety departments of the railways have always tried as far as possible to eliminate human imperfection. These circumstances point directly towards the installation of *electric interlocking devices* which not only ensure perfect safety, but also require a minimum staff for their operation.

The Technical and Economic Advantages of the Electric Interlocking Plant.

Interlocking devices have been used for a long time in railway safety plants, whether large or small. Not however until the last few years has the electric interlocking plant come up. Formerly the interlocking devices were of the *mechanical* type that is still the most commonly used. In such an interlocking plant all points, scotch blocks, semaphores and other signals, are connected to levers or cranks in the control cabin by means of steel-wireropes.

The wire passes several corner and support pulleys, is stretched by means of one or more weights, and is consequently hard to move. If, further, the inertia of the semaphore signal or the point is added, the range of the mechanical interlocking plant will be limited to about 1 000 m

X 1089 Fig. 1. Point on the line operated from a signal cabin at a distance of 1.5 km.

or less. Several interlocking plants have consequently to be installed in great station yards, and further, some kind of telephone system between the control cabins will be necessary.

The *electric interlocking plant,* with motors at all points and semaphore signals, can operate these by means of underground electric cables at almost any distance, and has thus an almost indefinite range. By means of an electric interlocking plant it is possible to operate points and signals situated on the lines at sidings, loading tracks etc.

A valuable device, which can only be utilized to its full extent in electric interlocking machines, is the *dwarf signal.* This signal is among the latest advances of signal technics. The dwarf signal consists of an iron case, about $^3/_4$ of a meter high, fitted with four lamps, the light of which is visible both day and night, as is the case with so called light signals. The dwarf signals are mounted on the left side, and at right angles with the track. They can show three signal combinations: »stop» (two lights beside each other), »clear» (two lights above each other), and »caution» (two lights at an angle of 45°). By means of these dwarf signals all shunters that are otherwise required in great station yards for the supervision of points, engine motions etc., become superflous. This signal arrangement facilitates the shunting work considerably, and gives great safety and speed thanks to the electric interlocking machine.

In mechanical interlocking machines all wires, corner pulleys, weights, semaphore wings, etc., are continually in motion, and subject to wear; they will thus often require repair and supervision. In cold weather the wires may get stuck. The means of transmission in the electric interlocking plant, underground cables, are independent of the weather, and in the semaphore signals there are no mobile parts. The semaphore signals with mobile arms have been replaced by the modern, powerful *light signals.* These latter consist of poles of medium height, fitted with signal lamps with scientifically designed lenses, which permit the signals to be seen both day and night. These signals have no mobile parts, and are further more easily visible in fog or other bad weather.

The most valuable feature of the electric interlocking plant is, however, the *track circuit.* The tracks, which interconnected in certain sections, are fed with electric current of low tension; the circuit is closed when trains or single vehicles pass, and the current operates relays or series of relays in the control cabin. These relays are, in their turn, connected so as to break or close electric circuits to signals, scotch blocks, flashlight signals, etc., in various combinations; thus an automatic signalling system is realized, which is of great value to modern railway technics. The trains themselves will to a certain extent operate the signals, and the human work thus becomes superfluous.

Other comparisons could be made, and cases cited in order to show the advantages of the electric interlocking machine in respect of both safety and staff requirements. The instances above may, however, be sufficient.

It stands to reason that the great advantages of the electric interlocking machine. The uncertainity as to whether the capital invested will pay any return or not, is probably the cause, why this new type of safety plant has not gained more ground than it actually has. Local conditions, of course, have considerable influence, but investigations have shown, that already in small stations estimates point to the employment of electric interlocking machines.

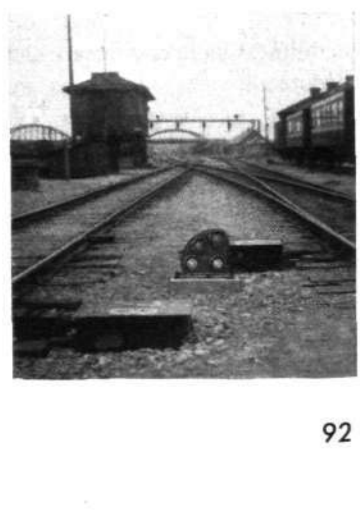

Fig. 2.
Dwarf signal and point drive motor.
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As a starting point the cost to the company of the existing safety plant must be figured out, *i. e.*, the cost of the safety plant of the station and adjoining lines, or in other words the whole range of the new interlocking plant. It is then of great importance to take into account not only the wage-bill for the staff in the actual interlocking service, but also for shunters, signal guards, lookouts, track road inspectors, repairmen and telegraph operators who exchange train questions and are responsible for train schedules, reserves, medical treatment, insurance, etc.

Concerning material costs it must be observed, that besides the direct cost for repair and maintenance of the interlocking plant, cables, signals, etc., the maintenance cost of buildings such as signal cabins and rooms for the staff is included.

If the estimates indicate, that an electric interlocking plant will be advantageous, the details remain to be worked out, so that the plant will give the best possible service, and at the same time the cost may be kept below a reasonable limit.

At this stage it is of great importance, that a traffic expert, well acquainted with movements of the trains in the station, should take part in the planning work, and get acquainted with the operation of the new plant, so that, already at an early stage, attention is given to the traffic points of view. Intimate cooperation between the technical and the traffic departments is vital in order to get the best possible result.

Before we proceed to discuss the planning of the electric interlocking plant, the main principles and operation of the plant will once more be considered.

The Planning and Working of the Electric Plant.

The fundamental principle of an electric interlocking plant is, as mentioned above, the use of insulated tracks with track circuits. Both the lines and the station yard are divided into a number of insulated track sections; these sections are fed with electric current, which operates the corresponding relays. When vehicles pass a section, the axles short-circuit the current; the relay is de energized but takes its normal position as soon as the short-circuit is broken, *i. e.*, when the vehicle has passed the section. This automatic operation of the relays is used for controlling other and considerably stronger currents for signals, etc. A vehicle or train can thus, by means of the automatic change of the signals, stop or warn other vehicles in dangerous proximity to its own track. As soon as the last axle of the vehicle has left the section, the corresponding points may be thrown over, which means that a road may be liberated as a train proceeds; the opposite is the case at mechanical interlocking machines, where the whole road is locked until the train has passed, or stopped at, the station. As mentioned above,

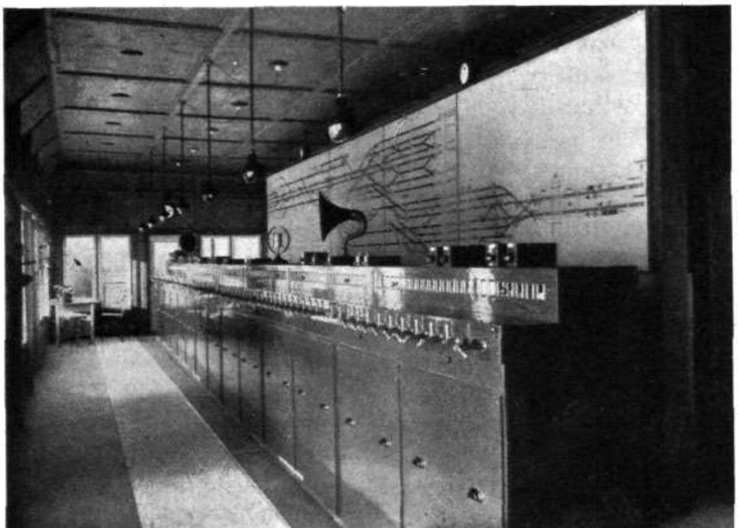


Fig. 3. Interlocking machine with illuminated track diagram.

X 5022

all signals regulating the movement of trains are light signals, giving great advantages. For shunting motions the above-mentioned dwarf signals are used, *i. e.* for permitting motions over one or more tracks.

In the signal cabin an illuminated track diagram is mounted. This diagram shows all signals, and with different colours in small signal windows if the signals are in »stop» or »clear» position, and further the positions of all point signals in the station yard. Other signal lamps show whether the sections are occupied by vehicles or not.

The staff of a signal cabin fitted with a track diagram is thus less dependent of whether the track range is visible or not. If a number of points and signals are included in the interlocking machine of a section of the station yard, where chiefly shunting of wagons, division of trains, shunting of engines, and similar, permanently varying motions occur, it is, however, important, that the motions should be visible to the staff. Part of the shunting will soon be familiar to them and, without being reminded by telephone, the staff will soon be able to establish the necessary roads, to help the shunters and see that all possibilities of the track system are utilized as far as possible. It will be the staff of the central cabin that will determine the speed of the shunting, and the greater the number of small movements it can see and anticipate, the faster and smoother the work will run. For the shunters must be distracted as little as possible by going to the telephone posts. When choosing the position for a new central cabin, it must be stated, whether there is such a shunting range, and in such case attention must be paid to this fact.

By mounting a track diagram of the adjoining lines in the station masters office (the train dispatching office), the reporting of trains may, as a rule, be eliminated. The trains will report themselves on the track diagram as soon as they leave the adjoining station.

The division and determination of the length of the insulated track current sections in the station yard, and in connection with this, the number of dwarf signals requires careful consideration. All movements of vehicles, which may be performed simultaneously and without hindrance on the existing tracks, must receive signals for these motions from the dwarf signals, but, on the other hand, these signals must indicate »stop», where different roads touch each other. When a signal indicates »clear», this means, that all points are in the correct positions, and the section free from vehicles. When »caution» is indicated, the points are in the correct positions, but there may be vehicles in the section, or the next dwarf signal may indicate »stop».

As long as a section is occupied by vehicles, no points in the section can be switched. The problem is thus to get the greatest possible freedom of motion, but at the same time sufficient safety. Sometimes a road may be considered of no importance as it is seldom used and connected to the adjoining track, thus saving a dwarf signal. This can, however, not be recommended. The time-table may be changed, the trains get other times of departure, and the shunting consequently has to choose other ways. It is far more expensive to change a plant, than to make it as complete as possible from the outset, and thus handle a change or increase of the traffic, which may occur in the future. Wherever possible, with regard to the positions of the points and the shunting work, the dwarf signals and sectionings must not be placed too near the points or scotch blocks. It may occur that a vehicle moves towards a signal indicating »clear» and that at the same time the interlocking staff wants to change other points farther on. The dwarf signal will then indicate »stop», and the point motor will start. If the engine driver does not succeed in stopping the train fast enough, it may occur that the signal changed from »clear» to »stop» is passed. A free track length of about 10 m between the dwarf signal and the point or scotch block will in most cases be sufficient to prevent this.

It must be observed that the dwarf signals should be placed so that they are easily visible to the staff concerned. The position of the dwarf signals may seem perfect on a drawing, but platforms, telephone and light poles, etc., will often screen them from sight. In consequence the position must be selected on the station yard itself.

At points separating different track groups from each other, or limiting transfer tracks to other station yards etc. it will often be advantageous to place signals, indicating to which track group such a point is thrown so that the shunters can see the road already at a distance, and push the wagons to these track groups at a suitable speed.

The staff serving the interlocking system conducts the shunting in the station yard by means of the dwarf signals. The corresponding switches in the central cabin must be accessible to the

X 1090 **Fig. 4. Repetition signal on the platform for the station master.**

operator. In a modern interlocking system the signal switches ought to be placed, not in one separate group as the signal levers in an interlocking machine of the old type, but alternating with the point switches, so that when one man has to operate a certain range of the station yard, he will find all switches in an order corresponding to the actual position of the points and dwarf signals. The staff can thus be better utilized, and has only to move along a certain range of the interlocking machine.

The positions of the fix signals wanted for train motions at the stations are so far given, as the home and starting signals are as a rule placed on the border-line between the station yard and the adjoining lines. In large stations a number of supplementary and repeating signals are required for driving across the station yard. When necessary, the engine staff may be informed on which track or track group the train will be received, or to which line the road for a departing train leads; this is performed by means of various signal combinations shown simultaneously with the »clear» signal.

In large stations fixed repeating signals in connection with home and starting signals ought to be mounted in such number, and at such places, that the engine drives may always easily know his exact position, and never need to hesitate, whether the road is clear, even if fog makes the signals difficult to observe. The driving speed across the well utilized station yard depends on these arrangements. For despatched trains a separate repeating signal ought to be situated near the place, where the station master or the person responsible for the despatching signals for the trains stands; this signal should indicate, that the road goes from the *right* track and to the *right* line.

It is often of importance, particularly in the case of late arrivals of trains, that the staff for the loading and unloading of luggage and mail, porters and ticket collectors are informed when trains are arriving at the station. This may be easily arranged so that when the »clear» signal is shown to a train, one or more signal lamps (preferably with coloured light) situated at convenient places, are automatically lit by the signal relays, and then automatically put out when the train has arrived at the station. In stations with several tracks the same principle may be used to indicate on which track the train will arrive; when the track is changed the staff thus needs no particular information. It has been found in practice, that, by means of this information system, the staff has time to move to the place where it is required at the moment, and, when the train succession is changed, rearrange wheel-barrows and platform trucks in time. The importance of every man being in his right place, and ready to start work as soon as the train has stopped, will be easily understood, particularly when the train stop is short.

It has lately become more common, that the roads across the station yards are optional, *i. e.*, that a train can use different roads to the same track. Such an arrangement gives a great flexibility to the movement of the trains, and permits better utilization of the track system. The trains as well as the shunting may then find their way where the road is free.

The number of switches in a modern interlocking plant operating a great station yard and the section blocks of the adjoining lines, would be very great, if certain steps had not been taken in order to prevent this. Thus, points are very often connected to the same point switch. 90 % of the points in a station yard may frequently be combined two by two, as both have to be thrown over in order to form a certain road. It is therefore quite natural that they should be operated simultaneously by means of the same switch, thus saving time and work. These points are often connected in parallel; in that case, they are thrown over in the same time as *one* point. The signal switches may be combined in the same manner.

In order that the shunting staff should always be in contact with the traffic manager of the station, and with the staff moving in the station yard, a number of telephones must be mounted at conventient places. For the shunting, a loudspeaker may be used to advantage, as the interlocking staff need not leave their place at the instrument table, but answers by arranging the shunting road required.

Section Blocking.

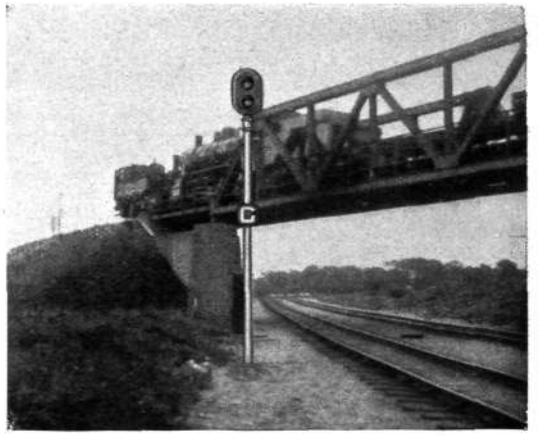
Concerning section blocking the electric interlocking plant offers great advantages compared to the old system. In the case of double track lines, where the signals must protect a train from being run into from behind, the signal plant may be made purely automatic. This will require a considerably smaller staff and further give greater speed in train despatching. When the line is free from trains all signals will indicate »clear». A train in motion will automatically change the nearest signal behind to »stop». This signal will then change to »caution» and finally to »clear» as the train moves on. The length of the block sections must be determined so that they are made short where the trains have a low speed, and longer where the trains pass at full speed so that the trains occupy the block sections about the same time, and thus can move on without unnecessary stopping or slowing down.

The number of block sections depends on the interval wanted between the trains on the line in question.

Concerning single track lines where the train direction is continually changed, the interlocking staff has to intervene by regulating the signals according to the time-table (semi-automatic system). The track current, however, is here also of great importance, as it prevents a new signal being given before a previous train has left the section.

When section blocks are used, guards at roads, bridges, etc., may be informed by means of light signals, automatically operated by the track current, when a train is on the line. Particularly when trains are late, or when extra trains are on the line, such an arrangement is of inestimable value, as it saves many telephone calls at a time when the station staff is paricularly busy.

The block sections, both automatic and semiautomatic, should be indicated by lamps on the abovementioned illuminated track diagram in the signal cabin, so that the staff may have a bird'seye view of train movements on adjoining lines. This is of great importance when the problem is to judge the times of arrival, and to prepare the road in the station yard, and set the home signal in »clear» position.

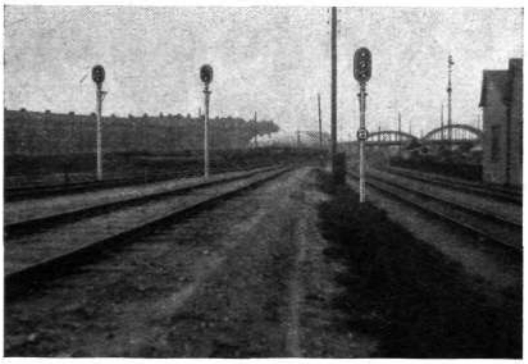


X 1091 **Fig. 5 Intermediate block signal, replacing a mechanical interlocking device.**

When a double track line is used as a single line, and trains move on the wrong line, the sectioning of this line is put out of function for these trains. By means of a switching device in the central cabin it is possible to switch over the track current, and in connection with separate single track signals make these latters operate in the same way as in a semi-automatic system, *i. e.* to prevent a train being despatched on the line before the first train has arrived at one of the stations.

The Master Central.

The modern interlocking cabin, where all central devices are assembled, all points are thrown over, and all signals are set, must be the point at which the control of train movements, as well as a certain amount of shunting, is concentrated. The employee in command must continuously follow the developments within the range of the interlocking plant, and by means of the signals on the illuminated track diagram, telephone information, and observations from the signal cabin form his opinion of the requirements of the moment, and in the best way serve the traffic, decide the succession of different movements, and work the station yard to capacity, without upsetting the time-



X 1092 **Fig. 6. Automatic block signals. Those marked B distant signals as well.**

table. The central cabin thus becomes a master control, which requires a skilled staff ready to act immediately, and well acquainted with the operation of the apparatus and the movements in the station yard. In emergencies, the orders of the traffic manager of the station can be confined to directions or orders concerning the succession of trains; the details are thus left to the staff, that has the best view of the operations, and is able to regulate the motion in the best way.

The experience from electric interlocking plants and electric section blockings with track current has shown, that these plants have functioned remarkably well, that they have surpassed expectations, and that they are far better than the old mechanical interlocking system, in respect of both safety and speed; besides, they give station yards and line sections a considerably greater capacity. Among experts there is only one opinion: that these plants meet all reasonable demands on economy. The cost of operation has come down to a fraction of what it was with the old methods.

The continuous control and interdependence of parts in a modern electric plant, has ensured traffic safety in a higher degree than when it is only based on human observation and attention. Every responsible railway management thus ought to do its best to extend the use of such plants in railway operation.

At no distant time the electric interlocking system will be installed in every station yard of importance, and the control of train movements on lines with heavy traffic will be ensured by means of automatic apparatus.