

ever, is susceptible of some improvement. In my own opinion a slight increase in the intensity of the beam of light, together with the decrease in the cost, which would follow the manufacture of it in large quantities will make it a very desirable adjunct to any block or interlocking system.

There are very few railroads east of the Mississippi, north of the Ohio and south of a line at about the average latitude of the St. Lawrence River which could not very easily and with little additional expense establish block signals at their regular stations, maintaining a nearly constant distance between them of five or six miles; I refer now to a single-track. I believe I am not wrong in assuming that on ordinary railroads trains will average a speed of twenty miles an hour. At this speed and with block stations five miles apart an apparent traffic of 96 trains in 24 hours is accommodated—on the assumption, however, that there shall be no breakdowns, no stops, a constant speed of 20 miles per hour, and a passing siding at each block station. These conditions are of course impossible; for there will be breakdowns, must be stops for passengers, freight and so forth; but by taking one-half of 96—that is, 48—we are, I think, quite within the bounds of probability, and at the same time make quite a respectable showing for a perfectly safe train movement on a single-track road. Examine this proposition carefully, and you will see that with 24 trains each way a day, moving at the rate of 20 miles per hour, each block station 5 miles apart, there will be a distance of 20 miles between each two trains moving in the same direction. Please do not understand me as saying that under ordinary circumstances there must be a space of 20 miles between each two trains—for it is not so. They may be any distance apart, so that it is not less than 5 miles.

Again, suppose the block stations are only four miles apart, while the trains run at the same speed as before. The apparent traffic would then be equal to 120 trains a day. Taking one-half of this as possible, we should have an actual traffic of 60, that is, 30 trains each way a day, with an interval of 16 miles between each two trains moving in the same direction.

There seems to me nothing impossible in this arrangement, and, while my figures are necessarily of an empirical character, they prove how perfectly possible and positive a block system may be.

The number of trains which may be run on any piece of road every 24 hours is determined through the combination of so many different conditions, besides the length of blocks, that no rule can be depended upon. What I wish to insist on is the fact that absolute block- ing is just as necessary and quite as possible on small roads with a light traffic as on roads with a heavy train service. Many things tend to increase the capacity of a piece of track—frequent and overlapping passing sidings, isolated pieces of double track, etc.; and as the capacity of a railroad naturally grows with the demand made upon it, so must the block system.

The method I have been describing is of the most elementary character. It requires nothing but the telegraph operator, who would be needed at almost every station even if there were no block system, and a two arm semaphore post connected with the telegraph office by a piece of wire or chain.

With blocks averaging five miles in length, the first cost of materials need not be needed at almost every station exceed fifteen dollars per mile. The increased cost of operation would vary greatly over and above certain fixed charges, such as oil and waste for the signal lamps; it might easily be very little, and could not be very much. The most important item would be the additional operators required over and above those necessary for the ordinary work of the road. This would depend greatly on the ingenuity and care used in the locating of the block stations.

[Mr. Faine here described the Hall, the Union and the Westinghouse electro-pneumatic systems.]

I am not in a position to know what the exact cost of maintenance is of the electro-pneumatic. I have been told, however, by persons using the system that the signals should be properly maintained at an expense of about \$30 per block per year. This would include the fuel, oil and waste necessary for operating the compressors and filling and cleaning the lamps, as well as the pay of all men employed in inspecting, operating and maintaining the system.

Although the cost of a plant of this character is large at the start, the cost of maintenance is so slight in comparison with the cost of maintenance of a mechanical system that its advantage will be seen at once. On a certain railroad the system of pneumatic-automatic signals has been put in, embracing a section of road seven miles long, four main tracks, with the block signals about half a mile apart. A mechanical system of the same length, with the block stations the same distance apart, would have cost to erect as much as did the automatic pneumatic. The cost of operating the mechanical system for one year, however, including the pay of operators, 22 of whom would have been required, would have been equal to about three times the sum which it has cost to maintain and operate the automatic, and in four years from the date that the automatic system was put in service this saving will have much more than paid for it, without at all taking into consideration the entire immunity from collisions which has been procured. This proportionate gain increases rapidly as the length of road protected is increased.

To give another illustration, all the elements of cost of a 14-mile section of double-track road, with the blocks varying from 1,300 ft. to 2,650 ft. in length, have been estimated. To erect a mechanical system of the same size would have cost somewhat less than one-third as much. To maintain and operate the mechanical it would have cost four times as much as would the pneumatic, and the net yearly gain in favor of the pneumatic would have paid for it in the amazingly short time of two years.

#### Some Railroad Crossings at Chicago.

With the large number of eastern and western systems of railroads obtaining an entrance, one after the other, into the heart of the city of Chicago, there have been established many complicated systems of tracks, not only for main-line but for yard purposes. Each road, as it procures a right of way into one or the other of the half-dozen great passenger stations, is obliged at times not only to use the tracks of existing lines, but to cross and recross many opposing lines. The Alton and Burlington roads use the Ft. Wayne tracks, the former north of Grove street and the latter north of Sixteenth

street, the Chicago, St. Paul & Kansas City uses the Wisconsin Central or Chicago & Northern Pacific tracks for quite a distance out; the St. Charles Air Line is used by and jointly owned by the Northwestern, Burlington, Illinois Central and Michigan Central for transfer from the west side of the river over to the lake shore. The Chicago, Madison & Northern, which is a proprietary line of the Illinois Central, will use these tracks east of the Air Line crossing, and the Western Indiana brings into the Polk street station some half a dozen or more lines. So that now, besides being extremely hard to pick out any good way of getting in at all, when that way is found it proves to be enormously expensive. Notwithstanding the fact that there are several of these passenger stations it is rapidly becoming a problem in some cases how to handle the trains at certain hours of the day. When the handling of a heavy suburban service and the departure of through trains occur at the same hours of the day on several large roads running into a single station, the question of changing a time card is a rather serious affair.

For the transfer and shipment of freight, this subject of track facilities is one of very grave importance. The number of freight houses is legion, and they are located in all parts of the city. This is not only true of the roads in general, but with some allowance is true of individual roads. The Northwestern, for instance, has large freight depots in several quarters of the city. The effort to get at their respective depots by each of the roads, it will be readily seen, produces a complicated network of tracks which, as a whole, will give one abundant exercise for his ingenuity for the same time.

The worst tangle which we know is the one illustrated here, extending from one-half to one and a half miles south of some of the principal passenger stations. Some time ago there was a move on the part of several of the entering roads to attempt to better the condition of affairs in this section of the city, and Mr. E. L. Corthell undertook to bring about some concerted action among the different companies for overcoming a part of the difficulties existing at these three points. Most of the study has been done at the Stewart avenue crossing, and it is here that the immediate work is to be undertaken.

The tracks east of the Indiana elevator are to be changed by crowding the Western Indiana tracks over, and giving space for a sixth track where now there are but five. From a point where the Santa Fé and Chicago, Madison & Northern cross the Fort Wayne, a double line of slip switches is run across the Alton and into the Western Indiana tracks, enabling the Santa Fé to use their Indiana tracks for their passenger service, the three tracks southeast of the Chicago, Madison & Northern being used for freight only. The work for this portion is now being pushed by the Morden people, who are making 45 crossings and 65 switches with frogs, besides 21 slip switches and all of the cut lengths. Every piece is finished and marked at the shops, and when laid down on the ground the whole needs only to be bolted together. The changes at the Air Line crossing at Sixteenth street were made by this same frog and crossing company a little over two years ago. They put in 125 crossings at that point.

It was proposed to put in a double crossover between the Santa Fé and Chicago, Madison & Northern near Twenty-second street so as to give opportunity for using the two Chicago, Madison & Northern tracks crossing the Western Indiana as a double-track system. This would facilitate the movement of two trains of the same road going in opposite directions, but would not allow two trains of opposite roads to cross the Fort Wayne tracks in opposite directions, as there would be a fouling point both east and west of their north and south tracks. A westbound Chicago, Madison & Northern train would foul an eastbound Santa Fé train at a point east of the Fort Wayne tracks, and an eastbound Chicago, Madison & Northern train would foul a westbound Santa Fé train just west of the Western Indiana tracks. Any such arrangement of crossovers would necessitate moving back the derailing switch so far that it would not be sufficient protection for the main crossing. Thus there are two sides to the question, and, although there are disadvantages in being confined to a single track for a short distance, still it has been thought best by some to put up with this inconvenience rather than adopt the other plan.

The two Alton tracks sandwiched in between the others east of the Ft. Wayne are old freight tracks. It will be noticed also that the two main-line Alton tracks cross each other soon after leaving the Ft. Wayne on account of this latter road running trains on the right-hand track, whereas the Alton uses the left-hand track.

Mr. Corthell's scheme is to erect a pneumatic interlocking tower at each of these three systems of grade crossings, and to erect a power-house at some centrally located point so as to supply power to the three interlocking systems. All three towers are to be connected by a system of electric calls and signals, so that when an out-bound Pennsylvania train passes the Sixteenth and Canal street tower it will notify the man at Stewart avenue and Grove street. Likewise when an out-bound on the Santa Fé passes the Sixteenth and Clark street tower that tower will notify the Grove street tower. Thus Grove street, knowing that both trains are coming and must cross, can judge which should have the right of way, and set his switches accordingly.

Each tower will have a man in charge who will have complete control over all interlockings at his crossing,

the only connection between the several towers being for purposes of notification, as by telephone, bell calls or automatic sight warnings. There will be a superintendent over the whole, whose duty will be to see to the keeping up of all machinery and appliances about the plant.

The size of such an undertaking as advocated by Mr. Corthell can be realized when it is considered that the interlocking at Stewart avenue alone would require a tower of nearly two hundred levers; and in order to run these crossings, as may be allowed by the new law, it becomes very essential that the pneumatic systems should work perfectly in every respect; and also, to give the most efficient service, there will be required a quick, clear-headed man in charge at each tower. This is illustrated by the count made at the Air Line crossing about a year and a half ago, when it was found that there passed over this crossing 1,063 engines, 1,202 coaches and 4,825 freight cars in one day, showing that if the blocking of trains is to be reduced to a minimum it is necessary to have the right man at the levers.

The idea of interlocking is strenuously opposed by some of the roads which have had little or no experience with the more improved methods and which think the old style the safest and best; but as the traffic is yearly increasing and already demands heroic treatment it is to be hoped that some such scheme as the above may be carried out. Taking into account the fact that these several nests are already established and that it is out of the question to tear them out and make a fresh deal, it would seem that the proposed plan would meet the requirements of the greatest number with the smallest amount of alteration. Should the interlocking plant be put in at Stewart avenue and Grove street, the improvement of the train service would be so noticeable that we doubt not the roads now objecting to this triangular plan would be glad to swing into line and become as strong advocates of interlocking as any of the others.

This enterprise is being pushed by J. F. Wallace, who has been for so long associated in business with Mr. Corthell, and who at the beginning of this year received the appointment of Engineer of Construction of the Illinois Central Railroad. Very great and, in fact, extraordinary difficulties arise in carrying out the scheme, from the numerous and often conflicting interests of the roads. Even where their interests do not conflict, there is often a mutual distrust which makes any agreement hard to get and harder to keep.

#### Pipe Culverts on the "Plant" System.

BY W. B. W. HOWE, JR., CHIEF ENGINEER.

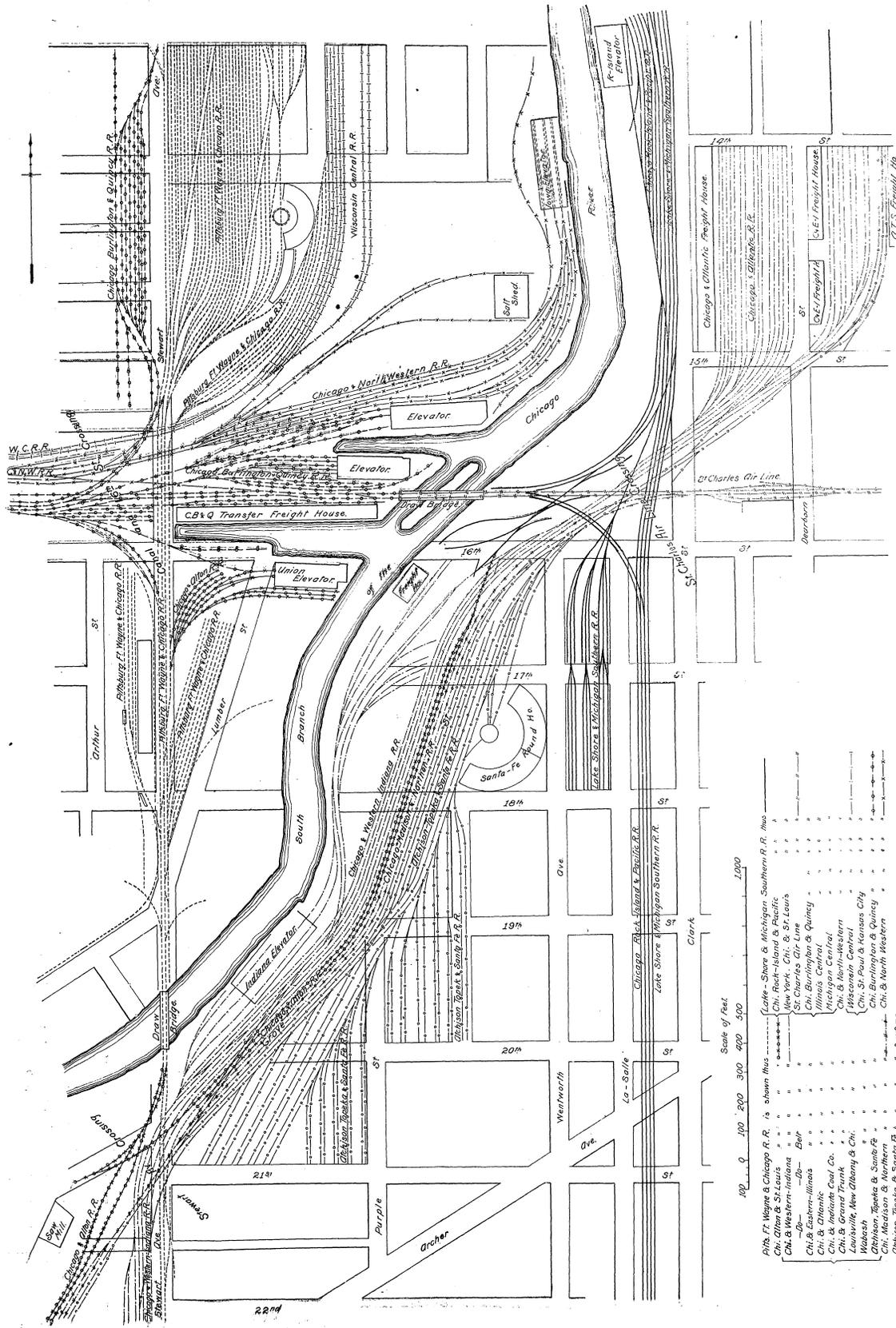
There is perhaps no one item in railroad construction and maintenance, which is of more importance in a small way than the proper treatment of the minor streams or drains, which must necessarily be crossed by the road bed, where perhaps, an area of two or three square feet, is all that is necessary to afford ample passage for the water. To provide for these, not simply in the sense of getting the track over them, but to dispose of them in such a manner that they will require little or no attention from those charged with the maintenance of the track, limits discussion to cases where permanent rather than temporary construction is recognized to be conducive to true economy.

The accompanying plans illustrate in a general way the standard practices of the Plant System, in the use of culvert pipe, which is employed in new construction wherever circumstances will permit, and will eventually replace the small trestles upon the older portions of the system. A short description of the conditions under which culverts of this character are found to be serviceable, and a few notes as to the proper methods to be employed in their construction, may be of interest.

A perfect road bed can best be obtained by preserving uniform bearing for the cross ties at all points. This idea has found expression in the practice of carrying the track ballast even over iron bridges, whose floors are specially designed with that end in view. There are cases it is true, in which this cannot be done, but where possible to adopt such a course, few will question the advantages to be derived from it. The difficulty of maintaining uniform conditions of line and surface, and of securing a smooth and easy-riding track, in the rapid transition from a well-ballasted bed to a rigid bridge floor, and *vice versa*, can only be fully appreciated by those whose duty it is to attain these results.

Where a stream is of sufficient importance to warrant the expenditure of a considerable amount for a masonry arch or iron bridge, the matter is usually placed beyond the everyday care of the section men, but the petty openings are disposed of too frequently in a temporary manner involving constant expenditure for maintenance, absorbing a portion of the time that should be expended upon the track, and destroying that uniformity in the condition of the road bed, to which reference has just been made. The use of culvert pipe offers a comparatively cheap method of providing for such cases, in a permanent and thoroughly satisfactory manner, subject, however, to two limitations, the height of the bank, or the depth at which the pipe can be placed below the track, and the total area of water-way required.

There should always be sufficient earth interposed between the top of the pipe and the cross ties, to afford a good cushion. One and a half diameters of the pipe should be the minimum in good practice, although in special cases, one diameter may answer, there is no



SKETCH MAP SHOWING SOME OF THE RAILROAD CROSSINGS IN CHICAGO.