A. C. Signaling for Chicago Terminals

Changes that Would Be Made Necessary by the Largest Electrification Project Ever Proposed

The electrification of the steam road terminals in the city of Chicago has been vigorously advocated for a number of years. In order to determine the feasibility and practicability of such electrification, the Chicago Association of Commerce appointed a committee early in 1911 to undertake the most complete investigation of the subject ever made. The body, known as the Committee of Investigation on Smoke Abatement and Electrification of Railway Terminals, has expended $600,000, contributed by the roads interested in this study, and has recently published its report in a 1,200-page volume, comprising a thorough treatise on the subject. The report draws the conclusion that only five per cent of the smoke of the city could be eliminated by electrification, which would cost at a minimum $178,127,230, and would result in a minimum net annual operating deficit of $14,609,743. It is therefore concluded that while electrification is technically practical, it is financially impractical.

EXISTING FACILITIES TO BE CHANGED

The committee made a very thorough study of the existing facilities within the terminal area bounded by the heavy line in the accompanying map, and one chapter of the report is devoted to a discussion of the feasibility of adapting these facilities to electric operation and the cost of making the changes. It is shown, for instance, that in this area of 428.3 sq. mi., 38 steam roads operate a track mileage of 4,502, on which are located 131 interlocking plants and 1,195 automatic signals. The grade crossing statistics show that there are within this district 199 crossings of steam roads, 206 crossings with electric railways, 1,442 with public streets, 15 with public footways, 286 with private team ways, and 9 with private footways, a total of 2,157. Of the 199 railroad crossings, 122 are protected by interlocking, 8 by gates and 27 by flagmen. Of the 206 electric railway crossings, 19 are protected by interlockings, 72 by gates and 33 by flagmen. Of the 1,442 highway crossings, 350 are protected by gates, 262 by flagmen, 32 by automatic bells and 390 by crossing signs.

The statistics covering signals and interlockings show that within the city limits there are 88 interlocking plants and in the entire area of investigation, 131 plants, controlling 3,903 switches and 3,276 signals. There are also within these limits the equivalent of 800 miles of single main track protected by automatic signals. The 879 automatic signals used on these lines include 553 semaphores and 326 discs. The largest interlocking plant within the district is the electric plant of the Chicago & North Western, at Lake street, which has 212 levers, of which 171 are working. The largest mechanical plant is that of the Chicago & Western Indiana, at the Illinois-Indiana state line, with 186 levers.

COST OF CHANGING SIGNAL SYSTEMS

In estimating the cost of changing existing facilities for electric operation, it was assumed that all facilities would be replaced in kind. While it is probable that a road having signals which are old, or unsatisfactorily located, would object to the reconstruction of its old system on the ground that it would be better policy to provide an entirely new installation, such an installation would, however, constitute a material betterment in an existing facility and that portion of the cost in excess of the cost of making the necessary changes in existing signals is not regarded as a proper charge against electrification.

In practically all cases the existing signal bridges could be adapted to the requirements of supporting structures for the overhead contact system by raising the cross spans to the proper elevation. No provision has been made in the estimate of the cost of alteration of signals to cover such work, this being included in the cost of the structures for the contact system.

In addition to the physical change in bridges and other structures supporting signals, which would be made necessary by clearance requirements, in the case of electrification, certain functional changes in all signals controlled by track circuits would be necessary in order to eliminate interference with the return propulsion current. The traffic to be handled electrically would be very heavy, making the traction current correspondingly large, so without doubt both rails would be required for the return circuit. This would, therefore, involve the use of impedance bonds in the track circuits.

While the changes in track circuits are the only ones considered imperative in the committee's report, it also discusses changes, termed optional, which would affect the economy of installation and operation. The estimates of cost presented in the report do not include such changes. For example, if an alternating current signal line were installed for the operation of track circuits, it would undoubtedly be economical to operate all of the functions from this power line, but in the committee's report it has been assumed that where batteries are now in service for the operation of direct current signal and switch mechanisms, these would be retained.

The estimates of cost are based on 1912 standards, allowance being made, in the form of a percentage added to the total figures, for the growth in facilities since that time. Two complete estimates were prepared, one assuming that a 2,400-volt d. c. overhead-contact system would be adopted, and the other that an 11,000-volt a. c. overhead-contact system would be preferred. The unit costs for changes to the signal system, as determined by the committee, are as follows:

	2,400-volt d.c.	11,000-volt a.c.
Track circuits	$ 1,400	$ 1,200
Switches within track circuit limits	400	300
Signal transmission line, per mile of duplicate circuits	950	950
Signal power substations, without buildings	11,000	11,000
Signal power substations, with buildings	15,000	15,000
Crossing bells with track circuits	550	550
Additions to interlocking plants for each additional lever	1,000	1,000

The number of existing units on each road was then determined, and these unit costs applied to them, to determine the total figure for each of the two control systems. The total number of units under each of the foregoing heads was found to be as follows: Track circuits, 2,073; switches within track-circuit limits, 896; signal transmission line, 343.1 mi.; signal power substations, 17; crossing bells with track circuits, 15; additions to interlocking plants, 158. The total cost of the changes for the 2,400-volt d. c. system is $3,995,795, and for the 11,000-volt a. c. system, $3,491,595. In determining the amount by which these figures should be increased to cover growth up to December 31, 1916, it was recognized that there was no logical basis for calculating this figure. It was shown that the total mileage of track will increase three per cent each year. On the assumption that the signal mileage will increase more rapidly than the track mileage, it was decided to fix this increase at 5 per cent. When applied to the four years, this makes an increase of 20 per cent. An additional increase of 20 per cent is allowed for contingencies, 10 per cent for engineering design, supervision and administration and 10.5 per cent for interest, insurance and taxes during construction at 1.75 per cent per annum for 6 years, December 31, 1916, to December 31, 1922. The total cost, including these items, is $6,993,919 for the 2,400-volt d. c. system, and $6,111,407 for the 11,000-volt a. c. system.

In addition to the two overhead-contact systems mentioned above, the report also considers the possibility of using the 600-volt alternating current third-rail system. Complete estimates of the cost of applying this system to the Chicago & North Western were made, and this cost was extended to cover the entire system by using the same ratios between the systems as were found to exist for that one road. The necessary changes in the signal system for the 600-volt, third-rail system would be practically the same as for the 2,400-volt overhead-contact system. But in addition it will be necessary to provide support for the signal transmission line circuit. The unit costs for the several items on the basis of 1912 are as follows:

	600-volt d.c.	2,400-volt d.c.	11,000-volt a.c.
Track circuits	$ 1,400	$ 1,400	$ 1,200
Switches within track circuit limits	400	400	300
Transmission line, per mile of duplicate circuit	1,670	950	950
Signal power substations, without buildings	11,000	11,000	11,000
Signal power substations, with buildings	15,000	15,000	15,000

Applying these unit costs to the number of units found on the Chicago & North Western, the total cost of the 600-volt system on this road was found to be $1,262,647, of the 2,400-volt system, $1,202,095, and of the 11,000-volt a. c. system, $1,033,195. The cost of these changes in the signal system of the Chicago & North Western on the basis of the requirements of 1922, would be as follows: 600-volt direct current, $2,210,036; 2,400-volt direct current, $2,104,051; 11,-

Chicago Terminal District Covered in Electrification Report. Location of Interlocking Plants Shown by Small Black Squares.

000-volt, alternating current, $1,808,422. The total net cost of the electrification of all roads in the city under the three systems would be as follows: 600-volt d. c., $188,132,314; 2,400-volt d. c., $181,891,122; 11,000-volt a. c., $178,127,230.

CHANGES IN COST OF MAINTENANCE AND OPERATION

Under the discussion of the effect of electrification on operating expenses, the committee's report takes up the various Interstate Commerce Commission accounts, item by item, and discusses the effect of electrification. Under account No. 13, of Maintenance of Way and Structures, which covers signals and interlocking plants, the committee states that data are not available from which the final net effect of the necessary changes in apparatus upon the operating and maintenance expenses of the signal installations can be determined, but from present knowledge and information, the effects of the changes are analyzed. The maintenance of track circuits would not be affected by the character of the current flowing in them, but the maintenance of certain portions of the controlling apparatus connected with the track circuit would be subject to change, owing to the requirements of additional apparatus for the alternating current circuit, which apparatus is not needed in direct current circuits. The omission of the track circuit battery would also have some effect. The impedance bonds and track transformers are additional apparatus, but both of these pieces of apparatus are durable and require only occasional inspection, repairs and renewals.

The additional maintenance expense for the added track circuit apparatus is estimated as follows: 600-volt and 2,400-volt, d. c. system, $12 per circuit mile per year; 11,000-volt alternating current system, $9 per circuit mile per year. It is assumed that the change from direct current to alternating current relays will not involve a change in maintenance expense. The maintenance of the battery, which will be displaced, is estimated at $1 per month per circuit, or $12 per year. This may be regarded as a credit, which, in the case of the direct-current systems, will offset the increased maintenance charge. In the case of the alternating current system, the credit of $12 more than offsets the additional charge of $9, leaving a credit of $3 per circuit mile per year.

The introduction of a transmission system for the track circuit current involves an added maintenance expense which is assumed to be equal to that involved in the maintenance of the high-tension transmission power line. Upon this basis the annual maintenance expense for the transmission system for track circuit current would be $40 per mile for the 600-volt direct current third-rail system, and $25 per mile for the 2,400-volt direct current, or the 11,000-volt alternating current system. The difference between the maintenance expense for the third-rail system and the overhead system is due to the necessity of including in the former the expense of maintaining a pole line, which, with the other two systems, is supplied by the supporting structures for the overhead contact.

As it is assumed that primary batteries now in service for operating signals and switches will be retained, the maintenance of these batteries will not be affected by the change in tractive power. Alternating current power from a steam power plant is, of course, much cheaper than direct current power produced by batteries, and for this reason a net saving in the cost of power would result from a change in systems were it not for the fact that alternating current track circuits require more energy than direct current circuits.

The maintenance and operating expenses of the signal power substations is dependent largely upon the local conditions in each installation. In cases in which the signal power substations may be located in buildings provided for traction power substations, or in or near other buildings where attendance is provided for other purposes, the added operating expense would not be great, but where separate plants are required for the signal power substations, the increase resulting would be appreciable. A detailed study was made of local conditions in the terminals with reference to this subject, and it is estimated that the expense of operation and maintenance of the signal power substations within the proposed limits of electrification would amount annually to 7 per cent of the installation cost. By the 2,400-volt direct current or the 11,000-volt alternating current system, a total of 17 signal power substations would be required, three of which would cost $11,000 each, and 14, $15,000 each, the average unit cost being $14,294. On this basis the annual expense for substations would be $1,000.

The application of the unit values discussed in the foregoing analysis to the total quantities involved within the electrification zone shows an estimated increase in account No. 13, Signals and Interlocking Plants, of $25,578 for the 2,400-volt d. c. system, and $25,548 for the 11,000-volt a. c. system. Reports furnished by the railroads indicate that the expense of operating and maintaining the signal systems of all roads within the proposed limits during the year 1912 amounted to $405,512. By adding to this amount the estimated increases incident to electric operation, the cost on the basis of a 2,400-volt d. c. system would be $431,090 and with the $11,000-volt a. c. system, $430,060.

Under account No. 90, Interlockers and Block and Other Signals, Operation, it is stated that the proposed change from steam to electric operation would involve no change in the number of operators or employees needed in connection with the operation of interlockers and signals. Therefore, no change in the expenditures chargeable to this account would result from the introduction of electric operation.

IMPROVING LAMP MAINTENANCE

A new set of general instructions for the cleaning, care and use of lamps has recently been prepared by the Great Northern and has been printed on rope tag cardboard, 12 in. by 18 in. in size, for distribution over the company's lines. The cards are to be posted on bulletin boards and in stations, powerhouses, signal towers, caboose cars, storehouses, shops and wherever lamps are repaired.

The upper portion of the card shows a side and front view of each of the ten lamps which are standard on this line, and below this are drawings of the detail parts of the lamp, such as founts, chimneys and burners. These drawings, with the list of standard fittings for each lamp, are reproduced in the accompanying illustration.

The following rules appear at the bottom of the card:

1. The lamps shown in the diagrams above are designed to burn kerosene oil, and must in each case be used for the particular service intended.
2. Lights wherever required must be used from sunset to sunrise, and whenever the signal indications cannot be clearly seen without them. Lamps must be kept in the best condition possible.
3. Lenses must not be removed from lamps for the purpose of cleaning them. If they cannot be wiped clean with waste or a piece of cotton cloth, they must be washed in the lamp with hot water and soap.
4. All lamps and lenses must be kept thoroughly clean inside and outside. All soot and dirt must be removed from perforated cone and collar used in ventilator openings.
5. Lamp wicks should not be trimmed with shears, but the charred portion should be broken off with the finger or with a stick, the wick being turned down so that only the charred portion is exposed above the wick tube. Should the wick fray out at the edges during this operation it can be slightly trimmed off with shears.
6. In filling lamp founts a space not less than one-quarter of an inch at the top of the fount should be left unfilled. This will give room for expansion of the oil as it becomes heated, and will prevent the flooding of the flame and possible explosion or burning out of the lamp.
7. When a lamp is first lighted the flame should be turned up to about one-half of the height required to give the full light and be allowed to burn ten minutes so that all parts become thoroughly warm, after which the flame must be adjusted to height which gives the best light.
8. Burners that have become gummed-up should be boiled in lye water for a few minutes. This will make the burners as good as new.
9. Lamps fitted with long-time burners are allowed to burn continuously day and night.
10. Lamps fitted with one-day burners must be taken down, cleaned and returned to proper place daily.
11. Long-time burners must be fitted with chimneys. Chimneys should be cleaned with waste or paper and should not be washed.
12. One-day burner founts, buners and wicks must be used in lamps Nos. 3, 6, 7, 8 and 10.
13. Long-time burner founts, burners and wicks must be used in lamps Nos. 4, 5, 9 and also in old standard switch lamps.