PROPOSED CENTRALIZED TRAFFIC CONTROL ON THE BOSTON AND MAINE

(A Study of the Feasibility of a Centralized Traffic Control System on the Boston and Maine Railroad Between Springfield and Greenfield, Massachusetts.)

by

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Submitted in Partial Fulfillment

of the Requirements for the

Degree of Bachelor of Science

at the

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May, 1958

Signature of Author . . . . . Signature redacted . . . . . .
Department of Civil and Sanitary Engineering
May 26, 1958

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in Charge of Research . . . . . Signature redacted . . . . . .

ABSTRACT

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Arthur Tilden Prentiss III

Submitted for the degree of Bachelor of Science
in the
Department of Civil and Sanitary Engineering
on May 26, 1958

The object of this thesis is to determine the feasibility of installing a Centralized Traffic Control System on the Boston and Maine Railroad's Connecticut River Main Line between Springfield and Greenfield, Massachusetts.

Examination of the physical plant and train operations was made, and a layout was proposed for a CTC installation with single track and selected passing sidings for that section of the line between Holyoke and Greenfield. This layout was checked by means of a time-spacing analysis and a redispatch of existing trains, and a detailed economic analysis was made.

A saving of $150,429 and an annual saving of nearly $9,000 could be realized through this project, but further study is advised because of decreasing passenger service.

Cambridge 39
Massachusetts
May 26, 1958

Professor Leicester F. Hamilton
Secretary of the Faculty
Massachusetts Institute of Technology
Cambridge 39, Massachusetts

Dear Professor Hamilton:

In accordance with the requirements for the degree of Bachelor of Science, I herewith present this thesis entitled "Proposed Centralized Traffic Control on the Boston and Maine."

Respectfully yours,

Signature redacted

Arthur Tilden Prentiss III

ACKNOWLEDGMENTS

I should like to express my appreciation to the several gentlemen who have helped to make this project meaningful and worthwhile by generously donating their time and assistance. Particularly, I should like to mention Professor A. Scheffer Lang of the Civil Engineering Department at the Massachusetts Institute of Technology; Mr. William Hartzell, Engineer of Signals and Communications for the Boston and Maine Railroad; and Mr. Charles P. O'Connell, Signal Supervisor for the Railroad at Greenfield, Massachusetts.

In addition to the assistance rendered me by the last two gentlemen, the reception which I have received from the Boston and Maine personnel has been most gratifying.

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SUMMARY

The object of this study is to determine the feasibility of installing a Centralized Traffic Control System on the Boston and Maine Railroad's Connecticut River Main Line between Springfield and Greenfield, Massachusetts.

After examining the train operations on this line with the aid of a graphic train chart, a preliminary CTC layout has been made. As a result of brief economic study and operational examination, certain elements of this preliminary design have been retained or eliminated as necessary. The final proposed layout has been discussed in some detail from the point of view of train operations, and a detailed economic analysis has also been made. Train operations have been studied by means of a time-spacing analysis, as well as by a redispatch of existing trains.

Although a capital saving of $150,429 plus a decrease in annual operating expenses of approximately $9,000 would be realized, it is pointed out in a final section that, under the present conditions of decreasing passenger train operations, a comparative study of alternate systems of operations might be wise before this CTC System is installed.

INTRODUCTION

CENTRALIZED TRAFFIC CONTROL (CTC)--A BRIEF DESCRIPTION

The Boston and Maine Railroad Rule Book defines a Centralized Traffic Control System as: "A system of railroad operation by means of which the movement of trains and engines over routes and through blocks on a designated section of track or tracks is directed by signals controlled from a designated point without requiring the use of train orders and without superiority of trains." Thus, in effect, a CTC System consists of a series of remotely controlled interlockings separated by automatic block signal territory. These interlockings are at turnouts to passing sidings or crossovers from one track to another in multiple-track territory. Controlled signals direct train movements through these interlockings and into the automatic block territory.

CTC has been successfully applied to single-, double-, and multiple-track lines with substantial savings.[1] Because of the control the CTC operator has over train movements, unusual circumstances may be dealt with more readily than with other systems of operation, thus minimizing train delay. CTC

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[1] A pertinent example of the savings realized through a recent CTC project is described in an article, "One Track Does Work of Two on Maine Central," which appeared in Railway Signaling and Communication for January, 1958.

has allowed the removal of one track in multiple-track areas, eliminating maintenance costs on trackage as well as on bridges, etc. In addition to the decrease in annual maintenance costs, savings may be realized through the elimination of large-scale reballasting and rail replacement projects on the track removed. Furthermore, certain train-order operators and switch tenders who have no additional duties may no longer be needed.

OBJECT OF THE STUDY

The Connecticut River Line of the Boston and Maine Railroad is a connecting link between New York City and the State of Connecticut to the south and the White Mountains, Green Mountains, Montreal, and Quebec to the north. From Springfield, where it meets the New Haven and Boston & Albany Railroads, the line runs north through the industrial areas of Chicopee and Holyoke and then follows the Connecticut River through Northampton and Deerfield to Greenfield, where it joins the Boston and Maine's Fitchburg Main Line between Boston and Mechanicville, New York. From Greenfield the Connecticut River Line continues northward to Brattleboro, Bellows Falls, and White River Junction, Vermont, at which point connections are made with the Central Vermont Railway to Canada and the Boston and Maine's line from Boston to Wells River, Vermont, and Berlin, New Hampshire.

Present operations on the Connecticut River Line suggest that a Centralized Traffic Control System may be feasible. The author has undertaken to investigate the train operations and physical plant on that part of the line between Springfield and Greenfield, Massachusetts, to determine if the installation of CTC would result in savings to the railroad.

EXISTING PLANT

The main line between Springfield and Greenfield is double-tracked throughout its 36.07-mile length. A large percentage of the line is on tangent track, but there are three sharp curves at Holyoke where speed restrictions are necessary. Grades are very light with a maximum of 0.76% northward at Riverside. The average grade is less than 0.30%. In general, the track is gravel ballasted, which keeps speed limits lower than desirable (50 mph maximum for First-Class Trains and 35 mph for freight). Recently, however, the railroad stone ballasted the northbound track from Northampton to Greenfield as the first step of a program to stone ballast the entire line. Some 15 miles of 85-lb. rail on each track between Holyoke and Greenfield must eventually be replaced with 100-lb. rail to bring this line up to standard.

At Springfield, the Boston and Maine uses the Boston & Albany passenger station and tracks for about 2,000 ft. between

the station and the W A Tower interlocking. For a mile and a half northward, there are yards on both sides of the track in which through-freights begin or end their run. Chicopee and Holyoke are heavily industrialized, and at the latter there is a yard west of the main line. From Holyoke to Northampton the main line is unobstructed by switches with the exception of a turnout to the Easthampton Branch at Mount Tom and a few scattered sidings between there and the Northampton station. At the Northampton station there is an 1,850-ft. track east of and parallel to the main line, where mail and express cars are stored. North of the station there are yards west of the main tracks. Mid-way through the yard there is an automatic interlocking with a double cross-over to allow trains to enter the Wheelwright Branch to the east from the main line and the yards. The Wheelwright Branch is a freight line only.

From Northampton to Deerfield Junction, there are ten industrial sidings, five of which are near the South Deerfield station. Deerfield Junction is a remotely controlled interlocking with a single crossover operated by train directors at East Deerfield. This interlocking allows movement to and from the East Deerfield Branch, which runs eastward to the East Deerfield yards and the Fitchburg Main Line to Boston. This arrangement is also used as a large wye between the Connecticut River and Fitchburg Main Lines.

Present signal circuits for the Connecticut River Line south of Greenfield end at Deerfield Junction. Between here and Greenfield station there are several yard tracks and a sixty-eight car siding east of the main tracks which ends just north of the station. A remotely controlled interlocking connects the Connecticut River Line and the Fitchburg Main Line, which passes under it and runs adjacent to it on the west for 2,000 ft. south of the station. This interlocking is operated by the train dispatcher in charge of the CTC System for the Fitchburg Main Line west of Greenfield.

CURRENT OPERATIONS

On the basis of the timetables in Appendix A, traffic between Springfield and Greenfield might be summarized as follows:

Monday Through Friday

First-Class Trains	Through Freight Trains
10 Northbound	3 Northbound
11 Southbound	3 Southbound

There is a local freight, E 4, from East Deerfield via Deerfield Junction to Easthampton via the Easthampton Branch and return and a local freight, H 2, which crosses the main line at the interlocking for the Wheelwright Branch.

Saturday

First-Class Trains	Through Freight Trains
9 Northbound	1 Northbound
11 Southbound	3 Southbound

Sundays

First-Class Trains	Through Freight Trains
8 Northbound	3 Northbound
7 Southbound	1 Southbound

Actual train times vary from the schedules so that some additional explanation of operations is necessary. Five First-Class Trains in each direction, as noted, run between Springfield and White River Junction. Some of these "through" trains connect with the Central Vermont Railway to Canada and the New Haven to New York and Washington; therefore, the chance of small cumulative delay is present. Trains Nos. 90, 92, 95, and 99 are mail and express trains and their schedules are not closely followed during heavy seasons such as Christmas. Their timetable schedules are just a reasonable approximation of their "average" times. Other First-Class Trains are local between Springfield and Greenfield and usually operate on time. With three railroads meeting at the Springfield passenger terminal, delays of up to five minutes may be encountered in going to and from the Boston and Maine's own tracks, but these are unpredictable.

Through freight schedules are not binding and on this particular line trains are often fifteen minutes to half an hour late leaving Springfield, and occasionally up to two or three hours late arriving. In general, Sundays and Mondays are light days and freights arrive early. The average north-

bound freight has seventy cars; southbound, ninety-five. J-S 2, however, often has up to a hundred and sixty or more cars. Local freight, E 4, which does the only local work on the line north of Holyoke, averages fifteen cars daily in each direction.

In addition to these scheduled freight trains, switchers operate at Springfield, Chicopee, Holyoke, and Greenfield and on the branches to Chicopee Falls and from Holyoke to Westover Air Base. These include three day-switchers and two freight-switchers in the afternoon and night at Springfield, one 16-hour switcher at Chicopee, two day-switchers and one second-trick switcher at Holyoke, and one round-the-clock switcher at Greenfield. These switchers work from the main line, but a detailed analysis of their specific operations is not within the scope of this investigation.

The freight-train schedules in Appendix A show the stops made by each train. Northbound freights enter the main line in Springfield at a turnout from the east yards at MP 1.68. Southbound freights use the so called "Brewery Track" into the west yards from a turnout at MP 2.58. At Chicopee, Holyoke, and Northampton a train is left standing on the main line while the engine does its switching. At Holyoke cars are picked up and set out in the yard west of the main tracks. As many as forty fuel cars for the Westover Air Force Base, in addition to other cars, may be dropped at Holyoke by south-

bound freights or picked up by northbound freights. Switching at Holyoke takes about fifteen minutes.

At Northampton cars are sometimes set out or picked up on the siding near the station, a five-minute operation. Usually, however, switching is done in the yards using the interlocking at the Wheelwright Branch in which case the train is stopped for fifteen minutes. At Deerfield Junction--Greenfield, southbound freights stop at Deerfield Junction where cars have been left on the East Deerfield Branch by a switcher. The road engine takes these and drops its East Deerfield cars there. Northbound trains generally pull into the station either holding the main line or using the sixty-eight car siding. Northbound cars are left in the yards for these trains by a switcher.

Local E 4 enters the line at Deerfield Junction and does local switching to Mount Tom and on the Easthampton Branch. It stops frequently at Deerfield and South Deerfield, the only places north of Northampton where it can clear the main line. At Northampton it works in the yards for a long period. H 2 makes up in the Northampton yard and crosses the main line to the Wheelwright Branch by the automatic interlocking, returning later in the day.

Present operations on this line are conducted by train orders supplemented by an automatic block signal system. There are train-order offices open continuously at Springfield,

W A Tower, and at Greenfield, where the Connecticut River Dispatcher is located. Intermediate offices at Holyoke and South Deerfield are open during the day only and the operators are also station and freight agents. The operator at the W A Tower also works the manual interlocking governing movements between the Boston and Maine tracks and the Boston & Albany and New Haven Railroads. There is a good possibility of eliminating this interlocking as part of a CTC project in the area, thereby eliminating the jobs of the three regular and two relief towermen. The complex movements handled at this tower make a worthwhile study of this proposal beyond the scope of the present thesis.

Predictions by railroad personnel are that freight operations between Springfield and Greenfield will remain constant while the number of passenger trains is expected to decrease greatly. A recent petition to the Massachusetts Department of Public Utilities to eliminate certain trains has met with considerable approval. These changes will be made soon and are considered to be the first step in a gradual elimination of a large portion of the passenger service.

PROCEDURE

Once the problem and general objectives had been defined, a solution was undertaken similar to that used generally in this type of study.[1] The author first rode over the line in a motor car and then supplemented his observations of plant and operations in discussions with operating personnel.

The next step was to prepare a graphic train chart showing actual train performance for a typical weekday. (see Appendix C) This meant that rather than using timetable times the recorded OS times were taken into consideration. However, the dispatcher's train sheets were available for only one month, and a change of schedule had taken effect shortly before the author examined these sheets. Since there are only two intermediate train-order offices, neither of which is open continuously, the available OS reports were limited in number. Therefore, the times shown on the graphic chart are at best only reasonable approximations of actual operations based on the information and advice the author was able to obtain. Furthermore, freight train operations are so variable that times shown in some cases are averages of widely differing times.

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[1] A comprehensive discussion of this method is found in Chapter III of American Railway Signaling Principles and Practices entitled "Principles and Economics of Signaling," published by the Signal Section of the Association of American Railroads.

With this chart, it was possible to observe the patterns of train meets that take place. Coupling this with the information of freight operation and general physical conditions, a tentative layout for CTC operation has been made as discussed in the next section. This proposed system was then studied to determine:

1. If it is consistent with good operating policy
2. If it is economically feasible

This two-fold investigation is necessary in considering any new system or changes in an existing system. The first step may be accomplished through a time-spacing analysis of the passing siding arrangement to determine the theoretical capacity of the proposed system. A redispatch of trains will then show how operations may be adapted to the new layout. In this case, however, it became apparent from a brief economic study that the comparatively high installation cost of CTC between Springfield and Holyoke makes it advisable to consider only that portion of the line between Holyoke and Greenfield. For this reason, a detailed operational analysis was not undertaken for the entire line. The necessity of a siding at South Deerfield is also somewhat questionable but will be discussed later in this study.

After investigating the tentative layout, a final layout was proposed incorporating those features of the original system that preliminary study had shown might be operationally and

economically justified. A time-spacing analysis of the passing siding arrangement and a redispatch of trains on the graphic train chart for this final proposal do show that it is operationally sound; so a detailed economic study of it has been made.

PRELIMINARY LAYOUT FOR A CTC INSTALLATION

GENERAL

After studying the train chart and considering operating factors, a tentative single-track layout with controlled passing sidings has been made. A discussion of some general factors will precede a description of the specific installation contemplated.

Siding lengths have been determined on the basis of a 175-car freight train of 47-ft. cars on the recommendation of the Boston and Maine Operating Department. This gives a minimum passing siding length of 9,195 ft. as shown in Appendix C. No attempt has been made to determine the specific "margin for non-stop meets," but an increase in the minimum desired length to 11,000 has been made to provide some margin. This should be sufficient inasmuch as freight trains do not often reach 175 cars in length, nor will meets between freight trains be frequent. Furthermore, the sidings at Holyoke, Northampton, and Deerfield Junction--Greenfield are located where freight trains must stop to do work, and running meets are not probable there.

With CTC, electric switch locks must be placed on all turnouts to sidings where trains can clear the main line as well as to parallel sidings with turnouts at both ends. This is necessary to prevent trains or engines from entering the

main line without authorization. On all crossovers, bolt locks must be provided for the switch at the end of the crossover not on the main track. Telephones must be placed at all controlled signals and turnouts and near all electric switch locks. In some cases where the need for electric locks is questionable, permission may be obtained from the I.C.C. to eliminate them.

Between controlled sidings an automatic block system with color light signals will be used on single track, and an average block of two miles is recommended by the railroad. All signal arrangements have been approved by the Boston and Maine Signal Department.

The CTC control machine will be placed in the dispatcher's office at Greenfield and operated by the dispatcher already there. There is a possibility that in the future, a single dispatcher at Greenfield will be able to operate CTC for the Connecticut River and Fitchburg Main Lines.

Details of the tentative layout follow:

SPRINGFIELD TO W A TOWER

The present arrangement between Springfield station and the Boston and Maine tracks at the W A Tower will be maintained and CTC will begin at the W A Tower interlocking.

W A TOWER TO HOLYOKE

This section of the line will remain double-tracked; how-

ever, the southbound track only will be signaled and used as the running track in both directions. The northbound track will be kept for use by switchers and can be used by regular trains if necessary.

BREWERY INTERLOCKING

To facilitate the movement of freight trains to and from the main line, a remotely-controlled interlocking will be established at the present turnout to the "Brewery Track" at MP 2.58. This installation will include a power turnout to replace the present turnout and a new spring switch turnout to accommodate northbound freights, which will proceed from the yards on the old northbound main track to that point. Signals at this interlocking will be placed to clear the road crossing 500 ft. to the south.

HOLYOKE SIDING

The Holyoke passing siding will include two interlockings with 11,250 ft. of the old northbound track as the siding. Although the northbound is designated as the siding, it will be maintained for relatively high speeds, as the passenger station is east of the main line and freights should remain on the main line to use the yards to the west. The southern interlocking at Willimansett, MP 6.48, will have a No. 20 power turnout while the northern interlocking at MP 8.64 will

have a No. 15 power turnout. This siding is long enough to allow large freight trains to stop at Holyoke without fouling the main line north of the interlocking.

HOLYOKE TO NORTHAMPTON

Between the Holyoke and Northampton sidings the southbound track will remain as suggested by the railroad. The northbound will be retired for 8.20 miles and the turnout to the Easthampton Branch will be equipped with a switch lock.

NORTHAMPTON SIDING

A 13,800-ft. passing siding will be left at Northampton. South of the station at MP 16.84 there will be a remotely controlled interlocking with a No. 20 power turnout. At this point, the main line will shift to the northbound track and the southbound will be considered the siding. The siding will end at MP 19.50 at another No. 20 power turnout. The extra length of this siding will permit 175-car freights to work in the yards and break their trains, if necessary, at the road crossing just north of the yards. Freights can also keep clear of the passenger station west of the tracks at the south end of the siding. At the present automatic interlocking, one crossover will be eliminated and the interlocking signals retired, as CTC will make them unnecessary. This will leave one crossover, which is sufficient.

NORTHAMPTON TO WHATELY

The old northbound track will remain and the southbound will be retired for 6.65 miles, as the northbound here is now stone ballasted.

SOUTH DEERFIELD SIDING

A 9,600-ft. passing siding will be left between Whately and South Deerfield because of meets occurring in this area. At Whately, MP 26.15, and at South Deerfield, MP 28.00, there will be interlockings with No. 15 power turnouts. Although this siding is less than the desired 11,000 ft., it has been placed to clear a major highway crossing at each end and is still larger than the 9,195 ft. minimum. North of this passing siding at South Deerfield an additional 3,300 ft. of the southbound track will be retained to serve as an industrial siding where local freight E 4 can clear both the main line and the passing siding and do its switching at South Deerfield. The smaller siding will have a No. 15 hand-thrown turnout at the south end where it leaves the passing siding, but a smaller turnout will suffice at the north end where it leaves the main line.

SOUTH DEERFIELD TO DEERFIELD JUNCTION

Here again the northbound track will be kept and 5.44 miles of southbound track will be retired.

DEERFIELD JUNCTION -- GREENFIELD

A No. 20 equilateral power turnout will be installed at MP 34.16, the end of double track. This equilateral will allow trains to maintain normal speed. It will be placed clear of the road crossing and will permit forty-three cars to be placed between there and the modified Deerfield Junction interlocking. The power switch to the East Deerfield Branch from the northbound track will remain, but the crossover between the two main line tracks will now be equipped with hand-thrown switches. Signaling will be changed as necessary and the entire interlocking will become part of the new CTC System. This arrangement will allow non-stop movement from single track to the East Deerfield Branch via the old northbound track and will be adequate. It eliminates the need for a new signal bridge should power switches be kept on the crossover. This will be the last interlocking on the new CTC board, although it is possible that CTC could be extended north of Greenfield in the future.

Between the end of double track and the Greenfield station area, 10,250 ft. of double track will be signaled for two-way main line operation. The interlocking at the Fitchburg Main Line will remain unchanged except for minor signal modifications to accommodate the double-running main line. Provision must be made to connect the two main line tracks north of Greenfield, and the best way to do this is

probably to make the gantlet track north of Greenfield station a single track with a power turnout at the south end and a spring switch on the north end. The signals now in place for the gantlet can be used, and the entire interlocking will be controlled from the existing CTC board for the Fitchburg Main Line.

A BRIEF ECONOMIC AND OPERATIONAL ANALYSIS OF THE PRELIMINARY LAYOUT

CONSIDERATION OF CTC FROM SPRINGFIELD TO HOLYOKE

Once the preliminary layout has been made, the next step is to study it from the operational and economic points of view. In this case, the section of the line between the W A Tower and Holyoke is somewhat different from the rest of the project, because of the large number of industrial sidings and yard turnouts and the consequent number of switch engines which operate in that area. Although, no detailed study of switcher movements has been made, it has been assumed that they may be adapted to fit the new system; but it is probable that some delays will be incurred.

Before considering train operations in this area to any greater extent, the author has found it best to make a brief economic comparison of the cost of CTC between Springfield and Greenfield and between Holyoke and Greenfield. On the basis of this comparison the possibility of installing CTC south of Holyoke has been eliminated, and further operational considerations for that area become unnecessary. This economic comparison appears on the next page. The figures shown for the Holyoke--Greenfield case have been taken from the detailed economic summary for the final proposals which appears on

A BRIEF ECONOMIC COMPARISON OF THE COSTS OF CTC BETWEEN SPRINGFIELD AND GREENFIELD AND HOLYOKE AND GREENFIELD

	Springfield to Greenfield	Holyoke to Greenfield
1. Cost of Installation		
a. Capital Investment		
Signaling	$592,109	$407,227
Track	(253,992)	(276,280)
	$338,117	$130,947
b. Operating Expenses		
Signaling	70,830	55,130
Track	(397,416)	(336,506)
	($326,586)	($281,376)
c. Total Cost of Project	$ 11,531	($150,429)

Page 31. To get the costs for the Springfield to Greenfield case, the data in Appendix D has been used. In this appendix, the cost elements are listed first for the final proposals, and then in another section additional costs are listed for the Springfield to Holyoke part of the project. To get the values shown in the comparative summary, this additional data has been added to the appropriate item in the final economic statement.

From this comparative statement, one can see that the relatively high cost of signaling between Springfield and Holyoke, which would not be offset by track retirements, leads to a total cost of the project which is $161,960 higher than the Holyoke to Greenfield installation. Following the criteria used in this report for maintenance savings on trackage retired (see Page 32) there will be no further decrease in annual maintenance in this area to offset the increased installation cost. For this reason, the author has decided to eliminate that portion of the project between Springfield and Holyoke as being economically unfeasible, and consider only that portion between Holyoke and Greenfield.

CONSIDERATION OF THE NECESSITY FOR THE SOUTH DEERFIELD SIDING

Although the Boston and Maine Operating Department at Greenfield does not feel that a siding is necessary at South Deerfield, the train meets indicated on the graphic train chart

show that some study should be made before eliminating this siding. A redispatch of trains was considered, therefore, without this siding, but the 14.66-mile distance from Northhampton to the end of double track at Deerfield Junction is so long that, although a redispatch can be made on the basis of the graphic train chart shown in this report, it would mean that trains would have to operate closer to schedule than can be assured by the data available. Small deviations from the redispatch will mean considerable train delays at certain peak hours. Therefore, on the basis of the existing traffic, the author does not feel justified in eliminating the passing siding at South Deerfield. If the present number of passenger trains is decreased, it will certainly be worthwhile to reconsider this decision since eliminating this siding will mean a saving of $38,000 plus labor costs in signaling, as well as almost two miles of track retirements and salvage.

These two features of the preliminary layout are the only questionable aspects of the project which the author feels should be discussed at this point. Having determined their relation to the final proposals, further investigation of them will not be made at this point, but will be deferred until the final layout has been described.

FINAL PROPOSED LAYOUT

Now that the questionable aspects of the preliminary design have been investigated, the final proposed layout may be made. The general discussion of the preliminary layout is applicable, as are the detailed discussions of the various elements, so that only a brief summary is necessary at this point. A line plan of the proposed system is found in Appendix B.

HOLYOKE

The end of double track will be at MP 8.64, the site of the proposed interlocking for the passing siding. However, since each of the two tracks leading to this point will be used for one-way operation only, this interlocking will have a spring switch from the northbound track to single track.

HOLYOKE TO NORTHAMPTON

Some 8.20 miles of northbound track will be retired leaving the southbound as the single operating track.

NORTHAMPTON SIDING

The 13,800-ft. siding proposed for Northampton will be installed as discussed on Page 17.

NORTHAMPTON TO WHATELY

Single track operation will be installed on the old northbound track and 6.65 miles of the southbound will be retired.

SOUTH DEERFIELD SIDING

As discussed in detail a 9,600-ft. passing siding plus a 3,300-ft. industrial siding will be left beginning at Whately and extending to South Deerfield.

SOUTH DEERFIELD TO DEERFIELD JUNCTION

The northbound track will be maintained for 6.22 miles from South Deerfield to the end of double track at Deerfield Junction, and the southbound will be retired.

DEERFIELD JUNCTION -- GREENFIELD

As discussed in detail on Page 19 double track will end at MP 34.16 and extend from there to the gantlet track at Greenfield, which will be made single track with a power turnout at the south end and a spring switch turnout to double track at the north end. No changes will be made north of this point. The Deerfield Junction interlocking for the East Deerfield Branch will be the last interlocking controlled by the new CTC machine at Greenfield; the former gantlet will become part of the Fitchburg Main Line CTC System.

OPERATIONAL ANALYSIS OF THE FINAL PROPOSED LAYOUT

Once a final design has been made, it is necessary to show that present train operations will be satisfactorily accommodated. The lengths and locations of the sidings and ends of double track have been designed for a 175-car freight train and allow space for such a train to work without interferring with the operation of other trains. No difficulty is expected in this respect, but it is necessary to show that the new system has sufficient capacity for current traffic. This may be accomplished in two ways:

1. A time-spacing analysis of the passing siding arrangement
2. A redispatch of trains

A time-spacing analysis consists of determining the gross headway between passing sidings and computing the theoretical capacity of the line using the formula:

$$\text{Theoretical number of trains per day} = \frac{1440 \times 2}{\text{maximum gross headway in minutes}}$$

The gross headway is the sum of the running times from one passing siding to the next and back again plus an allowance of four minutes for one train to enter and leave a siding. The maximum gross headway is simply the maximum value of gross headway obtained between the sidings of a particular installation. In this case, the maximum gross headway is forty minutes

and occurs between the Northampton and South Deerfield sidings as shown on the time-spacing graph in Appendix C. The theoretical number of trains per day on this line is then seventy-two. No system is expected to work perfectly though, so a correction factor must be applied to this theoretical capacity. A usual factor is 50%, from which the expected capacity is thirty-six trains per day. This exceeds the actual maximum of twenty-nine trains per day on this line.

Since there is no capacity problem, the next step in an operational analysis is to make a redispatch of existing trains on the graphic train chart. In this case, train operations are such that train delays that occur under the CTC System may be eliminated by slight rescheduling as shown on the graphic train chart. The one exception to this is found for the local freight E 4. The chart shows a 27-minute delay incurred to this train at Northampton prior to its returning to Deerfield Junction in the evening. However, because of the general nature of the data recorded on the graphic train chart, the author does not feel justified in saying that this delay will be consistent. Due to the nature of the work done by E 4, however, some delay should be expected with the CTC System. Therefore, in the final economic analysis a daily delay of thirty minutes has been arbitrarily assigned to this train.

As stated, no other delays have been considered because

of the inadequacy of the train chart data. To be able to predict train delay accurately, it is necessary to have some idea of how a variation in the running time of one train will affect all other trains on the line. Obviously, if a certain train is early on a particular occasion, it may be delayed by some other train on the line. Also, if this train is late it may in turn delay other trains or may itself be delayed. The data which this report presents can in no way account for such occurences. Indeed, an exact study of the type suggested would require the use of rather complicated mathematics. It must suffice for our purposes to say that no train delay, except that to E 4, is expected on the basis of the redispatch shown; but due to the nature of the data obtained, it would be incorrect to say that this is exactly the case.

DETAILED ECONOMIC ANALYSIS

The remaining task in considering the feasibility of this CTC project is to make a detailed economic analysis. A statement of this analysis appears on Page 31, however, the figures used are shown in more detail in Appendix D. The costs used for the various items have been given by Boston and Maine personnel for purposes of estimating the cost of this project, and to this end are adequate. Certain items may need some explanation.

In track salvage, 75% of the retired rail is considered to be suitable for reuse at a value of $35 per net ton. The remaining rail and other track material is scrap at $23 per ton. No value is given to ties removed, but generally up to 50% may be reused. The computations for track retirement have been made on the basis of fifteen miles of the retired track having 85-lb. rail and the remainder, 100-lb. rail. This assumption was made on the basis of the statement by an engineering official that fifteen miles of track between Holyoke and Greenfield had 85-lb. rail and must be replaced. However, the specific location of this 85-lb. rail was not ascertained and may be at locations where passing sidings will be left. Also it is assumed that the rail replacement program that is planned for the area is to replace the 85-lb. rail with 100-lb. rail as the line in general has 100-lb. rail.

ECONOMIC STATEMENT FOR CTC INSTALLATION BETWEEN HOLYOKE AND GREENFIELD

1. Cost of Installation		
a. Capital Investment		
Signaling		
New Signals	$433,627	
Retirements	(26,400)	
Track		
New Items	36,525	
Retirements	(312,805)	
		$130,947
b. Operating Expense		
Signaling		
Retirements	$ 26,400	
Cost of Retiring	28,730	
Salvage	(0)	
Track		
Retirements	312,805	
Salvage	(127,531)	
Cost of Retiring	56,830	
Cost of Relocations	750	
Expense of stone ballasting one main line track	(204,160)	
Expense of replacing 15 miles of 85-lb. rail with 100-lb. rail	(375,000)	
		(281,376)
c. Total Cost of Installation		($150,429)
2. Changes in Annual Operating Expense		
a. Reduction on Track Maintenance	($19,990)	
b. Increase in Signal Depreciation	8,145	
c. Increased cost of Train Delays[1]	3,061	
d. Total Change in Annual Operating Expense (Saving)		($8,784)

[1] This value is for the assumed 30-minute daily delay to local freight E 4 as discussed on Page 28.

Although the Boston and Maine's Maintenance of Way Department does not feel that substantial savings would be realized in track maintenance when on track is removed because of increased traffic on the remaining track, the author, on the advice of Professor Lang, has taken a value of 50% of the maintenance cost of one track as being saved when double track is converted to single track main line. No saving is claimed, however, when one track is left as a passing siding or the second track is retained and used somewhat as in the original proposal between Springfield and Holyoke. The value of maintenance cost per mile of track has been taken from the 1956 summary of average main line track maintenance costs for the Boston and Maine, published by the I.C.C., and is $2,000 per mile of main line track so that a saving of $1,000 per mile of track retired is claimed. There will also be certain savings in bridge maintenance where one track is removed; however no value has been fixed for this item.

There will be no change in signal maintenance for the new system as it is felt by the railroad that various maintenance factors for both systems will balance. Also, there is no salvage value shown for the retired signals. Some of this material may be reused but it is difficult to say just where or how much and, therefore, no credit can be taken in this particular project.

A further item that warrants mention is the saving of 52% of the value of retirements in the form of income tax in

the year the retirement takes place. Although this value would amount to approximately $170,000 it is not shown in the economic statement, as it is felt by the author that should this project be feasible such savings would be apparent to the people concerned.

CONCLUSIONS

The capital saving of $150,429 plus the annual saving of $8,784 associated with this CTC project indicate that it should be feasible. Although these values are in some ways approximate, the author does not feel that they contain any sizable errors. To this extent the installation of CTC under present traffic conditions, i.e. the traffic conditions under which this report was made, can be recommended.

As was noted early in the report, however, the railroad has received permission to drop certain of its passenger trains, and this trend toward reduction of service is expected to continue. Therefore, because of the apparent low annual saving shown above, a less expensive installation such as a block signal system on single track with selected passing sidings might be advisable. This type of system is effective with low traffic densities such as may some day be expected on this line. Before taking definite action, it might be well to investigate the feasibility of such an alternate system.

Since the railroad expects further decreases in passenger trains, it will be well to wait until a final equilibrium is reached and make a study based on this traffic, which will indicate what facilities are needed. Of course, if the rail replacement is critically needed at this time, it may be

inadvisable to wait for too long before beginning this project. This is a matter for the railroad to decide. In any case, it would be unwise to commence this CTC project without a further study of the type indicated above.

APPENDIX A

EXPLANATION OF FIRST-CLASS TRAIN SCHEDULES

Symbols Used

s Regular stop (If only one time is shown, it is the leaving time.)

f Flag stop to receive or discharge traffic

L Leave

A Arrive

e Stop to leave passengers on notice to conductor

v Stops on signal to take passengers

P "s" except Sundays

D Runs via East Deerfield Branch

X Does not carry passengers (Nos. 90, 92, 95, and 99 are mail and express trains.)

c No. 791 runs via East Deerfield Branch and into Greenfield by Fitchburg Main Line.

Note: Time difference between W A Tower and Springfield for trains Nos. 70, 72, 74, and 760 (Inbound) is to allow these trains to run to the New Haven yards and to back into Springfield passenger station.

Times shown for First-Class Trains have been taken from the Boston and Maine Railroad's Time Table No. 65, October 27, 1957.

FIRST-CLASS TRAIN SCHEDULE

SPRINGFIELD TO GREENFIELD OUTWARD TRAINS (NORTHWARD)

STATIONS	Miles from Spring-field	71 Daily C.V.Ry	X c 791 Ex.Sun Grnfld	73 Ex.Sun W.R.Jct.	X 90 Ex.Sun Boston	751 Sun.only W.R.Jct.	709 Ex.Sun Grnfld	92 Sun.only Boston	75 Daily C.V.Ry	94 Ex.S&S Boston	717 Ex.Sun Grnfld	77 Daily W.R.Jct.	723 Sun.only Grnfld	79 Ex.Sun W.R.Jct.	779 Sun.only Grnfld	729 Sun.only Grnfld
		AM	AM	AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM
Springfield		L 12.31	L 4.45	L 5.20	L 6.00	L 7.45	L 10.00	L 11.00	L 12.55	L 2.15	L 4.10	L 5.30	L 7.22	L 8.20	L 8.40	L 10.40
W A Tower																
Brightwood	1.99											P 5.35				
Chicopee	3.43	12.37	4.51	5.26	6.06	7.51	10.06	11.06	1.01	2.21	4.16	5.37	7.28	8.26	8.46	10.46
Riverside	7.26											P 5.42				
Holyoke	7.92	12.44	s 4.58	s 5.38	6.12	s 7.58 8.01	s10.14	11.13	s 1.08	2.30	s 4.22	s 5.45	s 7.35	s 8.37	s 8.57	s10.53
Mount Tom	14.72											5.53		8.47		
Northampton	17.05	12.55	s 5.12	s 5.58	6.25	s 8.14 8.17	s10.30	11.27	s 1.23	2.45	s 4.35	s 5.59	s 7.48	s 8.56	s 9.16	s11.08
Whately	26.14															
South Deerfield	28.37	1.08	5.26	s 6.14	6.39	8.31	f10.45	11.41	1.37	s 3.00	f 4.49	s 6.14	f 8.02	9.10	9.30	f11.22
Deerfield	32.70															
Deerfield Junction	34.60		D 5.34		D 6.48			D11.50								
Greenfield	36.07	s 1.19		s 6.25 6.50		s 8.42 9.10	A10.56		s 1.47 1.50	A 3.10	A 5.00	s 6.24 6.35	A 8.12	s 9.20 9.40	s 9.40 9.50	A11.34

FIRST-CLASS TRAIN SCHEDULE

GREENFIELD TO SPRINGFIELD INWARD TRAINS (SOUTHWARD)

STATIONS	Miles from Spring-field	70 Daily C.V.Ry	706 Ex.Sun Grnfld	710 Ex.Sun Grnfld	72 Daily W.R.Jct.	714 Ex.Sun Grnfld	716 Ex.Sun Grnfld	78 Daily W.R.Jct.	74 Daily C.V.Ry	724 Sun.only Grnfld	726 Sun.only Grnfld	X 95 Ex.Sun Boston	76 Ex.Sun W.R.Jct.	X 99 Ex. Sun Boston	760 Sun.only W.R.Jct.
		AM	AM	AM	AM	AM	PM	PM	PM	PM	PM	PM	PM	PM	PM
Greenfield	36.07	s 3.44	L 6.15	L 7.25	s 8.33 s 8.45	L11.20	L 1.25	s 2.43	s 5.00 5.10	L 6.20	L 8.25		9.44 f10.35		10.46 s10.48
Deerfield Junction	34.60											D 8.10	10.37	D10.34	
Deerfield	32.70		v 6.21	s 7.30			f 1.30								
South Deerfield	28.37	3.53	s 6.28	s 7.36	s 8.56	f11.30	s 1.35	f 2.53	5.20	f 6.30	s 8.25	s 8.18	10.46	10.42	s10.58
Whately	26.14		f 6.31												
Northampton	17.05	4.07	s 6.46	s 7.50	s 9.12	s11.45	s 1.51	s 3.08	s 5.36	s 6.45	s 8.50	s 8.32 8.50	11.05	10.57	s11.12
Mount Tom	14.72		s 6.49	7.53											
Holyoke	7.92	4.18	s 7.00	s 8.02	s 9.28	s11.57	s 2.06	s 3.20	s 5.53	s 6.57	s 9.02	s 9.15	11.20	11.10	s11.27
Riverside	7.26		f 7.02												
Chicopee	3.43	4.22	7.06		9.34	12.03	2.12	3.26	5.59	7.03	9.08	9.23	11.27	11.16	11.32
Brightwood	1.99			e 8.08											
W A Tower		4.28			9.38				6.04						11.37
Springfield		A 4.35	A 7.12	A 8.15	A 9.45	A12.10	A 2.20	A 3.35	A 6.15	A 7.10	A 9.15	A 9.30	11.40	A11.30	A11.42

EXPLANATION OF THROUGH FREIGHT TRAIN SCHEDULES

Symbols Used

L	Leave
A	Arrive
D	Drops cars
P	Picks up cars

Train	From	To
S-J 1	Springfield	White River Junction
S-M 1	Springfield	Mechanicville, N. Y.
S-U 1	Springfield	Wells River
M-S 2	Mechanicville	Springfield
J-S 2	White River Junction	Springfield
J-S 4	White River Junction	Springfield

Note: Times are shown at stations where information is available. The first time shown for each train at a station is taken from the Boston and Maine Railroad's Freight Train Symbol Book No. 66, effective October 27, 1957. The second time shown is an assumed time for a typical weekday based on an examination of train sheets and conversations with operating officials.

THROUGH FREIGHT TRAIN SCHEDULES

OUTWARD (NORTHBOUND) FROM SPRINGFIELD

	SJ 1 Daily			SM 1 Daily Except Saturday			SU 1 Daily Except Saturday		
Springfield		L 8.50 AM	L 9.10 AM		L 6.30 PM	L 6.30 PM		L 7.00 PM	L 7.00 PM
Chicopee				P			P		
Holyoke	D		A 9.30 AM L 9.45 AM	P	L 7.00 PM	A 6.55 PM L 7.12 PM	P	L 7.30 PM	A 7.45 PM L 8.02 PM
Northampton	D	L 9.30 AM	A 9.59 AM L10.14 AM	P	L 7.30 PM	A 7.27 PM L 7.42 PM	P	L 8.00 PM	A 8.17 PM L 8.22 PM
Greenfield	D P	L10.30 AM	A10.44 AM L11.30 AM	P	L 8.30 PM	A 8.15 PM L 8.45 PM	P D	L11.30 PM	A 8.50 PM L11.30 PM

THROUGH FREIGHT TRAIN SCHEDULES

INWARD (SOUTHBOUND) TO SPRINGFIELD

	MS 2 Daily Except Sunday			JS 2 Daily			JS 4 Daily Except Sunday		
Greenfield (Deerfield Jct.)	D	L 2.15 AM	L 2.30 AM	D P	L10.30 AM	A11.30 AM L12.30 PM	D P	L 9.50 PM	A 9.30 PM L10.00 PM
Northampton	D	L 3.15 AM	A 3.10 AM L 3.30 AM	D P	A11.15 AM				
Holyoke	P D	L 3.50 AM	A 3.47 AM L 4.05 AM	D P	L11.50 AM	A 1.14 PM L 1.30 PM			
Chicopee	D	L 4.15 AM	A 4.20 AM L 4.30 AM						
Springfield		A 4.30 AM	A 4.34 AM		A12.30 PM	A 1.45 PM		A11.00 PM	A11.10 PM

LOCAL FREIGHT TRAINS

E 4 -- East Deerfield to Turners Falls, Northampton, Easthampton and return--Monday through Friday. (Times shown are for a typical day.)

SOUTHBOUND (GOING)

Deerfield Junction	L 9.45 AM
South Deerfield	A 10.20 AM L 10.35 AM
Northampton	A 11.00 AM L 12.40 PM
Mount Tom (Easthampton Branch)	A 12.50 PM

NORTHBOUND (RETURNING)

Mount Tom	L 2.30 PM
Northampton	A 3.04 PM L 5.15 PM
Deerfield Junction	A 6.00 PM

H 2 -- Northampton to Wheelwright via Wheelwright Branch and return--Monday through Friday (crosses from Northampton yards to Wheelwright Branch).

OUTWARD

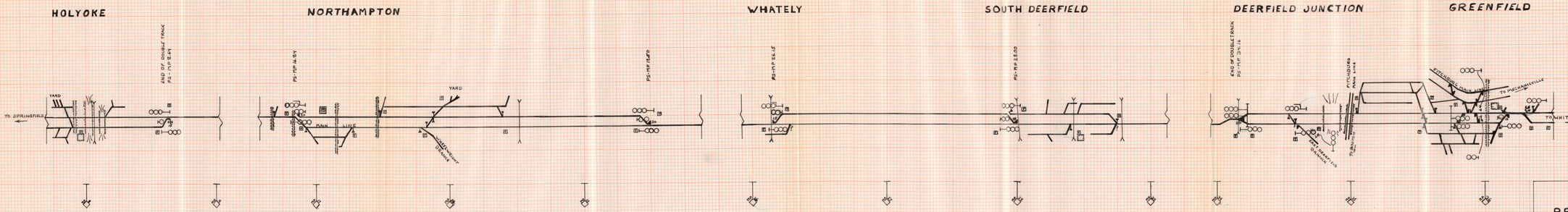
9.30 AM to 9.50 AM

INWARD

Tuesday and Thursday--2.45 PM to 3.00 PM
Monday, Wednesday, and Friday--7.45 PM to 8.00 PM

APPENDIX B

Plan of Proposed CTC Installation



LEGEND

- POWER TURNOUT (No. 15)
- SPRING SWITCH
- ELECTRIC SWITCH LOCK
- NEED FOR SWITCH LOCK QUESTIONABLE
- TELEPHONE
- PASSENGER STATION
- IMPORTANT ROAD CROSSING
- SIGNAL BRIDGE

BOSTON AND MAINE RAILROAD

PLAN OF

PROPOSED CTC INSTALLATION

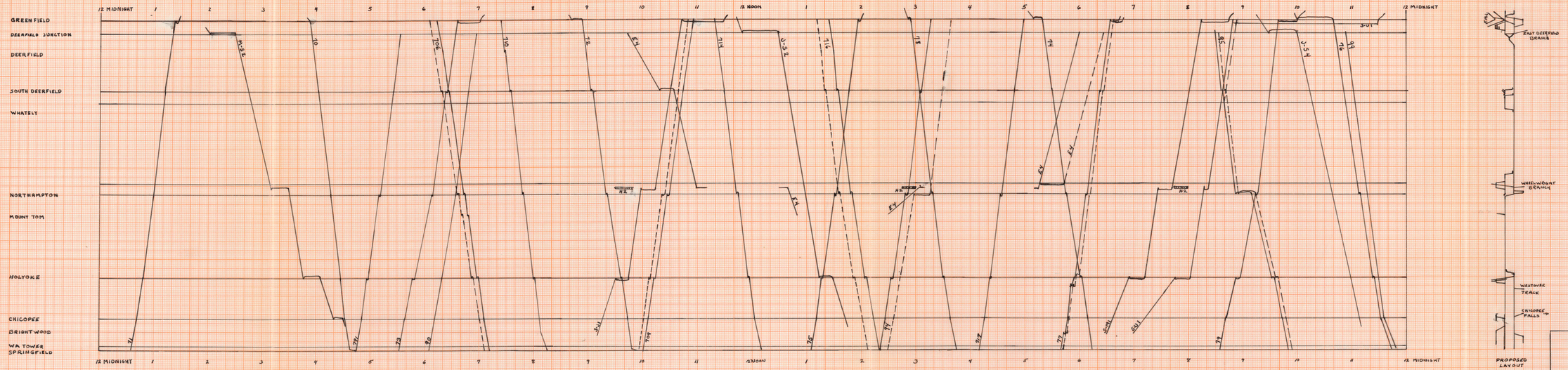
CONNECTICUT RIVER MAIN LINE

HOLYOKE TO GREENFIELD, MASSACHUSETTS

A. PRENTISS — MAY 26, 1958

SCALE 4" = 1 MILE

APPENDIX C



LEGEND

—— PRESENT OPERATIONS

- - - - REDISPATCHED TRAINS

GRAPHIC TRAIN CHART

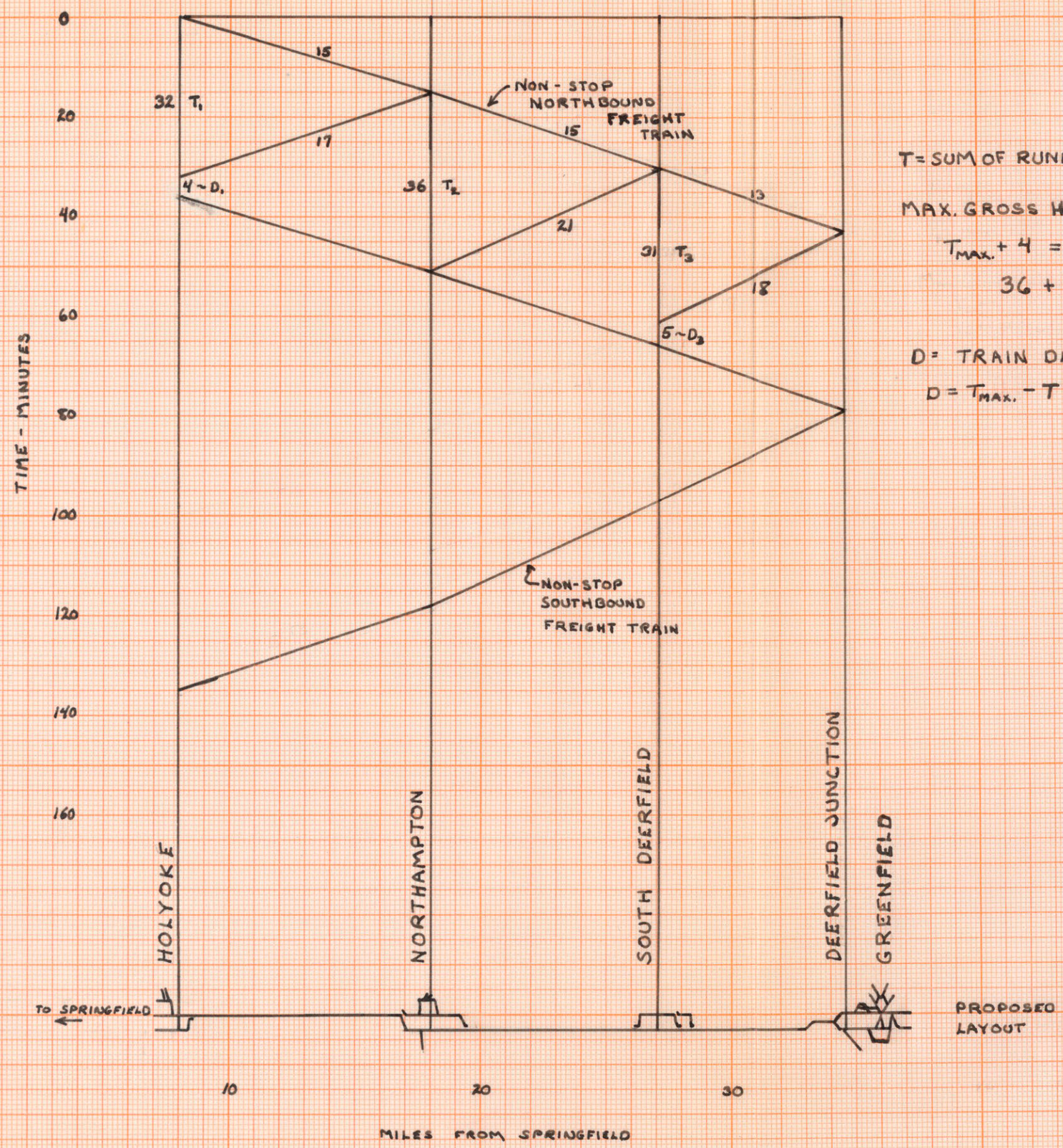
FOR

TYPICAL WEEKDAY

SPRINGFIELD TO GREENFIELD, MASSACHUSETTS

A. PRENTISS

MAY 26, 1958



T = SUM OF RUNNING TIMES

MAX. GROSS HEADWAY =

$T_{MAX.} + 4 = T_2 + 4$

$36 + 4 = 40$ MIN.

D = TRAIN DELAY

$D = T_{MAX.} - T$

TIME-SPACING GRAPH

HOLYOKE TO GREENFIELD

A. PRENTISS 5/26/58

DETERMINATION OF PASSING SIDING LENGTH

175	cars per train
x 47	feet per car
8225	feet -- length of 175 cars
30	feet -- length of caboose
240	feet -- length of 4-unit diesel engine
350	feet -- No. 15 turnout--P.S. to 13 ft. clearance
350	feet -- No. 15 turnout (add 50 ft. for each No. 20 turnout)
9195	feet -- length of siding P.S. to P.S. to accommodate 175-car train
1805	feet -- margin (see discussion Page 14)
11,000	feet -- siding length desired

APPENDIX D

COST ELEMENTS FOR CTC BETWEEN HOLYOKE AND GREENFIELD

SIGNALING

NEW WORK	Cost of Materials
HOLYOKE INTERLOCKING (End of Double Track)	$19,000
2 three-light interlocking signals	
1 one-light dwarf signal	
1 No. 15 spring switch machine	
Add 1 light to approach signal near Holyoke	700
NORTHAMPTON SOUTH INTERLOCKING	19,000
1 three-light interlocking signal	
1 three-light interlocking signal with cantilever arm	
1 two-light dwarf signal	
1 No. 20 power switch machine	
NORTHAMPTON NORTH INTERLOCKING	19,000
2 three-light interlocking signals	
1 two-light dwarf signal	
1 No. 20 power switch machine	
WHATELY INTERLOCKING	19,000
1 three-light interlocking signal	
1 three-light interlocking signal with cantilever arm	
1 two-light dwarf signal	
1 No. 15 power switch machine	
SOUTH DEERFIELD INTERLOCKING	19,000
1 three-light interlocking signal	
1 three-light interlocking signal with cantilever arm	
1 two-light dwarf signal	
1 No. 15 power switch machine	
DEERFIELD JUNCTION INTERLOCKING (End of Double Track)	
1 signal bridge	21,300
2 three-light interlocking signals on bridge	
1 three-light interlocking signal	
1 No. 20 equilateral power switch machine	

	Cost of Materials
DEERFIELD JUNCTION AT EAST DEERFIELD BRANCH Adopting present interlocking to CTC System, including 3 three-light interlocking signals and 1 power switch and relocating 1 signal and adding a cantilever arm.	$ 6,000
GREENFIELD INTERLOCKING WITH FITCHBURG MAIN LINE Change 1 one-light interlocking signal on existing bridge to three-light interlocking signal for two-way operation on Connecticut River Main Line.	2,000
GREENFIELD INTERLOCKING FOR GANTLET Change Gantlet to single track with power switch at south end and spring switch on north end. Tie present signals and new switches into Fitchburg Main Line CTC board.	24,000
GENERAL	
Block Signal System Between Interlockings	
6 installations with two-light approach signal and one-light block signal at same location. $4,600 per installation	27,600
1 installation with 2 one-light block signals at same location	4,100
Electric Switch Locks	
24 @ $2,500 each (6 at questionable locations not included)	60,000
Telephones	
21 @ $150 each (3 at questionable locations not included)	3,150
CTC Control Machine	35,000
Expense (additional) of changing 25.57 miles of single track main line to CTC @ $1,500 per mile.	38,355
Expense (additional) of changing 2.00 miles of double track main line at Greenfield to two-way operation with CTC	4,000
TOTAL COST OF NEW SIGNAL MATERIALS	$321,205
FIELD CONSTRUCTION AND ENGINEERING (35% of Material Cost)	112,422
TOTAL COST OF NEW SIGNALING	$433,627

RETIREMENTS	Cost of Retiring	Capitalized Value
PRESENT AUTOMATIC BLOCK SIGNAL SYSTEM		
25 one-light block signals		
$70 each to retire	$1,750	
$700 each capitalized		$17,500
4 two-light approach signals		
$70 each to retire	280	
$900 each capitalized		3,600
AUTOMATIC INTERLOCKING AT NORTHAMPTON	500	
1 three-light interlocking signal		750
1 three-light interlocking signal with cantilever arm		500
5 one-light dwarf signals		
$250 each capitalized		1,250
3 switch locks		
$100 each capitalized		300
DEERFIELD JUNCTION INTERLOCKING (At East Deerfield Branch)	200	
2 one-light dwarf signals		
$250 each capitalized		500
2 power switch machines		
$1,000 each capitalized		2,000
GENERAL COST OF RETIRING		
26.00 miles of double track circuits		
$1,000 per mile to retire	26,000	
TOTAL COST OF RETIRING	$28,730	
CAPITALIZED VALUE OF RETIREMENTS		$26,400

ASSOCIATED TRACK COSTS

NEW ITEMS INSTALLED

2 No. 20 turnouts for power switches	$7,400
1 No. 20 equilateral power turnout	4,200
3 No. 15 turnouts for power switches	9,000
2 No. 15 spring switches	6,400
2 No. 15 turnouts with hand-thrown switches	6,200
350 feet track @ $9.50 per foot	3,325
TOTAL COST OF TRACK ITEMS INSTALLED	$36,525

SAVING IN OPERATING EXPENSE

Stone ballasting 25.52 miles of second main line track at $8,000 per mile	$204,160
Replacing 85-lb. rail with 100-lb. rail on 15 miles of second main line track @ $25,000 per mile	375,000
TOTAL SAVING IN OPERATING EXPENSE	$579,160

RELOCATIONS

Cost of relocating one main line connection where second track has been removed	$750

RETIREMENTS	Cost of Retiring	Original Value
15 miles of main line track with 80-lb. rail		
$2,640 per mile to retire	$39,600	
$15,048 per mile original		$225,720
5.39 miles of main line track with 100-lb. rail		
$2,640 per mile to retire	14,230	
$15,048 per mile original		81,109
6 No. 10 main line crossovers (each includes two turnouts and 30 feet of track)		
$500 each to retire	3,000	
$996 each original		5,976
TOTAL COST OF RETIRING TRACK ITEMS	$56,830	
ORIGINAL VALUE OF RETIREMENTS		$312,805

SALVAGE ON RETIREMENTS

15 miles of main line track with 80-lb. rail

Rail - 112.1 tons/mile @ $35/ton	= $3,294/mile	
37.4 tons/mile @ $23/ton	= 860/mile	
O.T.M. - 50.24 tons/mile at $23/ton	= 1,156/mile	
(All weights of track items are in net tons.)	$5,940/mile	$89,100

5.39 miles of main line track with 100-lb. rail

Rail - 132 tons/mile @ $35/ton	= $4,620/mile	
44 tons/mile @ $23/ton	= 1,012/mile	
O.T.M. - 50.58 tons/mile @ $23/ton	= 1,163/mile	
	$6,795/mile	36,625

6 No. 10 main line crossovers

Rail - 3.87 tons each at $35/ton	= $135	
1.29 tons each at $23/ton	= 30	
O.T.M. - 5.92 tons each at $23/ton	= 136	
	$301 each	1,806
TOTAL TRACK SALVAGE		$127,531

CHANGES IN ANNUAL OPERATING EXPENSES WITH CTC

BETWEEN HOLYOKE AND GREENFIELD

REDUCTION IN MAINTENANCE

Maintenance on 20.39 miles of track removed at $1,000 per mile	($20,390)
Maintenance on turnouts and crossovers	
Increased maintenance on new turnouts 8 turnouts at $200 per turnout	1,600
Maintenance on turnouts and crossovers removed, 6 crossovers at $200 each	(1,200)
TOTAL MAINTENANCE REDUCTION	($19,990)

INCREASED DEPRECIATION ON SIGNAL INSTALLATION (2% of capital investment of signals--$407,227)	$8,145

INCREASED OPERATING EXPENSE DUE TO TRAIN DELAYS[1]

Crew overtime -- 130 hrs. @ $20/hr.	$2,600
Locomotive hours -- 130 hrs. @ $1.83/hr.[2]	238
Car days -- 81 @ $2.75 each	223
TOTAL ANNUAL COST OF TRAIN DELAYS	$3,061

[1] Based on assumed 30-minute delay to train E 4 (see Page 28).

[2] Hourly value of locomotive delay is based on a fixed annual cost of 10% of the initial investment, which is approximately $160,000.

ADDITIONAL COSTS FOR CTC FROM SPRINGFIELD TO HOLYOKE

SIGNALING

NEW WORK	Cost of Materials
BREWERY INTERLOCKING	$23,000
1 three-light interlocking signal	
1 three-light interlocking signal with cantilever arm	
1 two-light dwarf signal	
1 one-light dwarf signal	
1 No. 15 power switch machine	
1 No. 15 spring switch machine	
WILLIMANSETT INTERLOCKING	19,000
2 three-light interlocking signals	
1 two-light dwarf signal	
1 No. 20 power switch machine	
HOLYOKE INTERLOCKING	19,000
1 three-light interlocking signal	
1 three-light interlocking signal with cantilever arm	
1 two-light dwarf signal	
1 No. 15 power switch machine	
GENERAL	
Block Signal System Between Interlockings	
1 two-light approach signal	4,000
2 two-light approach signals at same location	5,100
convert 1 approach signal to new system	1,000
Electric Switch Locks	
19 @ $2,500 each (12 at questionable locations not included)	47,500
8 with bolt locks @ $3,000 each	24,000
Telephones	
13 @ $150 each (6 at questionable locations not included)	1,950
CTC Control Machine (Additional)	5,000
Expense (Additional) of changing 8.19 miles of 1 main line track to CTC @ $1,500 per mile	12,285

CREDITS	Cost of Materials
HOLYOKE INTERLOCKING (End of Double Track)	($19,000)
2 three-light interlocking signals	
1 one-light dwarf signal	
1 No. 15 spring switch machine	
Add 1 light to approach signal near Holyoke	(700)
TOTAL ADDITIONAL COST OF SIGNAL MATERIALS	$142,135
FIELD CONSTRUCTION AND ENGINEERING (35% of Material Cost)	49,747
TOTAL ADDITIONAL COST OF NEW SIGNALING	$191,882

ADDITIONAL RETIREMENTS	Cost of Retiring	Capitalized Value
Present Automatic Block Signal System		
10 one-light block signals		
$70 each to retire	$ 700	
$700 each capitalized		$7,000
General cost of retiring 8.19 miles of double track automatic block signal circuits	8,000	
TOTAL ADDITIONAL COST OF RETIRING	$8,700	
CAPITALIZED VALUE OF ADDITIONAL RETIREMENTS		$7,000

ASSOCIATED TRACK COSTS

NEW ITEMS INSTALLED	
1 No. 20 turnout for power switch machine	$ 3,700
2 No. 15 turnouts for power switch machine	6,000
1 No. 15 turnout with spring switch	3,200
2 No. 15 turnouts with hand-thrown switches	6,200
1,050 feet of track @ $9.50 per foot	9,975
Credit	
1 No. 15 turnout with spring switch	(3,200)
TOTAL ADDITIONAL COST OF TRACK ITEMS	$25,875

ADDITIONAL SAVING IN OPERATING EXPENSE	
Stone ballasting 8.19 miles of second main line track @ $8,000 per mile	$65,520

ADDITIONAL RELOCATIONS	
Relocate 1 No. 10 connection 450 feet	$900

ADDITIONAL RETIREMENTS	Cost of Retiring	Original Value
400 feet of main line track with 100-lb. rail		
$ .50 per foot to retire	$ 200	
$2.85 per foot original		$1,140
1 No. 10 turnout	200	455
2 No. 10 main line crossovers		
$500 each to retire	1,000	
$996 each original		1,992
TOTAL COST OF RETIRING ADDITIONAL TRACK ITEMS	$1,400	
ORIGINAL VALUE OF ADDITIONAL RETIREMENTS		$3,587

SALVAGE ON ADDITIONAL RETIREMENTS

400 feet of main line track of 100-lb. rail

Rail - .025 tons/ft. @ $35/ton	=	$ .88/ft.	
.008 tons/ft. @ $23/ton	=	.18/ft.	
O.T.M. - .0095 tons/ft. @ $23/ton	=	.29/ft.	
		$1.35/ft.	$ 540

1 No. 10 turnout

Rail - 1.56 tons @ $35/ton	=	$55	
.52 tons @ $23/ton	=	12	
O.T.M. - 2.96 tons @ $23/ton	=	68	
		$135	135

2 No. 10 main line crossovers

$301 per crossover (See Page D5)	602
TOTAL ADDITIONAL TRACK SALVAGE	$1,277