Traffic Studies Show Need of Balanced Budgets*

Train Movements Scientifically Scheduled Cut Down Side Track Delays and Speed Up Service

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THE PURPOSE of this study is to show that the operation of a freight train district or sub-division is a mathematical problem and no longer a matter of mere energy. It substitutes scientific methods for traditional procedure and points out the connection between the assignment of items in a well balanced improvement budget and this mathematatcal operation.

We consider four factors in our plant output of ton miles: (1) Ruling grade; (2) draw-bar pull; (3) gross tons per train, and (4) train speed in miles per hour. Further, every freight train district has a movement characteristic all its own, either a wave, a pendulum beat, a period or a cycle. For development of traffic capacity this "period" must be isolated. The train movement must be arranged in consonance with the period. The sidings and OS station spacing must synchronize with the period.

Would anyone overlook freight trains, under pay, spending 30 to 40 per cent of their trip time idle on side tracks while heavy outlays of capital are put into improved sub-structures? A misplaced siding may delay the average train on a sub-division eight or ten minutes with a cost to correct of only $30,000.

In one plan of budget improvements, there may be possibly seven or eight freight train districts or sub-divisions which are not entirely satisfactory as to present performance and an even worse overload appears imminent. In such a case the worst sub-division is selected and large outlays poured into it for double trackage or grade reduction, building up the capacity of this sub-division far beyond its immediate traffic requirements and carrying therewith a large load of non-paying betterments. In the meanwhile, nothing can be done to the six or seven other sub-divisions which equally require relief.

Plan to Permit Growth as Traffic Increases

Our alternative plan contemplates the study of each sub-division and the evolving therefrom of such a rearrangement of siding spacing and handling as will fairly meet the existing demands. We would provide such a layout as to permit its growth co-ordinately with year to year traffic increases into the ultimate double track. Such a program will supply the needs of several sub-divisions at a cost often much less than the single comprehensive overhauling of the selected sub-division.

Waste by idle trains may be the outcome of lack of slight rearrangement or of addition to existing facilities. The study develops certain laws of single track operation and proves the money value of the mathematical operation of trains; it prompts the use of the locomotive booster, super-heater, feed water heater, thermic syphon and arch, signaling, interlocking and, last but not least, a uniform scheme for the operation and arrangement of sidings and siding facilities.

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The length of sub-division is fixed so that there remain as variable factors only tonnage and time. The superintendent's business reputation rests upon his output of car-miles, engine-miles and good service.

Siding Delays and Train Operation

Formerly many practical transportation men felt that lap sidings from four to five miles apart on a single track line constitute its development to full capacity, due to the delay required to "head in" and "head out" while others believed closer spacing would increase the capacity. The delay incident to taking siding may be materially reduced by having all siding switches handled by the operators at the continuous service telegraph station sidings.

For a meeting on single track under our train rules, the "switch at which the inferior train takes siding" becomes a "bumping post" for the opposing train. With the recommended plan, it is feasible for both trains to "drift" the entire length of each individual siding at this meeting point. The next step in construction development as the traffic continues to increase is, of course, extending the individual sidings outward, as traffic demands, towards the ultimate double track.

There is another question that would seem worthy of some consideration and that is, should freight trains on a single track division be operated solely on a time card schedule or run extra? There are three plans feasible: (1) To run the trains as extras; (2) to run the trains on time card schedule made up by using some speed per hour for the run with meeting and passing points arbitrarily "strung" on the time card to fit superior trains; (3) to run the trains on schedules based both on such a spacing of leaving times as is found to be best suited to the operating characteristics of the division and, also, on the average performance of such trains as have actually left the sub-division terminal at about this interval apart.

Unforeseen contingencies are constantly arising and must be met with the most complete plan of movement. With a prearranged fixed time for leaving the terminal and a schedule based upon the actual average accomplishment, with meeting points of ordinary freight trains as a rule at open telegraph offices, there remains in the intermediate sidings the required reserve factor for contingencies. These include meeting points with superior trains or unforeseen delays during the "pinches" when, having lost the schedule, everyone knows that the endeavor is to get back in line.

Single Track Movements Must Be in Waves

The movement of trains on single track must be in waves. The continuity of the flow is broken at the meeting and passing points. The best condition exists when the waves marked by adjacent sidings are equal and the continuity of the flow least broken at the sidings. The waves are made up of three parts: (1) The running time between the sidings; (2) the time required to "head in" and "head out" at the sidings, and (3) the time required at the sidings.

We name the sum equal to the time of the train at the siding plus the running time to the next siding, including the time needed to "head out" and "head in," the "time period." We name the time equal to the sum of the time of a train at a siding plus the time required to the next siding, heading out and in, plus the return trip of the opposing train to the first siding and any time needed for it to "head out" and "head in," the "release cycle." The time period is the wave or motion one way of the "shuttle." The best condition of operating efficiency and capacity is created when this motion is not too long and is also uniform with its neighbors.

It is taken for granted that the counselor, in his design, will not consider the question of "fleeting" trains for the reason that waste is at once introduced by means of the delayed time of a train awaiting the arrival of the "fleet." It is also presumed that the employment of the method of "fleeting" trains and the use of blind intermediate sidings may be a part of the everyday operation in emergencies which constantly arise.

In the design of the sub-division this study uses the OS sidings as limits for the "release cycle" and takes for granted the provision of at least one intermediate siding for the necessary routine reserve factor for emergencies such as the delay to one train or the approach of a passenger or other superior train.

The time period should be reasonably uniform without regard to traffic density. It is only a question of quantity as to whether there are trains meeting at every siding or at but few. The "release cycle" is measured when a train "A" meets opposing trains at two successive sidings. The second of the two following trains cannot leave its meeting point until the "go" of the train ahead and the "come" of train "A" complete the "release cycle." Any variation in time periods manifests itself in an increase in waste as delay at the siding. It is the contrasting average delays at the OS sidings which indicate immediately whether the siding spacing is correct. It must always be borne in mind that a superior train standing at one station may delay an opposing inferior train at the next adjacent station just as much as if it were in motion between stations.

Eliminating Lost Time and Increasing Gross Tons

The Adamson Law may have its undesirable features but it also has one big asset, which is that it has convincingly pointed out the gain of the moving train as opposed to the loss of unproductive time. Punitive overtime stimulates a search for the causes when desired speed cannot be maintained.

Ordinary freight trains standing in side tracks for more than 20 per cent of the entire trip are proper subjects for intensive supervision. An advance estimate of how a train ought to perform throughout a train sub-division, based solely upon examination of the track, becomes merely a theory. A similar impression based upon the work of an occasional train becomes a mere opinion.

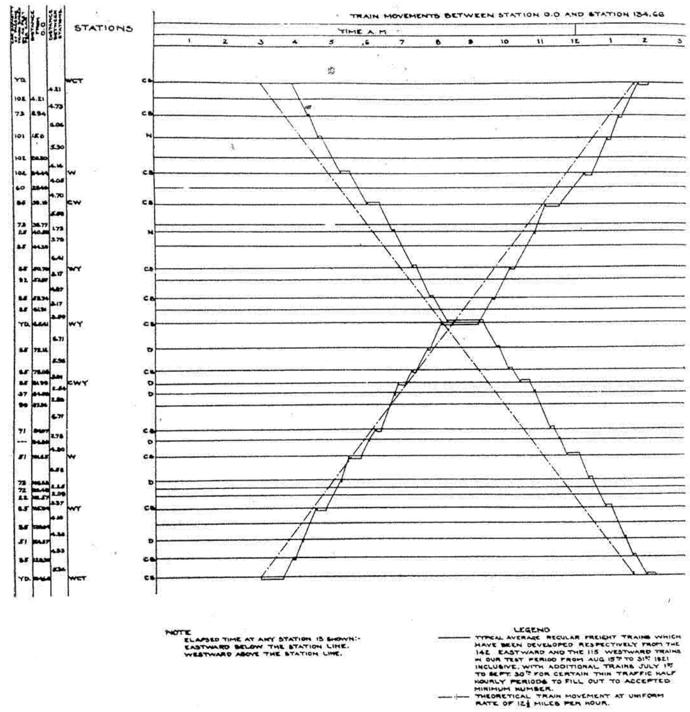
A sub-division plant turns out ton-miles as its finished selling product. It buys train hours as its raw material input. An increase in gross tons may be expected to increase the non-productive time in side tracks so that the motive power aids, such as the "arch," the thermic syphon, the superheater, and the booster, must be supported by Track Capacity Helps, such as the respacing of sidings, adding of signaling and interlocking and proper arrangement of other service facilities at stations.

It would appear quite undesirable to add money to one pocket by increased loading while at the same time taking it in part from the other through increased waste time on side tracks.

In the art of handling a single track railroad freight sub-division, any consideration of "miles-apart" in locating the siding is wide from the point; the question solely in hand is the "minutes-apart." The matter of gradient is one of the factors in fixing the number of minutes-apart for the sidings, another is the time required for service or work at the station.

Units in Track Capacity Studies

The units which stand out prominently in track capacity studies are: (1) The time period required by a train at one siding plus the time required to move to the next and get "in to clear"; (2) the sum made up of the delay of the train in the westward direction at an OS siding plus the running time to the next siding plus the return time of the opposing eastward train; (3) the sum made up of the delay of the train in the eastward direction at an OS siding plus the running time of this train to the next adjacent siding, plus the return running time of the opposing westward train. Under train rule superiority and single track operation these units fix the traffic capacities and it pays to study the district from these various points of view before reaching a conclusion.



Typical Average Freight Train Movements Based on 142 Eastward and 115 Westward Trains. Dot and Dash Lines Represent Theoretical Train Movement at 12½ m.p.h.

We pick the OS sidings for the reason that a reserve factor must be allowed in a practical scheme of operation to cover the emergencies and this is offered by the blind intermediate siding. We know that the whole district train movement must be based on its use of, and departure from, the telegraph station sidings. We propose to reduce the unproductive time at the stations.

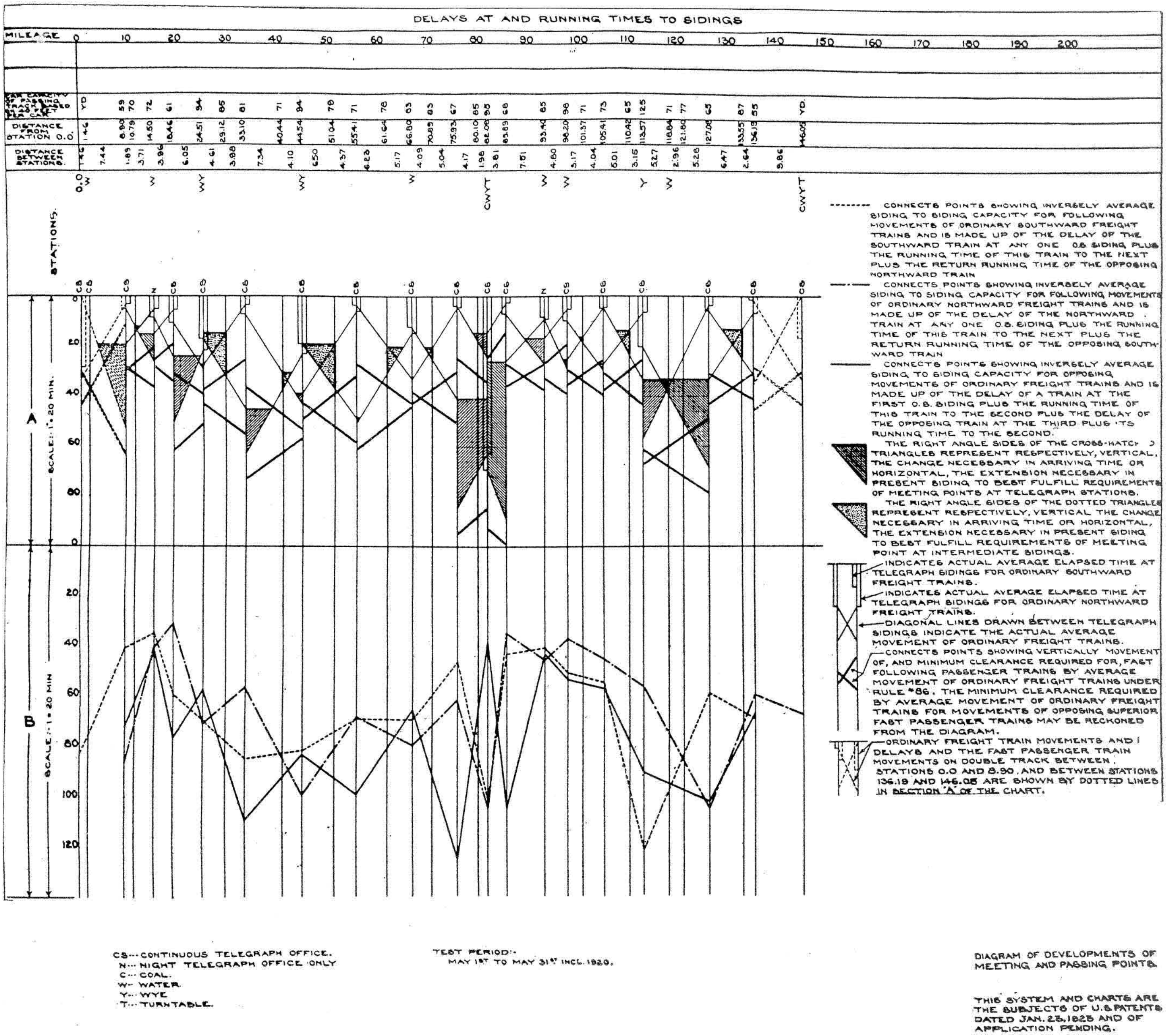
It is quite necessary for the dispatcher to know for future planning whether each train is keeping in step and making good on each "period" and "cycle" and this information can well be given at the end of each "period" and "cycle." It follows that if it is determined from the data at hand that the physical characteristics of a single track sub-division permit a "cycle" of one hour for starting ordinary freight trains from the terminal and operating them over the sub-division, the telegraph stations should be spaced in unison. This has been checked with their actual spacing and found good practice.

Sidings Fixed for Community Service May Cause Losses

The traffic requirements of ticket sales or handling freight should not be preferred factors in the location of the OS telegraph offices. The saving practicable on a $50,000 a month expenditure for freight train expense on a freight sub-division by a correct location of the continuous service telegraph station sidings, is too great to be controlled by meeting-the-public reasons which apply to but a fractiton of the 24-hr. day and can usually be more economically handled otherwise.

A 145-mi. freight train trip, made on the average in 12 hr. 5 min. and costing $201.09, represents 28.7 cents a minute or $17.21 per hour. With road service practically the only creator of "ton-miles" we must jealously watch each idle train-minute spent on any track.

Devices are available that will pay for themselves in three months, six months or a year and that in doing so will add 200, 500 or even more tons to a freight train, depending upon the physical characteristics of the road. Such devices should make up a good part of any improvement budget. A booster that will add 350 tons to the train load over the entire train district by 16 per cent increase in tractive power on the usual few short pulls with but 5 per cent increase in static weight; an interlocking plant; an isolated remote control switch, should each be a first preferred item.



Graph Shows Locations Where Greatest Delays Occur. Vertical Lines of Triangles Represent Change Necessary in Arriving Time or the Horizontal Sides Represent the Extension Necessary to Present Sidings If No Change in Arriving Time Is Made

Balanced Expenditures Needed

A broad decision as to the balancing of various classes of expenditures must be made. In one recent case an expenditure of $30,000 for a "Traffic Capacity Help" added 400 gross tons to the trainload with a return of 70 per cent per year on the investment.

The fixed and steady burden of the few heavy increases in capital charges, such as double tracking, grade reduction, and bridges for heavy power should be assigned to their proper balance in the budget with the "constant, steady stream of relatively small expenditures" for track capacity which may be depended upon to give immediate returns in direct ratio to the normal increase in traffic. There will be, under this policy, no improvements proposed which would be thrown away later on account of double tracking when the traffic density really forces consideration of such an expenditure.

Speed Requirements and Effect on Costs

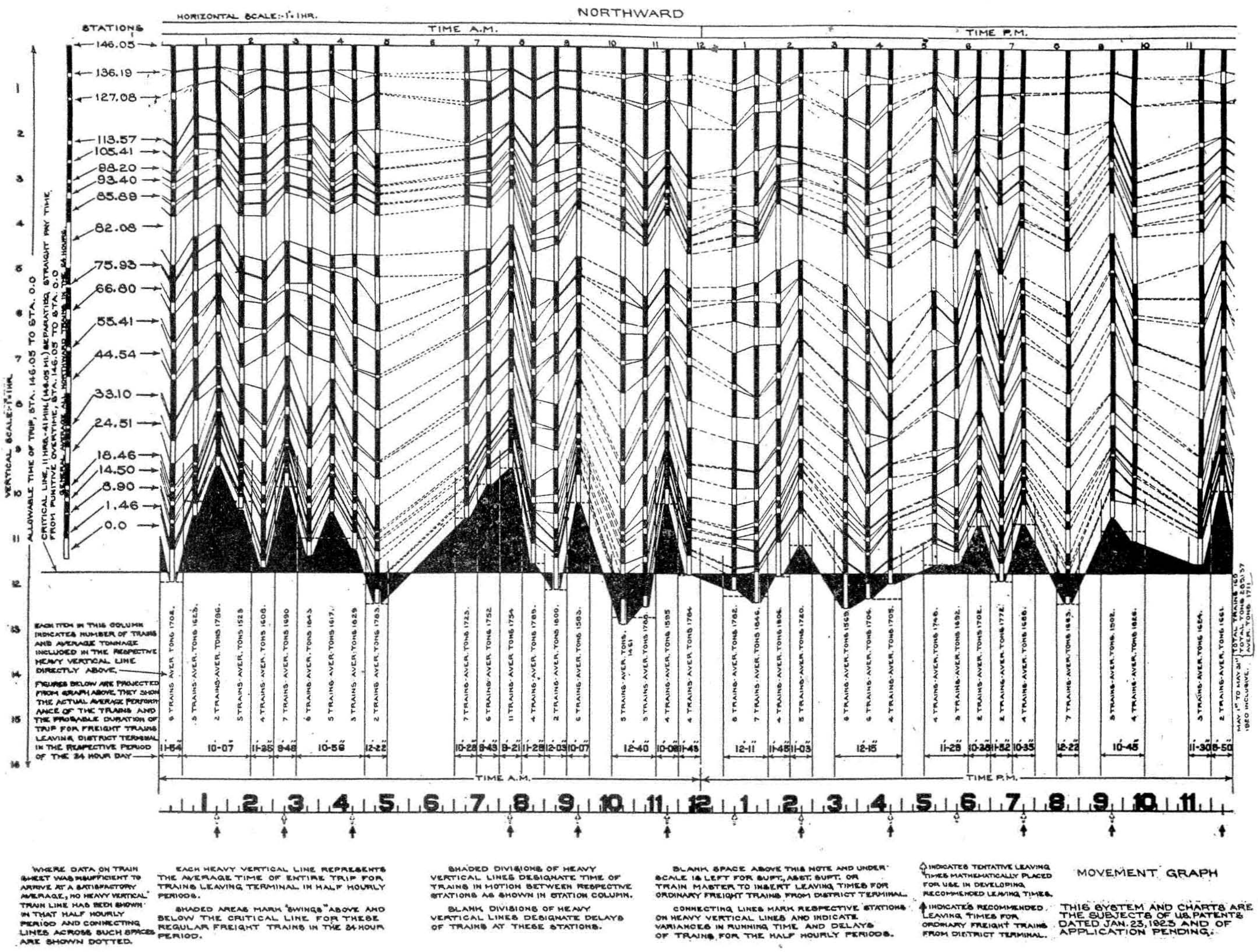
An average speed is required for freight trains, between stops, of 20 miles per hour or greater, so that due leeway may be allowed for reasonable delays at stations and yet the average rate of speed between terminals held above the critical line separating punitive overtime from the straight pay of 12½ miles per hour. In justifying this average of speed, it becomes desirable to study roughly the account, "Cost of Train-miles, Freight Trains." The amount of money involved per month in this account for a single track sub-division of reasonable traffic density often is more than $50,000 and sometimes reaches $75,000. This amount is divided approximately into thirds for the items: (1) Locomotive Repairs; (2) Wages, and (3) Fuel. A saving of one per cent means from $500 to $750 per month and the effort made towards such end becomes, thereby, well worth while.

The distribution of accounts on the mileage basis, which is in fairly constant ratio to the hour basis, makes it simple and practicable to find, in a convincing way for the practicable man, the money equivalent of the time saving returns of our various track and equipment attachments under present operating conditions. We should all aim upwards for a performance of "20 miles per hour in motion between sidings" and downwards for "20 per cent of trip on side track." In passenger terminal work, the minimum "reserve factor" as developed by experience, for flexibility in allowing the spacing of independent schedules, has been two to one, viz: as much time between trains as required by each train.

Effect of Variation of Periods

A study of the operation of the usual freight train subdivision will show, as a rule, a wide variation in the average "period" between telegraph offices. If the train periods between several adjacent sidings vary within wide limits, the whole remaining dependent movements in that vicinity shut down for an interval when one period is noticeably longer than the remaining dependent and interlocked movements. The latter must await "their turn," therefore the "turns" between sidings must be reasonably uniform if a fairly steady train movement is expected. Anything else quickly brings "lag," made up oftentimes of wasteful delay on side tracks.

To make a single track do the work of a double track on a sub-division as far as the probable traffic density is concerned, consists in forwarding the trains from the subdivision terminal at such times as the developed ex-



Individual Time Cycles Compiled from Average Schedules from Which the Best Available Spacing of Leaving Times from Terminals Is Selected as Shown on the Clock Time Scale perience by actual average performance demands and in "putting your house in order" as to keeping in step the time "period" between sidings.

There may be train hurdles such as "pockets" or "blank walls" scattered throughout the district or sub-division 24-hr. day. These "blank walls" are created by "siding time spacing periods" being poorly matched, together with an unfavorable combination of superior trains. The cure is to change the schedule so as to miss the "blank walls" or to secure a betterment appropriation for either the rearrangement of sidings or signaling, or both, at the spot to reduce the "time period" and make "an opening in the wall." Fortunately, as a rule, a small capital expenditure is necessary or a relatively unimportant change in method is required. In railroad operation, selected attachments often will make a single track line do the work of a double track line nicely, as far as both existing and prospective traffic density demands.

Remote Controlled Switches Help Operation

From the financial return viewpoint one can hardly afford to have train crews handle switches at continuous service telegraph offices on "big power" districts. With a rule requiring uni-directional traffic on the sidings, the heading-in point being at the "lapped ends," it is relatively cheap to install mechanical interlocking levers in the telegraph office to handle the switches. A spring switch at remote ends of sidings (with a shock absorber to protect the switch point, and with automatic electric signals to register the contact of the switch point with the stock rail), or else a remote control operation will save a stop for the trains in heading out and are helps which are being used successfully.

The study of the problem should be given the necessary support and appreciation. One reason it has not preceded in its field the scientific advance of the telephone, is not only the fact that the great number of transportation executives have no leisure for deep study and therefore for creation of the necessary statistics, but also that such men can neither adequately understand nor interpret such statistics for other classes of men.

The Need of a Research Organization

It follows clearly that there must be some skilled research organization which has the necessary familiarity with movement of trains built up to handle such work for our busy division and general transportation officers. Its name might be expressed by the term "Traffic Capacity Counseling."

For the purpose of study of single track operation by this "system" I have developed the following:

RAILROAD OPERATION

Laws of Single Track Capacity

(1) Unit of Freight Train Operation.—The normal unit for study of freight train operation is the sub-division (district).

(2) Measure of Efficiency.—The measure of efficiency of the district for the ordinary freight train is the movement of the average train.

(3) Meeting Point.—A meeting point is complete when the trains are "in the clear."

(4) Capacity Varies with Time Spacing of Sidings.—The capacity of a district for ordinary freight trains varies inversely with the maximum time between being "in the clear" at adjacent sidings and may be increased by decreasing this time whenever the latter may be excessive, either (1) to take siding, (2) to perform other service, or (3) to make the run between stations.

(5) Capacity.—The greatest capacity follows with least waste such operation of a single track district that each freight train meets an opposing freight train at each siding.

(6) Opposing Movements.*—For the meeting point at siding B in a consecutive series of sidings A, B and C, the delay at A to that train which is approaching B from towards A plus the running time from A to B should equal the delay to the opposing train of the pair at C plus its running time from C to B.

(7) Capacity of Opposing Movements.—For the greatest capacity and efficiency the sum of the delay and subsequent running time between adjacent sidings for either train of a pair must be the same for any meeting point on a district.

(8) Opposing Movements of "Fleets of Trains."—Fleeting trains increases capacity at a sacrifice of economy through the delay consequent to moving the "fleet" into the meeting point.

(9) Following Movements — Theoretical Spacing.* — The minimum best theoretical spacing of following freight trains in leaving a district terminal and operating throughout a district is fixed by the cycle of movement which is the sum of the running time of a train from siding A to siding B, plus the return trip of the opposing train from B to A plus the time for inferior train to enter and leave siding.

(10) Capacity for Following Movements.—For greatest capacity and efficiency, the cycle of movement between adjacent sidings for spacing following trains should be the same for each two adjacent sidings on the district.

(11) Following Movements Actual Service Spacing.†—The best actual service spacing for following freight trains in leaving a district terminal and operating throughout a district is fixed by the cycle of movement which is the sum of the delay at station A to that train which is approaching station B and A plus the running time from A and B plus the return running time B to A.

(12) Delays Due to Time Card and Train Orders Operation.—Conferring superiority by right, class or direction under the existing train-rule plan may create unproductive time and thus become due to the contrasting inferiority, an adversely limiting factor of the capacity of the train district in case of any delay at the siding.

The Development of Money Saving Schemes

I develop from the charts and graphs: (1) The traffic capacity of the sub-division; (2) the best available schedules for the operation of ordinary freight trains on the sub-division as it stands, and (3) (a) the correct location of siding, (b) the best physical handling of siding switches, and (c) location of station train service facilities, to secure an improvement in the existing transportation plant, both without excessive capital outlay or production of non-paying betterments.

I believe that a satisfactory, sound and money saving scheme of traffic capacity development for road improvement work and methods listed in order of preference to increase capacity on single track lines and at the same time avoid non-paying and burdensome betterments is to:

(a) Rearrange the location of sidings in accordance with the best available siding spacing cycle for estimated traffic requirements.

(b) Relieve the trains at continuous service telegraph sidings of handling the switches, including the remote ends of both laps, by installing mechanical connections for the near switches and low voltage remote control connections or automatic spring points for the far switches.

(c) Assist the train dispatcher in preventing non-productive time due to delays at sidings, by (1) Installing isolated controlled manual blocks to move trains between the continuous service telegraph sidings and the non-telegraphic siding next adjacent in either or each direction; (2) Rearrange water supply and coaling stations so as to permit service on more than one track, in one convenient location to avoid extra moves and to suit the traffic.

(d) From time to time, as traffic requires, extend one or both ends of sidings with the signaling until, eventually and coincident with the business demands, the complete double track is supplied. For motive power improvement work and methods install the arch, thermic syphon, feed water heater, superheater and "booster."

An intelligent, systematic and comprehensive program of relatively inexpensive improvements for the benefit of the ordinary freight train may be reasonably expected to result in an attractive new average movement of 20 miles

*Note—(6, 9, 11) The exception is a yard which absorbs trains without interference to or from opposing trains.

†Note—At a district terminal, time ends when the train is placed on designated track or crew relieved.

per hour between OS stations and 20 per cent of total trip on OS side tracks.

The Graphs and Their Use

The movement of the average ordinary freight train has been gradually outlined in the graphs. On the upper left hand edge of the graphs is set up one average train for the entire test period. Stretched across the upper half of the graphs, and on the same scale for comparison's sake, are test period trains segregated into half-hourly average groups throughout the 24-hr. day. The minimum number of individual trains, making up the average for each half-hourly period, is three. The variations, as between both the average running times and delays both at each OS station and for the complete sub-division trip, are thus brought into prominent notice.

Opportunity is so given for local study of the performance at each OS station and for each half-hourly period. It does not always follow that the presence of superior trains or physical misfits of the sub-division are the sole cause of waste. It may be that a trainmaster, with the information before him, may materially improve operating methods at an OS station for a certain period of the day and make, thereby, a marked improvement in the entire sub-division output. The average ordinary freight train is the product which is feeding through the plant. Cutting out a section of waste time anywhere affects the entire sub-division movement for the better.

The graphs, in addition to their use as an aid to the transportation officer in making a study of his plant, also furnish a recommended time table for the operation of ordinary freight trains through the clock time scale near the bottom of the graph and the time cycle, as the best available leaving times of trains from terminals may be plotted on the graphs. The basis of such a plotted recommendation is that a repetition of an actual average performance may also be reasonably expected.

One graph illustrates, in a way, the gain that is practicable by the method of "running through" instead of tying up one crew and calling another. A diagram shows the comparison of an actual average schedule with the theoretical 12½ mi. per hr. line.

Use of the Clock Time Scale

The individual time cycles are compiled from the average schedules and tabulated for each OS siding spaces. From this table is selected the best available spacing of leaving times for the terminal for following trains. This it plotted below the clock time scale by the blank arrows and with the help of the half-hourly average the best tentative leaving time for ordinary freight train may be selected and plotted by the full arrows.

With selected times designated by the full arrows as starting times and actual average half-hourly schedule accomplishments as recorded on graphs, a tentative printed time table is developed upon which to base the actual daily operation of trains or to plan for new traffic requirements.

From the facts brought into prominent notice by the graphs and diagrams, coupled with local studies of the district, decision may be quickly reached as to how to bring in step the various siding spacing periods and cycles and whether it will be advisable either to "head in" or "head out" by signaling or interlocking, lessen the service time at siding by rearranging water facilities, etc.

From the data which have been presented I believe that I am well warranted in concluding that before any extensive outlay is authorized for either double track, grade revision or heavy power, there should first be made a thorough scientific transportation survey of any freight train district to develop the possibilities of traffic capacity increase by both the addition to or rearrangement of present single track facilities and the addition to the locomotive of the arch, thermic syphon, feed-water heater, superheater and "booster."

I also believe that a thorough scientific transportation survey of any busy freight train district is fully warranted for use by the officers: (1) In conference with traffic people as to what can be done with ordinary freight trains; (2) in making time cards for ordinary freight trains, and (3) in forwarding and operating ordinary freight trains.

History of the P. & R. Signal School

THE signal school of the B. R. S. of A., Local No. 26, on the Philadelphia & Reading with headquarters at Reading, Pa., was organized in October, 1919, with the following officers: Chairman, E. W. Reich; secretary, G. C. Hartline and treasurer, M. T. Rhoda. The meetings for the first several months were held in the city Y. M. C. A. at Reading. Blackboard sketches were used in outlining the principles of signaling. The interest displayed by the members resulted in the expansion and development of the school to such an extent that more spacious quarters were required, which were provided by the railway company in the lower part of the P. & R., Y. M. C. A.

At its present location, the school has installed model tracks equipped with working models of the different types of automatic signals in use on the railroad. On March 1, 1922, a Balioptican machine was purchased which will take photogravures 5 in. wide of variable lengths. Through the untiring efforts of the instructor, Signal Foreman W. E. Skinner, sketches have been furnished and used to a decided advantage in the Balioptican machine. Various phases of signaling from track circuits on automatic signals up to and including approach and route locking have been studied, which is in line with the policy of the school in seeking to broaden the field of usefulness of employee to employer.

On March 24, 1921, J. F. Talbert of the Union Switch & Signal Company gave a lecture on Type T-2 a. c. signals, while on June 19, 1921, P. G. Pendorf of the National Carbon Company talked on the primary battery and its uses. On June 20, 1922, E. H. Watkins of the Electric Storage Battery Company gave a lecture on the construction of the various types of storage cells and their use in modern railway signaling. On August 29, 1922, J. M. Spangler of the National Carbon Company talked on high voltage primary batteries, dry batteries, etc., in the course of construction and their relative merits. For the meeting of May, 1923, the occasion of the first annual banquet, E. S. Berry of the Hall Switch & Signal Company gave a lecture on general signal equipment.

The work of the signal school has been a decided factor in the efficient maintenance of signals which has resulted in greater economy in train operation by "Keeping Trains Moving". The prospects are bright for future developments which will lead to a still higher degree of efficiency because of a continued desire on the part of the school's members to be prepared in advance for future requirements of railroad signaling. This signal school claims to be the first organized school in the country, conducted solely by the members of the signal department who are paying dues and paying for the service of the instructor, and attending the school on their own time.