Railway
Signaling &
Communications

Railroad in metropolitan area might also handle rapid transit trains.

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In spite of the large expenditures for urban highways in recent years, urban traffic congestion is still an unsolved problem. The dispersed pattern of urban growth based on auto transportation, plus increasing traffic congestion, has made a mass transit solution based on traditional methods of surface transit virtually unworkable.

There exists a need for rapid transit systems to link together the focal points of a modern community. Such a system must provide high schedule speeds and must be carefully integrated with existing surface operations and such new forms of distribution as are under development, and must have adequate station parking facilities to encourage motorists to leave their cars.

The pattern of operation indicated is a clear departure from classical rapid transit having two or three stops per mile and a schedule speed of 20 to 25 mph.

By virtue of their location, many railroad rights of way are well suited for the rapid transit service just outlined. The use of an existing right of way for a new rapid transit service offers four important advantages:

- Initial construction costs are reduced.
- Disruption to existing neighborhoods is reduced.
- Tax losses to the communities are reduced.
- The railroad achieves a more economical operation by selling or leasing its excess capacity.

There are two ways in which a rail-

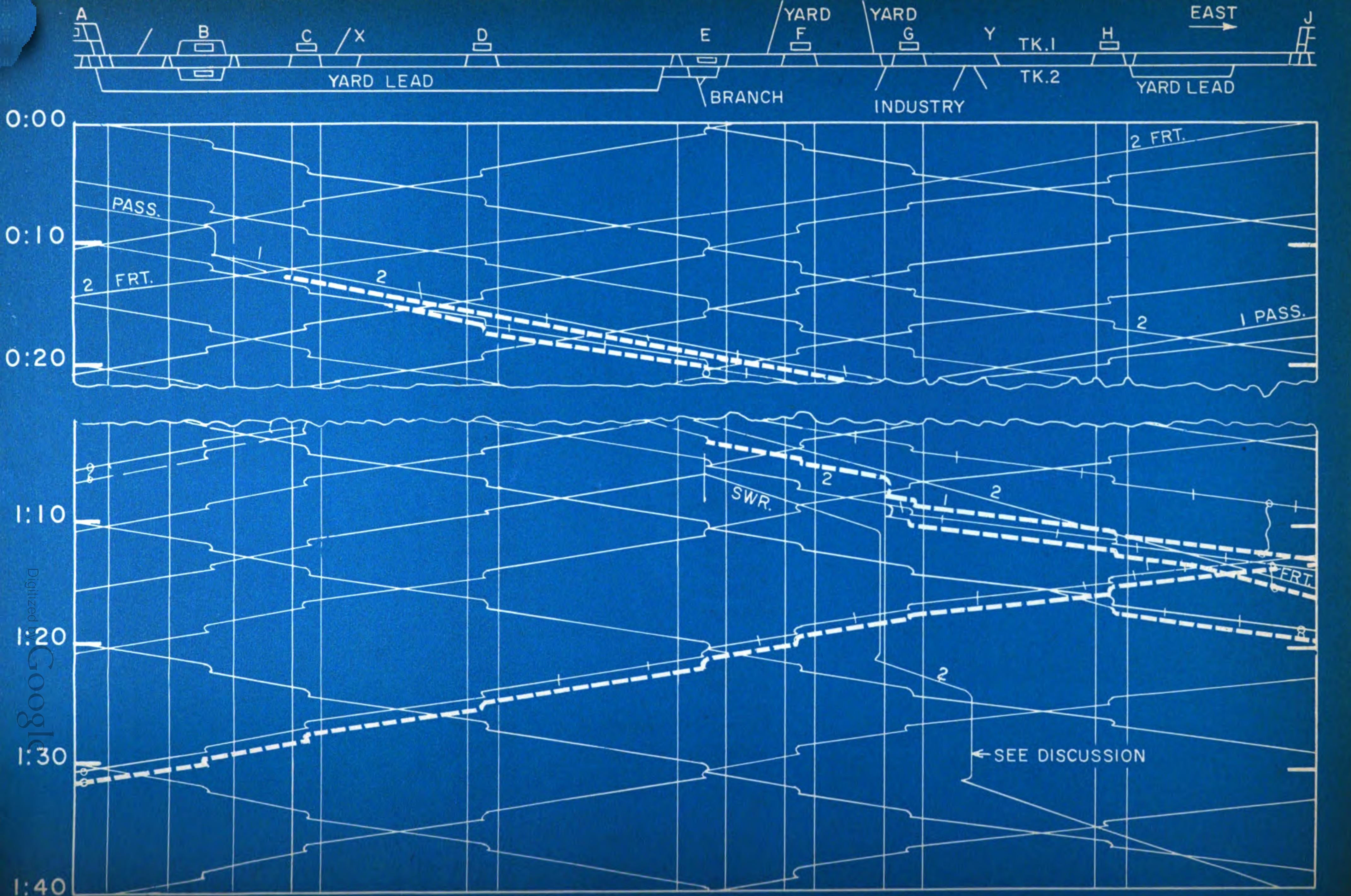

FIG. 1 GRAPH LINES REFER TO REAR OF TRAIN. 1" = 10 MINUTE 1" = 1 MILE

ad right of way may be used to provide rapid transit service: (1) Rearrange existing railroad facilities to provide for separate rapid transit facilities within the railroad property lines. (2) Operate the rapid transit service on railroad tracks.

The first method presents no particularly serious problems. If space is not readily available for rapid transit facilities, consideration can be given to streamlining the railroad plant by installing a traffic control system, by diverting traffic over an alternate route, or by closing or relocating particular railroad facilities that would interfere with the proposed service. The second method introduces a number of important problems which will be discussed.

If railroad and rapid transit services are to be operated on the same plant, the design of that plant must reconcile the markedly different characteristics of the two types of service. Some of the design considerations are:

- The railroad cannot be expected to alter drastically the pattern of operation of its long distance trains to accommodate the requirements of a rapid transit operation on a short segment of its line.
- Even though they may have a timetable schedule, the occurrence of a railroad train must be considered a random event.
- In some cases, the railroad may be able to alter its operation of switching and terminal moves to accommodate the peak hour requirements of the rapid transit service.
- The rapid transit service requires a high degree of punctuality.
- The rapid transit stations and cars must fit the loading gauge standards of the railroad.
- Provision should be made at station areas to permit the movement of wide shipments.
- The effect of grades and railroad crossings at grades must be considered.
- The signal system must be compatible with the railroad's standard practice.

To meet rapid transit requirements, the signal system must be designed to permit minimum train separation while maintaining adequate braking distance for railroad trains. With freight train braking distances at 60 mph of the order of 7,000 ft (full service application on level track) a 5-aspect, 4-block signal system having 2,500 ft blocks is indicated. This block length would permit passenger train operation in excess of 80 mph.

Signal indications based on railroad train characteristics are more restrictive than necessary for rapid transit operation. A 2,500 ft block provides ample braking distance for an 80 mph rapid transit train. With this block length, it would be desirable to have rapid transit trains operating with 3-aspect, 2-block signaling. This can be accomplished by setting up a dual system of signal indications, one for railroad trains and one for rapid transit trains, as detailed in Table 1. (Relief from the requirements of ICC RS&I No. 136.23 would be required for this type of operation.) It is a basic requirement that each signal aspect have only one indication; otherwise, unsafe conditions can result. With railroad and rapid transit services being operated by completely separate organizations, this condition is satisfied by the system (Table 1) since within each organization, each aspect has a unique indication.

Indications of aspects calling for a speed reduction in preparation for a diverging move at an interlocking would remain the same for both operations. (Approach-medium, for example) Train control, if used, would be the same type as the railroad used.

With a basic signal system outlined, it is now possible to consider the rapid transit headway that might be operated if freight trains are to be sandwiched in between rapid transit trains. The signal system would force a freight train to regulate its speed so that it would follow a leader at approximately braking distance from the red signal protecting the leader. The worst case occurs with the leader just leaving a block so that separation between the two trains is freight train braking distance plus one block. Similarly, a rapid transit train following the freight would be two blocks behind the freight. The total headway distance then is three blocks plus freight train braking distance plus freight train length plus one rapid transit train length. This last length may be considered short compared with the other dimensions. The headway time is the headway distance divided by the schedule speed. A curve may then be plotted of minimum headway vs. schedule speed.

Workable rapid transit headways become possible with schedule speeds above 30 mph. While the mixing of railroad and rapid transit trains precludes the operation of 90 sec headways, few cities require such a service. A five minute headway at schedule speeds in excess of 30 mph would adequately serve most middle sized cities and less densely developed areas of large metropolitan centers. If the rapid transit service can be given the exclusive use of the tracks during rush hours, this signal layout would permit 90 sec headways at 40 mph schedule speeds.

There are other problems to be con-

Rule	Aspect	Standard Code Indication	Rapid Transit Indication	Train Control Inductor (If used)
281	Green	Proceed	Proceed	Clear
281A	Green/Yellow	Proceed Approaching Second Signal at Medium Speed	Proceed	Acknowledge
282A	Yellow/Yellow	Proceed preparing to stop at Second Signal	Proceed	Acknowledge
285	Yellow	Proceed preparing to stop at Next Signal. Train exceeding Medium Speed must at once Reduce to that Speed.	Proceed preparing to stop at Next Signal. Train exceeding Medium Speed must at once Reduce to that Speed.	Acknowledge
291	Red*	Stop: Then Proceed at Restricted Speed	Stop: Then Proceed at Restricted Speed	Acknowledge
292	Red	Stop	Stop	Acknowledge

* Indication qualified by distinguishing marker.

Table 1—Standard code and rapid transit signal indications.

sidered besides a headway calculation. These are most easily visualized by means of a model as shown in Figure 1, where distance is plotted on the abscissa and time on the ordinate. In this model, rapid transit trains use a double track railroad between points A and J, a distance of 10.2 miles. Rapid transit stations are located at A and J and at intermediate points as shown, Pertinent railroad facilities are indicated. Station B is also a suburban stop used by railroad passenger trains. It is assumed that the rapid transit line provides a 5 minute headway during a one hour peak period and a 10 minute base service. A number of railroad trains occur at random during the peak hour. Trains operate under traffic control system rules with a block signal system similar to the one previously outlined. There is a 30 mph speed restriction for a distance of one-half mile just west of station E.

As a first step, a rapid transit schedule was constructed. Since the primary purpose of this model is the study of conflicts between rapid transit and railroad trains, a simplifying assumption of an average acceleration rate of 1 mph/sec to 70 mph was made. A braking rate of 3 mph/sec and 30 sec station stops were assumed. This results in a running time of 18.6 minutes for the 10.2 mile distance and a schedule speed of 32.7 mph. This schedule was plotted as shown in Figure 1.

To leave one track clear for wide loads, a single station platform is located outside the tracks. This arrangement also reduces station costs as bridges or tunnels to the platform are eliminated. Leaving times of westbound rapid transit trains were then adjusted to meet eastbound trains between stations. With this arrangement, opposing trains normally meet at station E and facilities there were arranged to permit this.

Several typical railroad trains were then added to the model. The freight

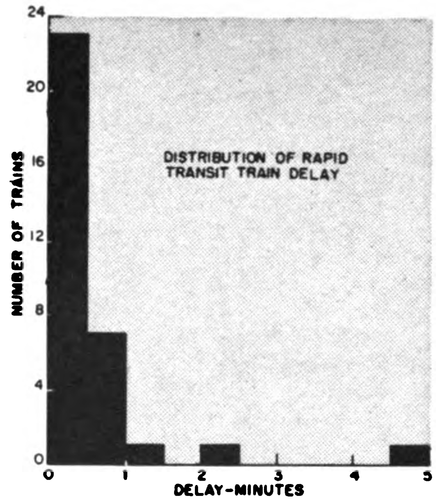

Fig. 3—Frequency distribution of delays of rapid transit trains.

trains are assumed to be one mile long and the passenger trains about 1,000 ft long. With the projected operation displayed on the model, the problem then is the design of a track layout that will resolve the conflicts among the various trains. The approach used in the model is shown in Figure 2. In this arrangement, a single interlocking is located at each station. The station track, however, is outside the interlocking limits. This arrangement results in a more economical signal design than having a separate interlocking at each end of the station while retaining the operating flexibility of two interlockings. Additional facilities were added to this basic arrangement where required.

At this point the problem is fully defined. Redispatching the operation on the proposed track layout gives the results shown in Figure 1, where the broken lines show the changes in train operation caused by operation on the given track layout.

A switcher working the industries on track 2 between stations G and H will cause delay to rapid transit trains. This can be eliminated by installing an interlocking crossover at Y. The need for this crossover can be determined by considering the frequency and the time of day at which this operation occurs. Similar remarks apply to crossover X.

When a high density operation with trains having widely differing characteristics is proposed, train delays are inevitable. At the beginning of a study, some criteria should be established to gauge the performance of proposed plants. These would properly include a statistical analysis of expected delays. While such a project is beyond the scope of this paper, Figure 3 shows a plot of the frequency distribution of the delays of the rapid transit trains graphed in the model. A study of this distribution for a larger number of trains would permit the construction of realistic operating and equipment schedules and reasonable coordination with feeder schedules.

The effect of drag freights on rush hour operation is clearly shown. If they are operated frequently, it may be necessary to restrict them during rush hours. Rush hour restrictions to trains that are powered to make at least rapid transit schedule speed should not be necessary, unless they are of exceptional length.

If some restrictions are placed on rapid transit minimum headway, it is feasible to mix transit and railroad traffic on the same plant. By constructing a model that takes into account all relevant operating conditions, it is possible to see the operating problems that occur, devise a plant to meet them, and to see the effect of that plant on the operation. An analysis of the operation in the model permits the comparison of that operation with previously determined standards, and once a design has been established, the construction of working schedules.

There are areas where the excess capacity of railroad lines can be used to provide rapid transit service. RSC

Editor's Note: Mr. Garrison's article. above, is an answer to a previous article we published concerning the practicability of mixing rapid transit and conventional railroad trains on the same trackage (RSC August 1962, pages 13-17). The author of this earlier article was Wilfred Sergeant, assistant general superintendent transportation, Canadian National. He contended, in general, that it would be better to provide separate tracks and signaling for rapid transit operation. To handle more than 10-12,000 passengers per hour would require, Mr. Sergeant contended, that separate mass transit techniques should be used, rather than a mixing of rapid transit and conventional railroad trains.

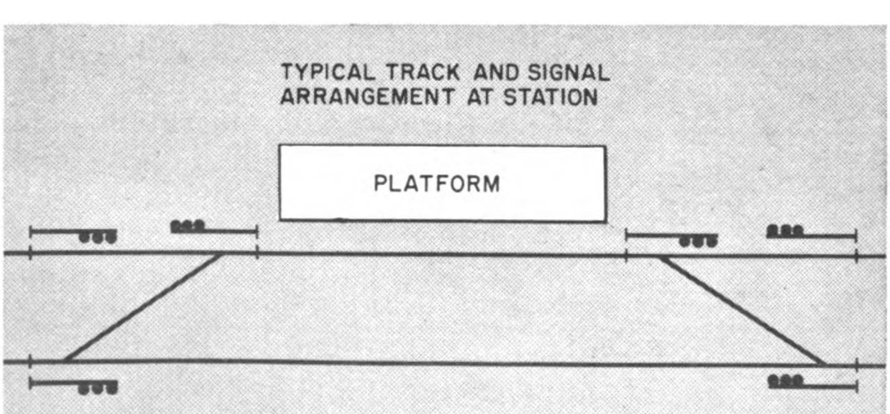

Fig. 2—Station track is outside interlocking limits.