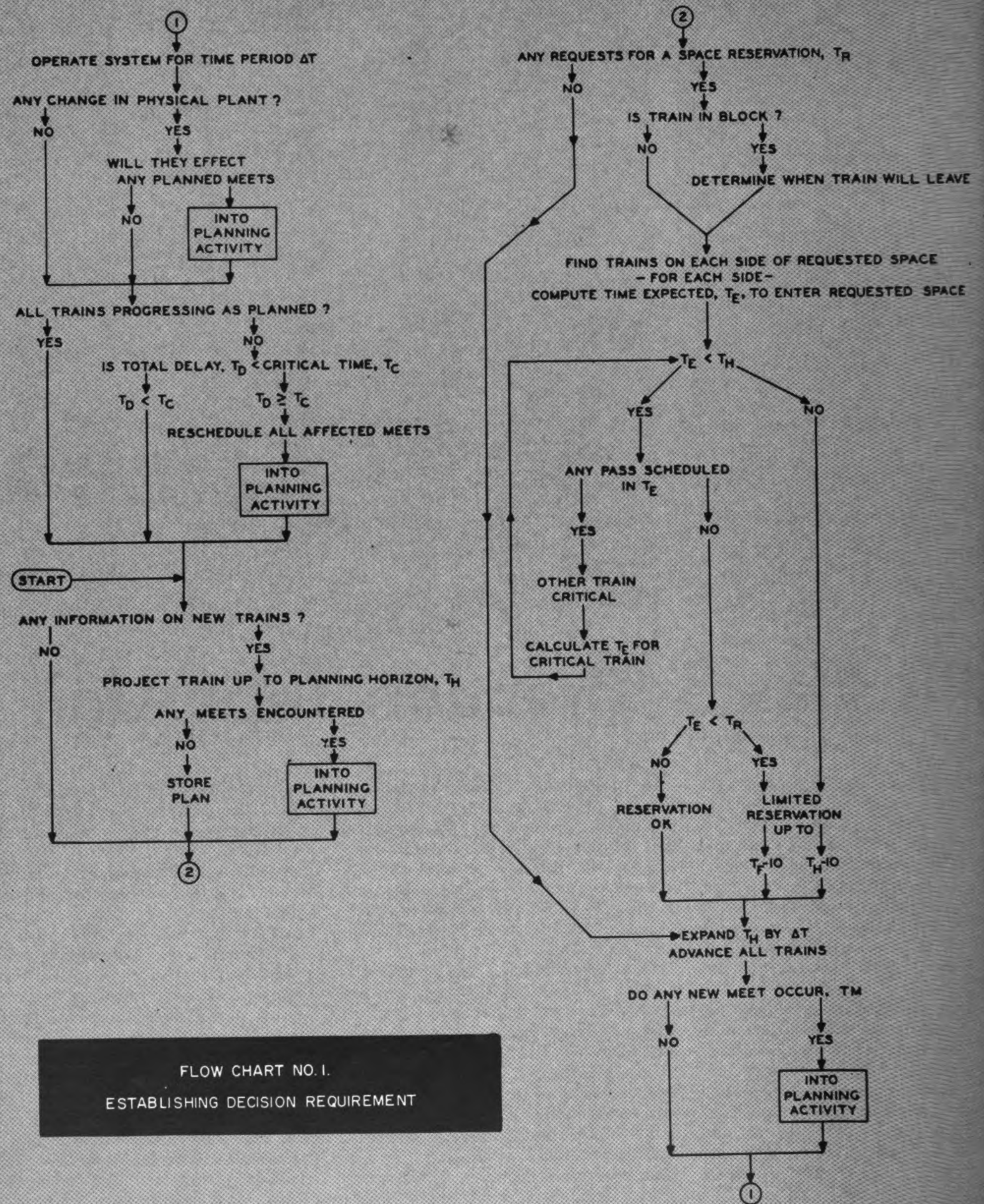
Digital Computer Simulates CT



FLOW CHART NO. 1.
ESTABLISHING DECISION REQUIREMENT

spatcher

A computer can aid a train dis-patcher in controlling a single-ack railroad with CTC. How this is ›ne was described by John L. Gable, ›erations research analyst, The Mil-aukee Road, at a recent AIEE meet-g (RS&C July 1960, page 24). The ›e of a digital electronic computer for is simulation raises one peculiarity hich should be noted. In real life, me is an on-going, continuous thing; ıe dispatcher can react to things as ıey happen. But the computer will ıke discrete increments of time—as ne or as rough as we want them, de-ending upon the fineness we want in ıe simulation—and analyze the events ıat occurred during the time interval.

During our contemplated simula-on, the computer will cycle by mov-ıg the time threshold (the present ıovement) forward by "delta t" min-tes. It will then progress all the trains cross the system by the proper mounts. The program will then re-iew the data for the time period to ee if any of the following types of vents have occurred (flow chart 1).

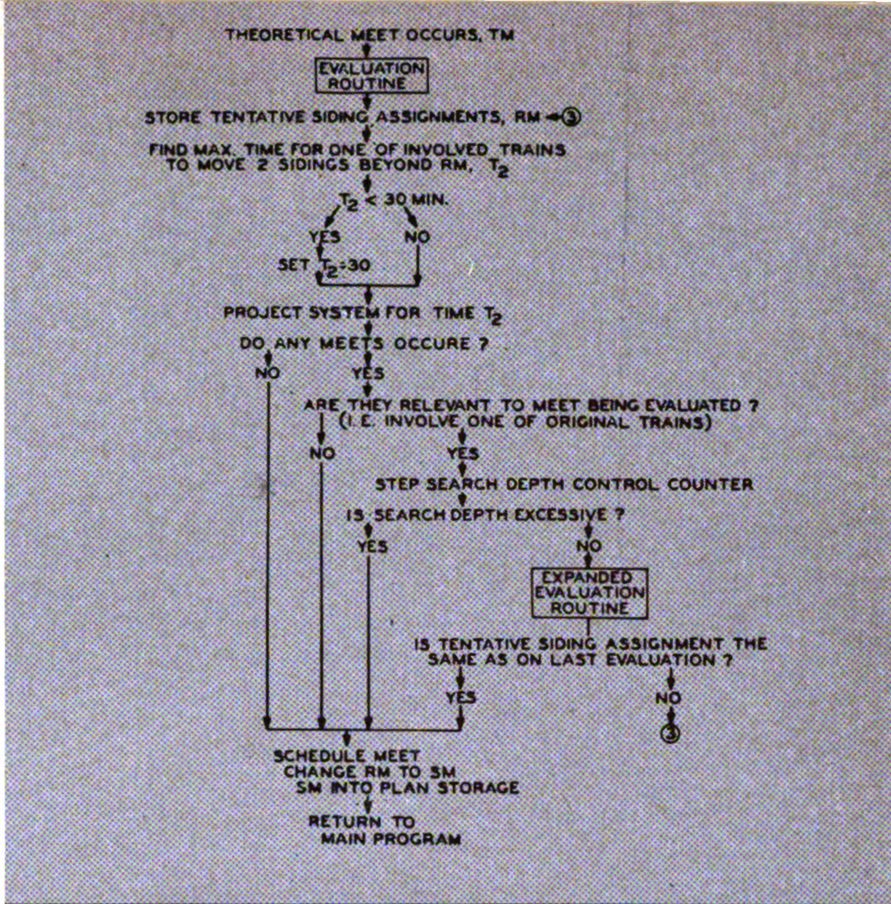
First, the computer will check to see f any changes in the physical plant ıave taken place. Have any switches ›r signals become inoperative; have ıny sidings been blocked by cars set ›ut for hotboxes? If so, the siding is ıo longer usable for running meets, :hough it may still be utilized for a ›emi-saw-by meet. Will any of these :acts cause the dispatcher to change his ɔlans?

Second, are there any trains which are falling behind their contemplated performance? If so, is their delay suffi-cient to require a rescheduling or re-planning of meets?

Then the computer would project the performance of all the trains into the future for time "delta t." It would then investigate these anticipated movements to see if any theoretical meets occurred. If they did, the com-puter would then have to go into a planning routine to assign the meet to a siding.

Finally, the computer would investi-gate any requests to reserve a block of time on a segment of the railroad for use by a switch or maintenance crew. Depending on the priority of the re-quest, will the dispatcher have to change his plans?

A plan is a projected or anticipated course of action. For any particular in-stant, with its particular set of trains, locations, directions and velocities, a large number of courses of future ac-tion are available. Some plan evalua-tion technique—analogous to the use by a human of judgment criteria—will have to be developed. These are three levels of activity which must be carried on by the decision simulation program: (1) establishing decision re-quirements—**flow chart 1**; (2) plan-ning activity—**flow chart 2**; (3) plan evaluation and choice—**flow chart 3.**



FLOW CHART NO. 2. TYPICAL PLANNING ACTIVITY

Let us proceed by investigating the type of elevation criteria which might be developed for discriminating be-tween alternate choices when a theo-retical meet or pass has appeared. Consider for a moment a train per-formance ratio—

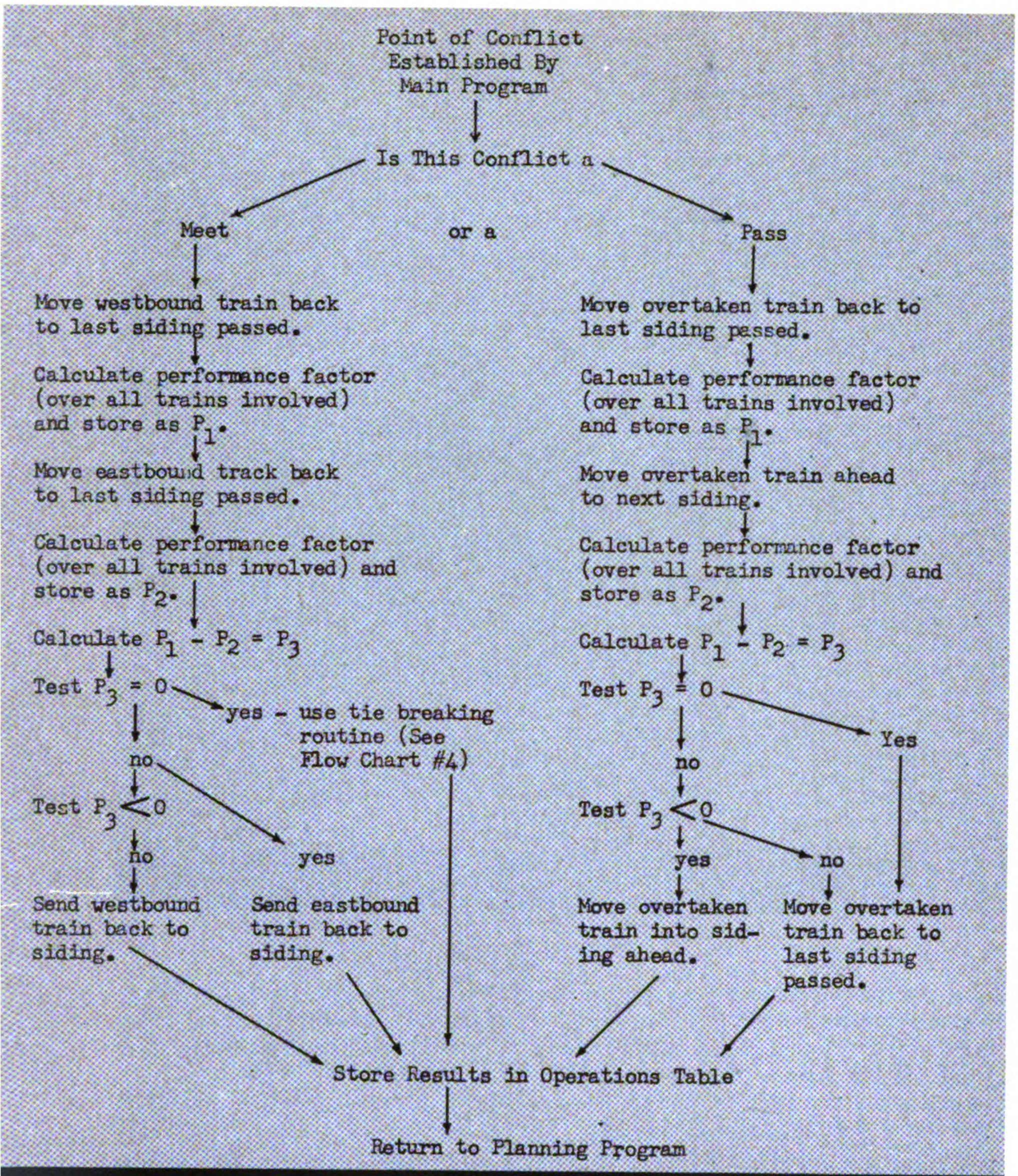
$$P = \sum_{i=1}^{m} W_i \sum_{j=1}^{n} \frac{T_{ij}}{t_{ij}}$$

Where:

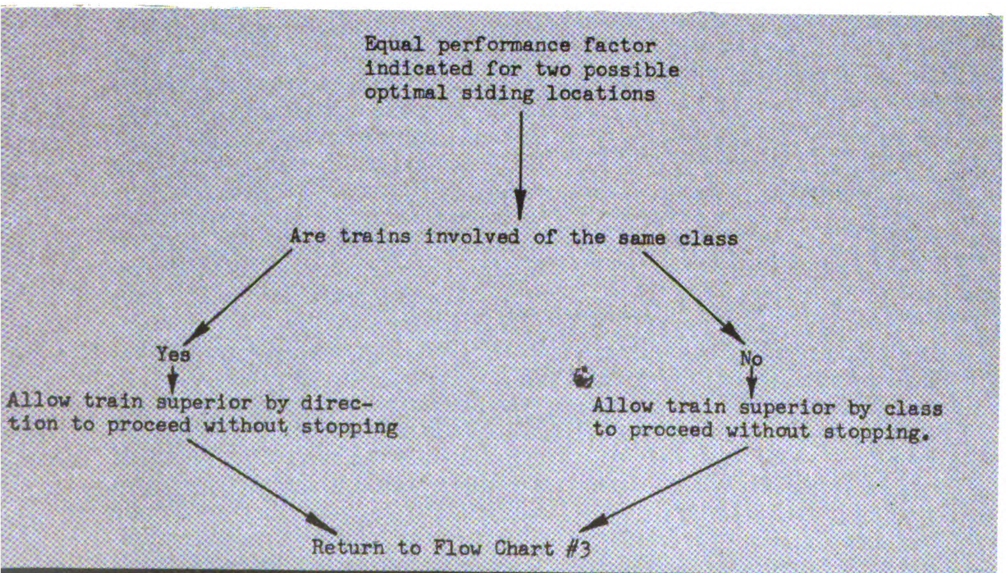
- t_{ij} is the actual time, including de-lays, required for a train to trav-erse a segment of track (note that t_{ij} is always greater than zero).
- T_{ij} equals expected best perform-ance of a train with no delays—includes factors for engineer capabilities, weather and track conditions.
- i equals train number.
- j equals track segment number.
- **m** equals number of trains being considered in planning a group of meets.
- w_i equals train priority weighting factor.

The train weighting priority factor, w_i allows us to place economic value on the advancement of passenger trains before freight trains. It also allows for the following: a passenger train might be held in a siding for 3 min. while a freight train continued on the last half mile to get into a siding, rather than holding the freight train at a siding 10 miles down the track during the 15 or 20 min. necessary for the passenger train to cover that distance. The weighting factor is of prime impor-tance and seems to have some corre-spondence to the judgments reached by train dispatchers. The following weights are suggested for the first runs of the simulation: 1st train class, w_i is 1.0; 2nd class, w_i is 0.6; 3rd class, w_i is 0.4; and 4th class, w_i is 0.2.

Concerning our theoretical meet; if it occurs at any unoccupied siding, we can schedule the meet right there. If the meet would occur between two sidings, the program has to decide which one to choose in order to mini-mize delay time or maximize train per-formance. How this is done is shown in flow chart 3.



FLOW CHART NO. 3. TYPICAL EVALUATION PROCESS



FLOW CHART NO. 4. MEET TIE BREAKING PROCESS

COMPUTER DISPATCHING

continued

The program developed first places a train into one of its sidings and then evaluates the performance of the system. Because it takes a while for a stopped train to get back speed up, the time span included in the determination of the performance ratio should extend enough beyond the contemplated meet so that both trains will again be performing at their capabilities.

The program then does the same thing using the siding on the other side of the place where the theoretical meet should have taken place. It evaluates the effect upon performance of having the meet in this siding. It then develops the difference in performance between these two decisions. If this difference is sufficiently great, it establishes this theoretical meet at the most desirable siding without regard for searching further for other possible good meets. Reasoning is that if the meet is going to occur within 100 yards of a siding, it doesn't pay to search beyond this for a good siding location. However, if a theoretical meet should appear to occur five miles out between two sidings, ten miles apart, then later events are likely to have a more substantial effect upon the economic desirability of where the meet is made.

Theoretical Meet Assigned

After a theoretical meet has been tentatively assigned to a siding, the program proceeds to calculate the time required for each train to progress through two sidings beyond this tentative position. If this time is less than 30 min., a minimum search value of 30 min. is used. All other trains upon the railroad are then projected ahead for this 30 min. or passing area search time. If any meets occur during this period of time and if they are found to be relevant to the original meet being established, i.e., they also involve one of the two trains involved in the original meet, the program then comes back and investigates not just the original two-train combination but also the additional combinations produced by the introduction of the additional train.

This group of tentative meet assignments is then reviewed by an expanded evaluation process to choose the optimum allocation of train-siding combinations. If this deeper level of investigation leaves the original tentative assignment of a train to a siding unchanged, the meet is firmly established at that point. This decision is recorded in the decision planning record and control returns to main program. •