RAILWAY SIGNALING AND COMMUNICATIONS

AUGUST 1960

Automation on the Russian Railroads

Translated by

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from the Russian periodical, "Railroad Transport." Because the signal engineer, perhaps more so than anyone else on the railroad, will be involved in the techniques of automation, we present this article here.

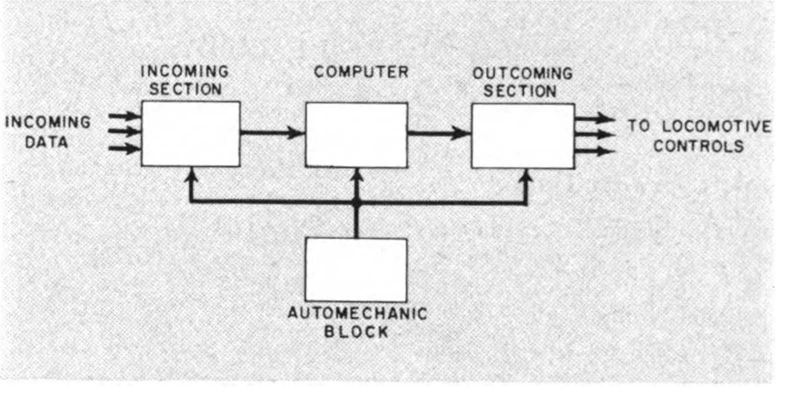


Figure 1: The simplified block diagram of the automatic controls now under test.

● At present only a few methods of automation are employed by the railroads but in the future much wider use of automation is expected. Quite a few scientific establishments and universities are involved in the development of this equipment. For instance, problems of automatic operation of cars in classification yards and problems of automatic operation, acceleration, and braking in mountainous regions are being studied by government institutions. Of course, the best solution would be to develop something that will perform the functions that human beings are performing.

Automatic operation leaves to the human element only the function of following up the equipment of the "automatic motorman." Unfortunately, such equipment has not yet been developed, equipment that could be substituted for a human being's eyesight and hearing; equipment that could realize the conditions of the track occupancy ahead of the train, aspects of the signals, and acceleration or retardation.

This new equipment must satisfy the following conditions:

Prerequisites

1. It should insure movements of the trains according to schedule.
2. It should provide the most economical operation, insofar as speed, safety and loading are concerned.
3. It should control the acceleration and retardation according to the demands of wayside signaling.
4. It should have, at all times, complete check on the application of energy and application of brakes to the locomotive.

Safer, More Economical Operation

If the above functions are performed by the "automatic motorman," very little will be left for the human motorman to do. Much safer operation will be accomplished and the operation prescribed by automatic equipment, closely following train graphs and providing for the most economical way of applying the motive energy, will result in reduced cost of transportation.

In actual operation of the railroad, the weight of the train, train resistance and the characteristics of motor equipment and braking equipment seldom correspond to the theoretical data, and as a result, deviations of actual train movements from those prescribed by the train graphs will develop. In addition, unforeseen emergency stops and reduced speeds will also result in deviations from prescribed data. It is the experience of the motorman which compensates for bad conditions and keeps the trains running. With automatic equipment, corrective measures could be taken by the equipment automatically with greater precision than is possible with the best qualified motorman.

The amount of energy used by the train, to a great extent, depends on the experience of the operator. With automatic equipment the most economical speed, resulting in a saving of fuel, would be prescribed and lower costs will result. Present day techniques of automatic controls are closely associated with high speed computing machines. In simple form, automation could be presented as in the block diagram of Figure 1.

Keep Speed at Predetermined Level

In the process of train movement, comparison of actual speed of the train with that prescribed by the graphs is continuously maintained. If a deviation of speed occurs, the automatic equipment performs the necessary changes in controls to keep the movements of the train within the prescribed limits of the schedule. It is not expected that the automatic equipment will bring the train back on schedule if some unforseen emergency stop or reduced speed occurs. This defect could be partially compensated by the use of the curve $t = f(s)$, time-distance curve, and the curve $v = F(s)$, speed-distance curve. By so doing, "automachinist" (automatic equipment) will direct the movement of the train with respect to the schedule.

Modern locomotive controls are generally provided with a few steps of control, but should be provided with a much greater number of steps for smoother operation by automachinist. With an insufficient number of steps, automachinist will be unable to maintain the schedule because the disagreement between the actual speed and prescribed speed could not be eliminated.

Compensate for Lost Time

Introduction of the element of time into the calculator will provide automachinist with an additional factor to compensate for these shortcomings. Automachinist will be able to maintain the schedule more readily, if in addition to the requirements of speed, the factor of predetermined time of arrival at destination is also introduced. The use of high speed computers in the automachinist equipment will greatly simplify the problem.

The incoming data of distance covered by the train, its speed, time, profile and grade, and signal aspects are fed into the incoming block of the automachinist, all in a form readily usable by the computer, which is the main part of the automachinist. It is the computer which selects the required controls based on information fed into it. It is the computer which selects controls for moves on schedule and with the least amount of energy expended. The outgoing block collects all data evaluated by the computer and formulates it in definite requirements of locomotive controls.

Step by Step Evaluation

As an example, let us follow automachinist in selecting the controls. Assume that at a certain moment the train operates on the first point of control, according to requirements of lowest amount of energy consumed. Based on this characteristic, on theoretical speed and length of the block of track ahead, the computer foresees a late arrival at destination. Immediately the computer seeks another solution, using the same incoming data as before, but with a proposed change of controls to the next higher point of the locomotive motor control characteristic. All this time the train is still driven with previously determined controls. If the result of the second computer evaluation is still "arrival late", the computer seeks the next solution on the third point of characteristic of motor control. At the same time, the computer sends out the change of controls to take place in the locomotive to switch to the second characteristic.

If the result of the third evaluation reveals that the train will arrive at the destination ahead of schedule, the third evaluation will continue to circulate and repeat evaluations with changing data as movement of the train progresses, such as speed, distance, time, etc. When calculated time approaches the assigned time the automachinist sends the appropriate requests to the controls of the locomotive.

In this fashion a continuous attempt is made to keep the train movements on schedule even if time was lost on an emergency stop or reduced speeds. The computer also could be fed with data requiring reduced speeds on portions of the track where it was deemed necessary. Generally speaking, both types of computers, digital and analog, could be used. But locating electronic computers on locomotives is not desirable because of the short life of electron tubes, susceptibility to vibration at high speeds and accelerations, and unreliability for the precise type of work required. The better type of computer is one using magnetic cores.

Magnetic Core Computer

The calculating block of an automachinist will consist primarily of magnetic rings, 3 to 7 mm in diameter, possessing rectangular hysteresis loop characteristics (Figure 2). The magnetic rings are supplied, as shown, with three windings through which electric currents are passed to compare the required data, the actual data, and the data for the controls.

Elements of the magnetic loop could be in either one of the two stable magnetic conditions, marked on Figure 2 as point "0" and point "1". With current in winding "required", loop passes from condition "0" to condition "1", and with current in winding "control" from condition "1" to condition "0".

It is very easy and simple to enter any information into the computer in the form of numbers. For instance, the three aspects of the wayside signal could be represented with three numbers: red = 0, yellow = 1, green = 2 and assigned to two rings in the form of binary numbers: 00, 01, 10 (a binary number is a number in the system based on the number 2).

The scheme of the automachinist making use of a digital computer (Figure 3), is as follows: Incoming data in binary form is fed into several separate blocks. The speed and distance covered by a train are obtained from the wheel rotation, the diameter of the wheel, and the time of read out, and expressed in binary form on the proper scale. The other blocks will also

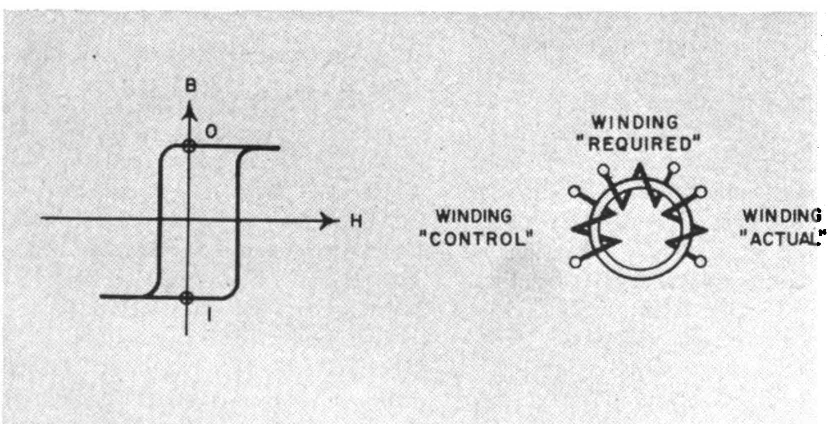
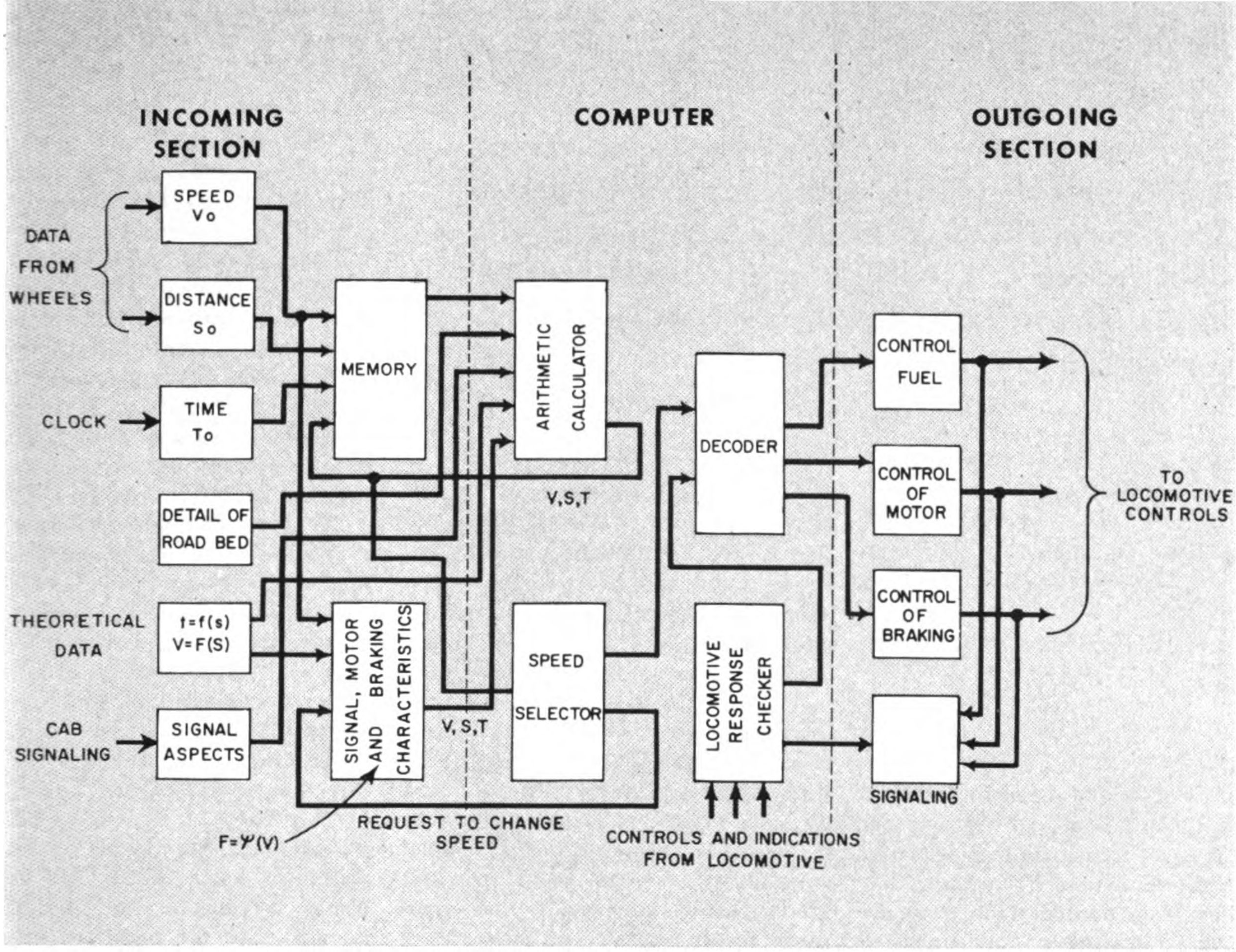


Figure 2: The magnetic cores proposed for use in the computer have a rectangular hysteresis loop. The material changes magnetic polarization rapidly and is easily saturated.



igure 3 illustrates the flow of information through the various components of the "automachinist."

ıterpret their respective data in biary form.*

To determine the time the train is t a certain point on the road, the asic equation of motion would be sed, together with other factors reıted to the requirements of the most :onomical way of train control. 'hese equations are solved in the comuter, with the data fed into the inɔming portion of the automachinist.

The equation of the train movement usually represented in the form of ifferential equation of the second rder.

$$\frac{d^2s}{dt^2} = A\,\frac{F_k - W_k - B_k}{P+Q}$$

'here F_k = the force of pull of the locomotive in kilograms

W_k = total train resistance in kilograms

B_k = braking force in kilograms

P = weight of the locomotive in tons (1,000 kg)

Q = total weight of the cars and load in tons

A = acceleration in kilometers/hour/hour due to a force of one kilogram applied to weight of one ton.

The computer will calculate the speed, distance and the time. The obtained solutions will be compared with those required by the graphs and the required control will be applied to the locomotive. At the same time the computer will determine the most economical control from the point of costs of energy.

The most convenient types of locomotives suited to automechanic controls are electric and diesel locomotives. They have a centralized and not too complicated system of control. Application of automechanic on electrified railroads may result in considerable energy savings.

At present, the Pensenski Railroad is conducting tests of automation. Tests of automachinist on the Kubichev-Besimianka Railroad indicate that the automachinist responds faultlessly to signaling on block control territory, selects the most advantageous speed and braking, and takes into account the profile and alignment of the roadbed and the load of train, continuously performing the required computations.

Automation will improve the use of existing locomotive equipment and improve average speed of operation. It will result in a saving of energy used by 5 to 7%, and improve the capacity of the road by 15 to 20%. At present the Leningrad Institute of Engineers of Railroad Transit is developing the automachinist for steam locomotives. The next improvement of the automachinist should be equipment to respond to the same stimuli as a human being's senses of eyesight and hearing. Research in the development of mechanical models of organs for eyesight and hearing and the necessary transmission of these sensing processes is under way in many research laboratories and universities. It could be said assuredly, that the task of the machinist (engineman) on the railroads will be lightened more and more quite soon.

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*Editor's Note: It is assumed that the ıeasurements will be made using an idler 'heel, or a special small wheel for the ıurpose, to avoid errors due to wheel lippage.

NEWS BRIEFS

(*Continued from page 48*)

same capacity to Clovis. **Thomas G. Rhodes,** signal inspector at Raton, N. M., has been promoted to assistant signal supervisor at Las Vegas and has been succeeded by **Alva J. East,** signal construction foreman. A biographical sketch of Mr. Bickel's career was published in Railway Signaling and Communications, March 1959, page 55.

CANADIAN NATIONAL. **Harry Life,** operations superintendent for central and eastern Canada, has been appointed superintendent telegraphs for the Maritimes at Moncton, N. B., succeeding **Hugh Marquis,** retired (RS&C, June 1960, p. 69).

LOUISVILLE & NASHVILLE. **D. F. Crook,** assistant supervisor signals, at Robards, Ky., has been named supervisor communications and signals at Evansville, Ind.

ST. LOUIS-SAN FRANCISCO. **K. B. Gardner,** assistant communication and signal supervisor at Amory, Miss., has been appointed communication and signal supervisor there, succeeding **P. W. Davis,** transferred to a similar position at Springfield, Mo. **G. E. Benedict,** senior draftsman at Springfield, has been named to succeed Mr. Gardner as assistant communication and signal supervisor at Amory. **L. R. Everett,** communication maintainer at Tulsa, Okla., has been promoted to assistant communication and signal supervisor, with the same headquarters. **D. R. Holt,** wire chief at Ft. Scott, Kan., has been named operations supervisor at Springfield.

Supply Trade News

RAILROAD ACCESSORIES CORP. Appointed exclusive distributor for Semper-Seal, a new epoxy-type resin cable splice and blocking compound made by **C&S Products Co.,** Windsor Locks, Conn.

HOLAN CORP. **Charles S. Ca field, Jr.,** has joined the company district manager at York, Pa.

PREFORMED LINE PRODUCTS CO. Established an eastern area headquarters office at 1116 Kingwood Drive, Falls Church, Va., under the supervision of **Fred J. Lekson,** district manager of sales.

S&C Man Observes Russian Railroads

L. B. Yarbrough, superintendent of signals and communications, Wabash, was one of eight railroad men who spent six weeks observing Russian railroad operations. Here are some of his comments on their signaling and communications practices.

Signaling: Each rail line is carefully graphed to determine its capacity. Until that capacity is filled, no expansion of facilities is undertaken. There is still considerable use of wire-pull banjo signals and dispatching by use of train staffs. The dispatcher records train movements on a graph. This graph has the "norms" printed in light lines, and as a train progresses, the dispatcher merely darkens in the line. These norms are set up to distribute the trains evenly throughout the day so that there are no peak traffic periods. If, for instance, a line has a 100-train per day capacity, but only 75 trains are operated, there are 25 vacant "norms." If an extra train is to be run, it follows one of the vacant norms.

As traffic increases, the line may be double-tracked with block signals, electrified, or CTC installed. Electrification and signaling usually go hand in hand. CTC is never installed on double-track lines. Continuous track circuits are used: 75-cycle ac where 50-cycle traction is used; 50-cycle where dc propulsion is used, and dc track circuits elsewhere. Coded track circuits are also employed. Signals are color-light or searchlight and cab signals and inductive train stops are provided on some high density lines. Aspects are similar to AAR practice with one or two arms. Special blue and lunar white aspects are used at interlockings to permit switching moves. Standby battery is provided as in U. S. practice, except that open-top cells are still frequently used at interlockings. Relays, signals, retarders, and other signal equipment have been patterned after those of U. S. manufacturers.

New interlockings are all-relay and busy terminals have pushbutton automatic routing machines. Switch machines are electric. Automatic interlockings are non-existent. Highway crossings are virtually nil, but those that exist have normally-down pole barriers.

Single-track operation predominates. At each line of road station, a station master directs switch tenders located at ends of sidings to throw switches for train movements. Even where CTC is in use, each station has a small machine with controls for local operations. One 50-mile line had a central control machine and 10 local machines, one at each of the stations. The local machines are not normally used for routing through movements, but for local switching at the station master's direction.

There are a number of gravity classification yards with manual pneumatic retarders. They are currently experimenting with one automatic yard.

Communications: The dispatcher has a telephone line with selector ringing. There is some radio used in electrified territory, transmitting at 2–2.6 mc about 5 miles through space and about 18 to 20 miles by inductive coupling to the catenary and line wires. They are experimenting with microwave. The railroads have their own separate, independent communication system.