AUTOMATIC FREIGHT TRAIN IS CREWLESS

Automatic train operation around the clock, 24 hours daily, seven ays per week the year 'round, is en- bling the Iron Ore Co. of Canada to ul 20 million long tons annually of ude iron ore from loading pockets at e mine site to a dumper at the crush- site. Four 18-car ore trains are shut- ing back and forth along a 5.7-mile ne, each taking approximately 80 min- tes for the round trip from loader to usher. The single-track railway, lo- ated near Labrador City, is capable of andling 55,000 long tons (2,200 lb per n) of crude ore per day. Each of the ur trains is powered by a convention- l GP-9 diesel-electric locomotive. The utomation controls—built by General ailway Signal Co.—provide for com- letely automatic, simultaneous opera- ion of four trains.

The operation of each locomotive is irected automatically from the way- ide by coded AC current. The code onsists of AC energy at 60 cycles that interrupted 37.5 (service brakes), 75 .5 mph), 120 (15 mph), 180 (30 mph), r 270 (reversing) times per minute. The code rate, as well as a lack of code, determines the nature of each command given to a train.

The inching (⅛ to ⅜ mph) or slow speed, while loading and while precision spotting for dumping, is controlled by tone modulated 960-cycle carrier signals. These signals are applied to wire loops between the rails.

The AC coded controls and tone controls, or commands, are transmitted continuously in the rails toward the movement of the train, providing a positive and continuous check of track conditions, such as broken rails, switch position, or presence of other trains. On the train, these commands are picked up by receivers, inductively coupled to the rails. The commands are compared with actual train speed, as detected by an electronic speed governor. The resultant output is then converted to relay operation, automatically controlling the throttle and brakes in a proper manner for best locomotive handling.

Each train is arranged so that its locomotive pulls the loaded cars to the dumper (crusher) and pushes the empties back to the loader at the mine. Since the locomotive is always on the dumper end of the train, a special car on each train is also equipped with code-receiving equipment, as this car is leading when empties are pushed back to the loader.

At the loading point, the automated locomotive pushes the empties into a tunnel, stops, reverses, and draws them slowly out as they are loaded from a chute in the tunnel roof.

When the train is loaded, the loader operator pushes a button to send the train on its six-mile automatic trip back to the dumper (crusher) at speeds up to 30 mph. Before the train starts, however, the block system checks ahead to the siding to determine whether it is safe for the train to proceed. Loaded trains operate on the mainline only, and empty trains take the mainline or the siding. Under ideal speed conditions, and for optimum performance, each loaded train makes a nonstop meet with an empty train at the passing siding near the loaders.

A complete cycle of normal operation

for four ore trains consists of the following procedure:

(1) Loaded train A starts for the dumper, while train B is being loaded, train D is being unloaded, and empty train C is enroute to the loader.

(2) Loaded train A makes a nonstop meet with empty train C, while loading and unloading of the other trains continue.

(3) Loaded train A arrives at the dumper as empty train D departs. Trains B and C are both now being loaded.

(4) Empty train D starts back to the loader as train A starts to unload.

(5) Conditions are the same as in step 1, except loaded train B is now ready to start for the dumper.

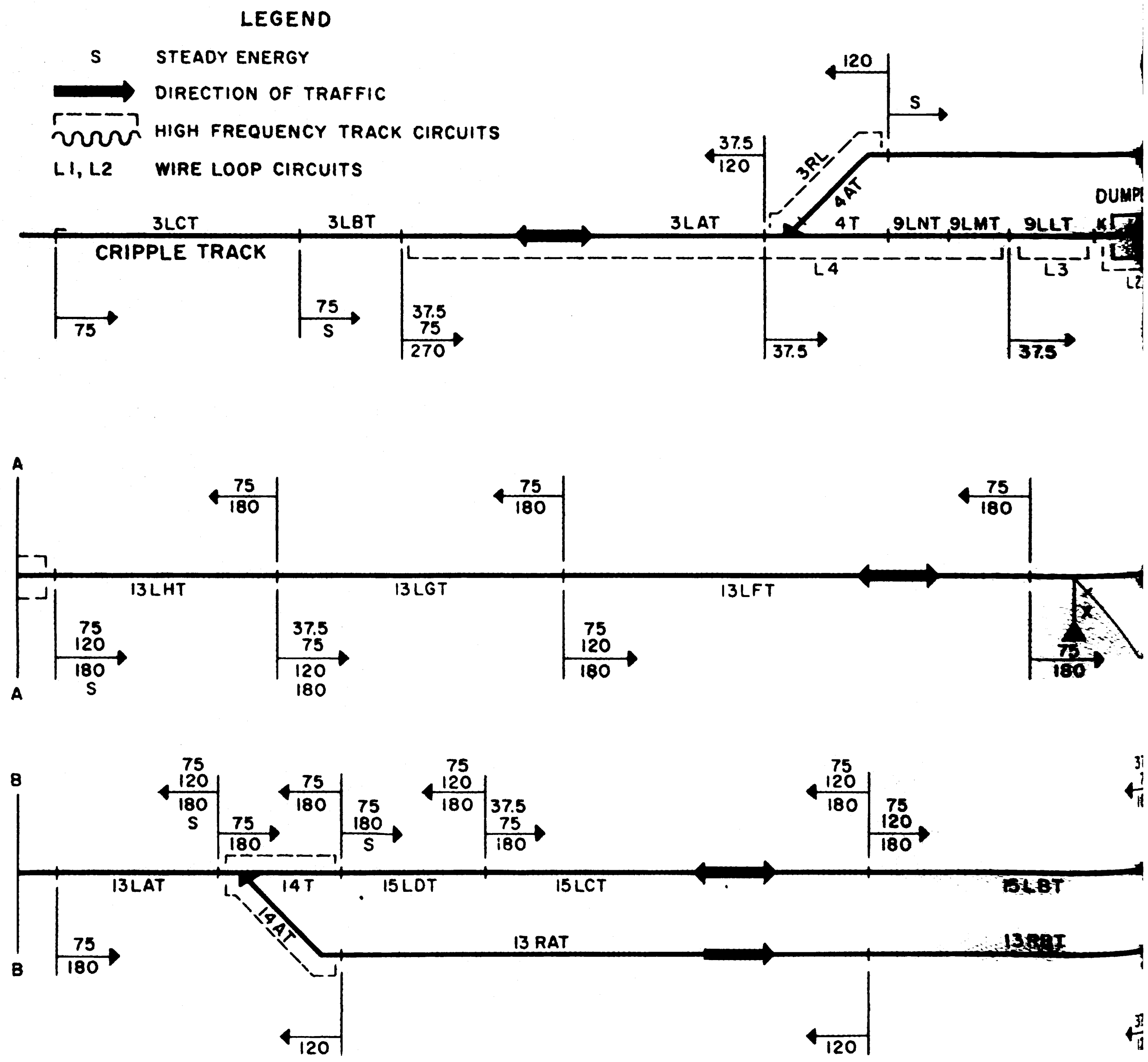
The detailed track diagram shows all of the possible codes that can be applied to the rails, one at a time in a given track section. In order to visualize the operation in greater detail, assume that the same conditions exist as shown in the simplified track diagrams showing the cycle of operation.

Train C is receiving a 180 code and is proceeding northbound on the single track. Loaded train A has been released by the loader operator to the automatic system. It receives a 120 code, which causes it to proceed over switch 18 reverse at 15 mph. It then slows to 7.5 mph when receiving the 75 code in approach to switch 14.

Assuming a nonstop meet, northbound train C on the single track receives a 120 code in approach to switch 14, and moves over the switch reverse at 15 mph. If track conditions permit, train C continues at this speed over switches 16 to 18 reverse to the emp
loader. Meanwhile, train A receives th
180 code and proceeds southward
30 mph on the single track to th
dumper. It receives the 120 code i
approach to switch 10 and reduc
speed to 15 mph. If the dumper
occupied, train A receives the 37.
code and stops at a point 1,400 ft fro
the dumper location. If train D has pr
viously left the dumper, train A wou
not stop until within 200 ft of th
dumper location.

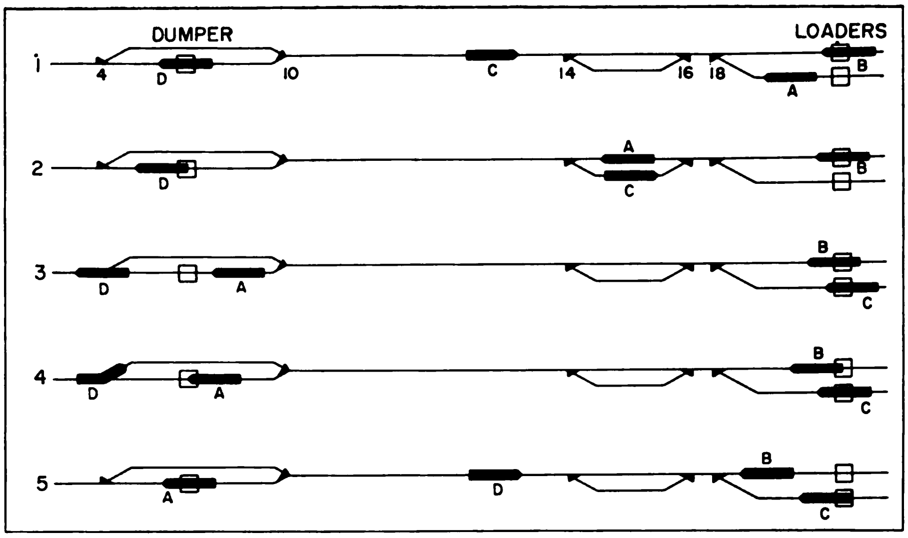
Automatic spotting at the dumper
accomplished by applying modula
carrier frequency to wire loops L1. L
L3 and L4, and applying the 37.5 co
to the rails. The 37.5 code is used
cause the train to stop should the mo
ulated carrier signals be cut off.

When ready for train A, the dump

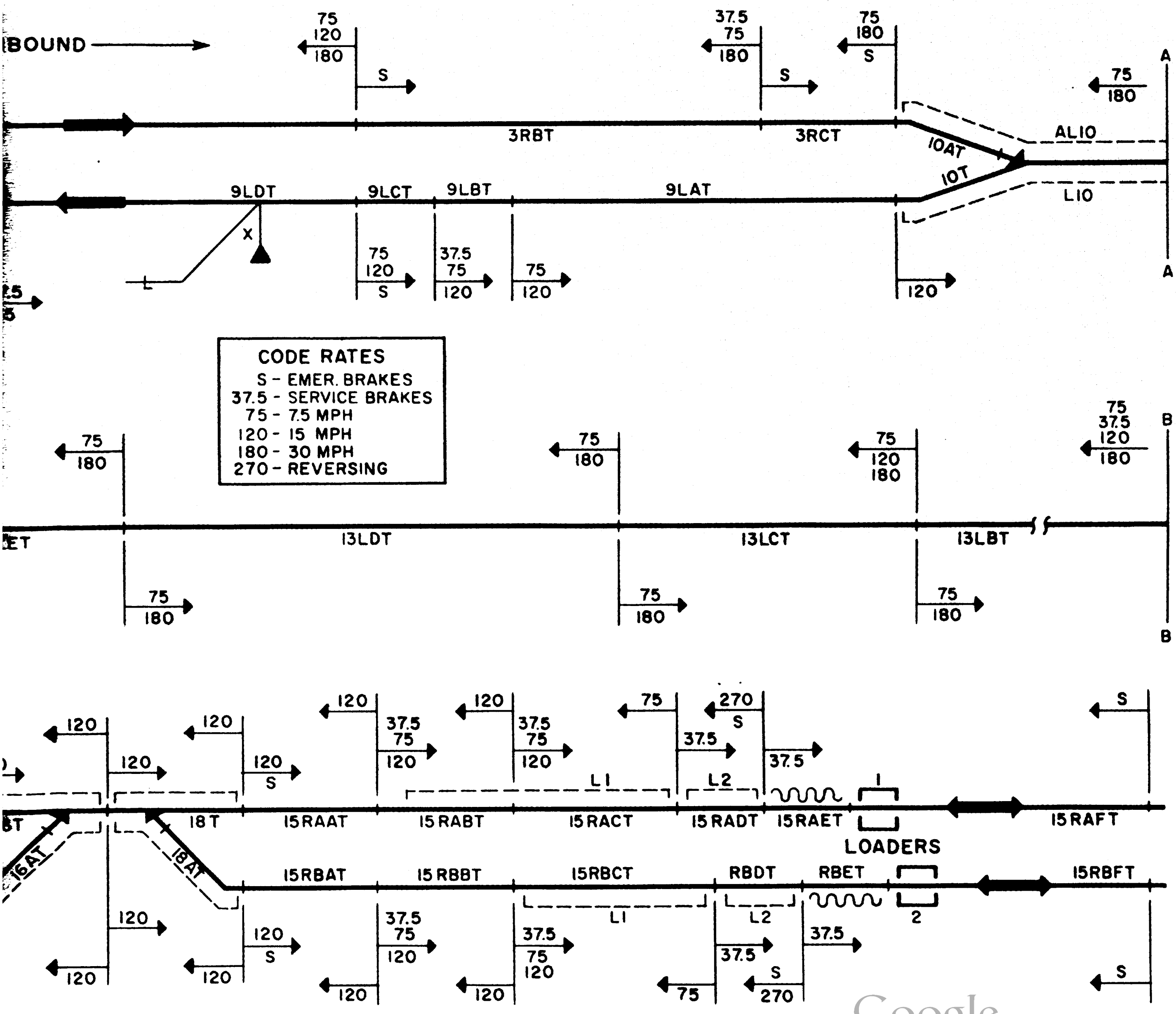


erator pushes his release train push-tton, causing the loaded train to au-natically advance at 2 mph to a point ere the locomotive brakes are ap-ed to stop the first car within the mping tolerance of ±7.5 in. This itrol automatically spots the cars and ovides interlocking to prevent train vement during the dumping oper-on.

Track circuits determine when the is properly located for dumping. tector units determine whether the has stopped in the long side or the ort side of the tolerance. The brake tiation point for stopping the next in the dumping cycle is then modi-l automatically to ensure that the pping of the cars will not gradually l out of tolerance with a consequent s of time to respot.



Block diagram shows how four ore trains are operated simultaneously.



The editor's impressions of the automatic ore haulage operation.

Of the several things that impressed this visitor to this area—it is remote, being about 650 miles north of Montreal, Que., on the western edge of Labrador—the two outstanding are the magnitude of the job of mining the ore, it's earth moving on a vast scale, and how much conventional equipment was utilized in the automatic train operation. This latter fact means that a more widespread application of ATO is possible than has been heretofore realized.

The amount of material to be moved—55,000 tons daily—from mine to crusher necessitated a railway. The crude hematite ore has about 37% iron, which after crushing and concentrating, is brought up to 66% iron for shipment to Sept Iles. Just to give an idea of what's involved, here are some figures: An average of two feet of overburden is washed off first. Next, holes are drilled for blasting; a normal blast, I was told, will loosen 300,000 tons of crude ore. The ore is loaded by Marion electric shovels with 10-cu yd buckets into Euclid tractor trailers holding 100 tons. Driven down to the loading site, these trailers are side dumped into a hopper. When in full operation, IOC will have three shovels and 15 trucks in service at a time, with one shovel a five trucks out for servicing.

The crude ore, which may be in chunks up to ft in diameter, is loaded into the 100-ton ore c for hauling to the crusher or dumper. Here an i tial crusher chews up the ore into 6-in. bites. N the ore travels through six airfall mills, which u steel balls to grind the ore, and finally the crude put through three stages of spirals or centrifug for separating the iron from the rest of the mater From this stage powder-like material is 66% ir which is loaded into Quebec North Shore & Lab dor cars for hauling to Sept Iles. To sum it up, tons of crude ore produce one ton of concentra ready for shipment. IOC is now building a pellet ing plant at Labrador City, which when complet next spring, will produce about 5 million tons ⅜-in. to ½-in. pellets. With the pellet plant in f operation, IOC will produce about two million to of concentrate.

To handle this volume of material between mi and crusher, an automatic operation was necessar It takes only one minute to dump the ore truck one minute to load each railway car and anoth

Manual override of the spotting control is provided to stop the operation instantly and to control the train manually.

After all the cars have been dumped in train D, the train receives the 75 code and automatically proceeds at 7.5 mph until the last car is clear of junction switch 4. The switch then automatically throws reverse. Train D now receives the 270 code, transferring control from the locomotive to the tail car for the reverse movement and stopping the train.

The tail car receivers now pick up the 120 code, and the train proceeds over switch 4 reverse onto the runaround track. If the single track is not occupied, train D receives the 180 code and proceeds over switch 10 reverse and down the mainline at 30 mph.

Train C receives the 75 code after passing through switch 18 reverse, and thereby reduces speed to 7.5 mph. It then receives a reverse tone and stops about two or three car lengths from the loader. The 270 reversing code is then applied to transfer the control end from the tail car to the locomotive. A continuous tone, plus a 75 code, continues the operation of backing into the tunnel. As the train passes appropriately located insulated track joints, it stops. With the first car behind the locomotive properly positioned, the operator pushes a button to start the train moving at inching speed out of the tunnel. By means of a tone-modulated carrier signal, the operator has a continuously variable control of this inching speed while loading. After loading, the operator returns control of train C to the automatic system.

Train B has, in the meantime, left the loader on its return trip to the dumper.

The train-carried equipment receives commands from the rails (coded AC signals or tone-modulated carrier signals) and, in turn, interprets these commands, causing the proper operation of the power and brake equipment. The train response is constantly monitored and compared with the commands. The moment that actual operation does not agree with the operation called for, corrective action is initiated automatically.

Receivers are mounted ahead of each of the two leading wheels, with the coils approximately centered over the rails and about 6 in. above the rail head. Direction selection components on the locomotive provide the choice of tail car receiver output or locomotive receiver output, depending upon the direction of travel.

On the locomotive, the signal from the selected receivers passes through tuner which (1) detects the rate co from the coded track circuits, or detects the tone reception from high-frequency track circuits. The t control amplifier amplifies the rate c signal and produces rectified AC pu which are fed to the direction selecto

On the tail car, only rate code puls can be received. These pulses are a plified in the tail car train control amplifier, producing rectified AC output t operate a code-responsive relay. Th coded signal is then transmitted vi trainline cable to the automation equipment rack on the locomotive.

On the locomotive, the selected signal operates another code-responsive relay which pulses at the code rate being received from the rails. Coded information is then decoded to tell the train what action it should take. No code, or steady, means apply emergency brakes; a 37.5 code means apply service brakes; a 75 code means proceed at 7.5 mph; a 120 code means proceed at 15 mph; a 180 code means proceed at 30 mph; and a 270 code means reverse control ends.

The train speed indication portion of the equipment includes an axle generator, which is mounted on the journ box of the locomotive so that the rota ing element is driven by the axle. Th ıute for unloading from railway car into the sher. The 100-ton capacity railway cars are side npped.

'he ore trains are operated push-pull with the -9 1,750-hp locomotives (previously in service on QNS&L), hauling loaded trains down to the sher and pushing the empties back to the load- site at the mine. To alert personnel of a train's ›roach, headlights on the locomotive and tail are lighted continuously. Also, the locomotive l rings continuously and yellow revolving bea- ı lights atop the locomotive and tail cars are ıted.

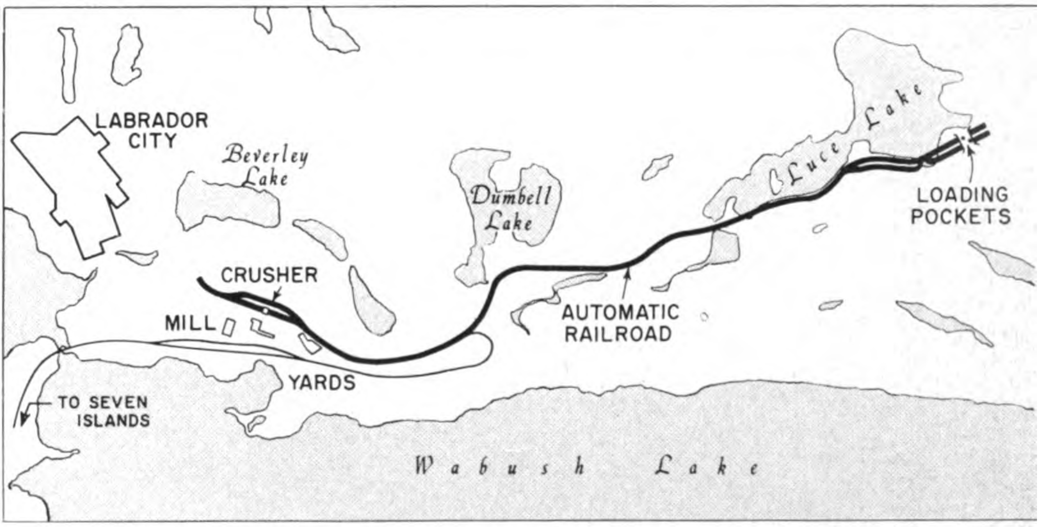
[he only time the locomotives will be taken out service is for refueling and inspections or other vicing. A red "emergency stop" pushbutton is unted on each side of the locomotive and may be ɜrated by a person on the ground. A red indica- n lamp is lighted when this pushbutton has been ɜrated. Alongside the red button is a black push- tton which, when operated, places the locomo- e on automatic control.

Upon looking into relay housings, I found con- ntional code transmitters, code following relays, etc., normally used with coded track circuit installations. To be sure, there are many new techniques and engineering that went into this ATO installation, but the amount of conventional equipment would seem to indicate that ATO has a bright future.

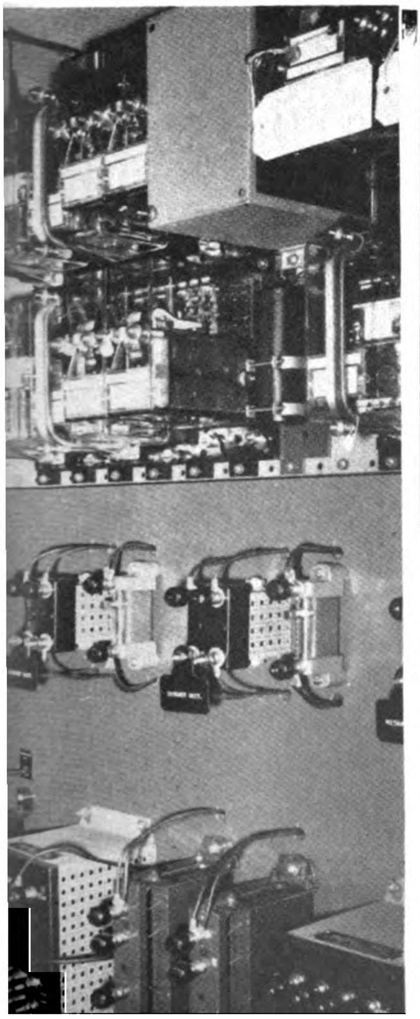
And it has, if the comments I heard from others who inspected this automatic ore haulage system are any indication of things to come. Several persons remarked that ATO is a natural for several similar mining operations that are now in service. One, for example, might be copper ore haulage on the Bingham & Garfield between the Bingham, Utah, copper mine and the smelter at Garfield, about 16 miles. General agreement was that the labor and political problems would be the most severe to overcome in the application of ATO.

There was some comment that this ATO installation might be extended to the 37-mile line that connects Labrador City to the mainline of the QNS&L, 224 miles north of Sept Iles.

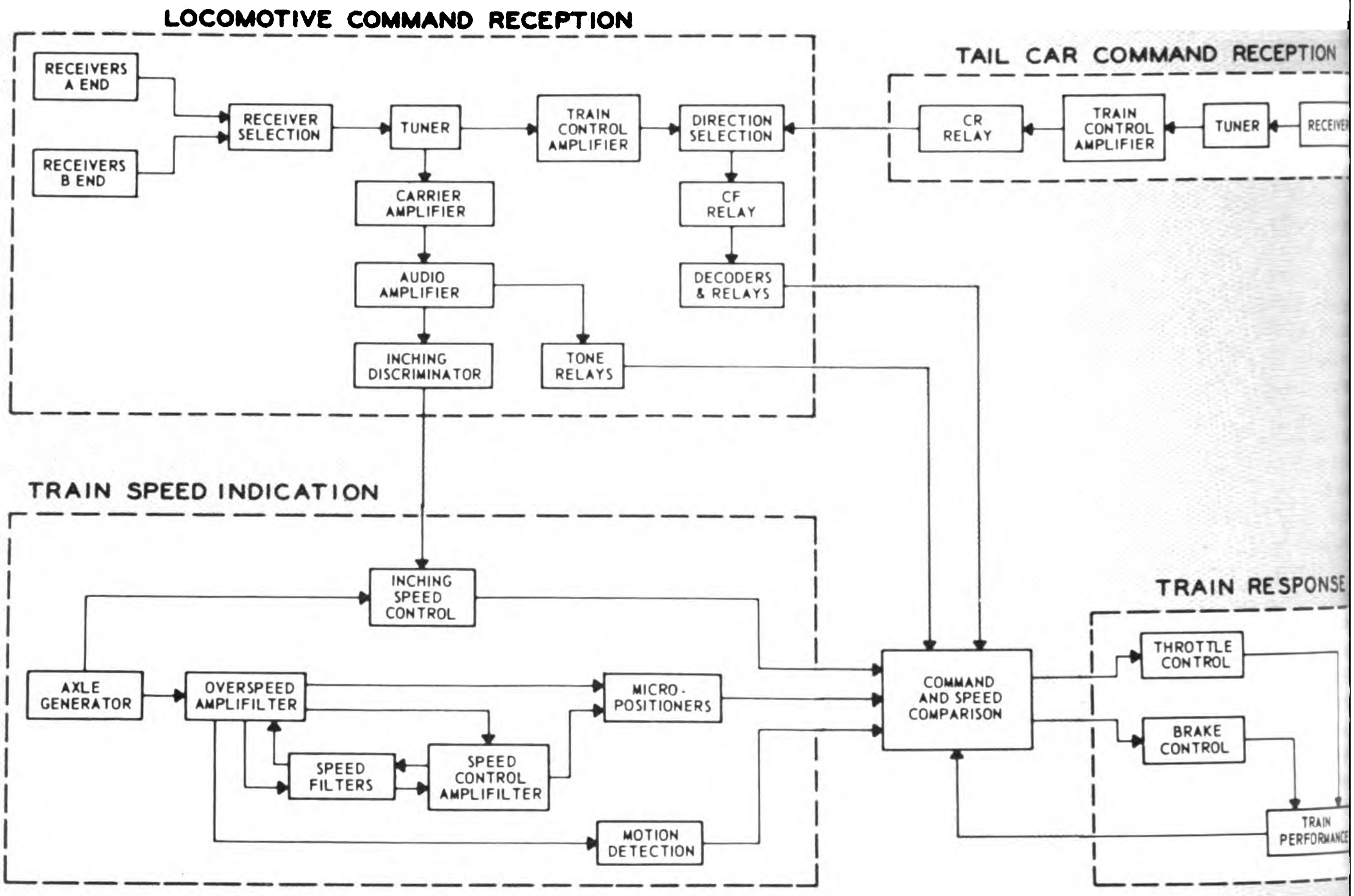
A lasting impression of this automatic ore haulage operation is that it operates smoothly and efficiently day-in and day-out without human attendants.



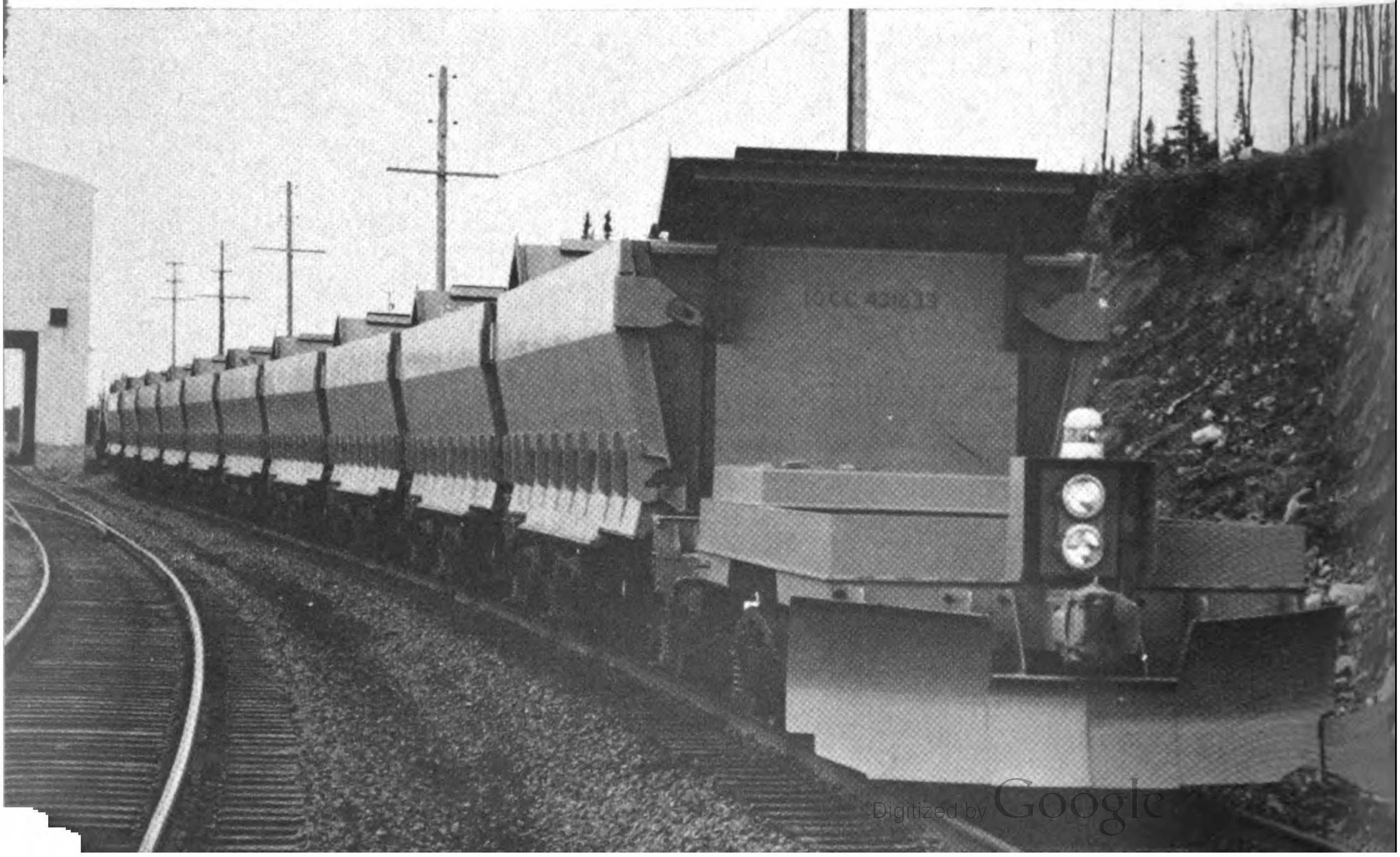
Four 18-car ore trains shuttle along this 5.7 mile railway between the loading pockets at the mine and the dumper at the crusher. The line has a continuous 0.2% descending grade from the pockets to the crusher. Concentrate ore is hauled by QNS&L to its Seven Islands port facilities.



Wayside equipment (left) includes transmitters for sending various codes into the track rails. The 60 cycle AC codes include 37.5 (service brakes), 75 (7.5 mph), 120 (15 mph), 180 (30 mph) or 270 (reversing). Tone-modulated 960 cps carrier signals are used for inching (1/8 to 3/8 mph).



Block diagram shows arrangement of receiving, sensing and command units on locomotive and tail car (below).



ıerator produces an AC voltage with ·requency proportional to the speed the train.

Outputs of the axle generator and associated electronic equipment are ɔd to detect (1) speeds ½ mph above below the selected speed, (2) overɔed—when the train is 2 mph over ː selected speed, and (3) motion—ıen the train is moving more than nph.

The various outputs from the comınd reception and train speed indican sections of the train-carried equipɔnt are compared in the command d speed comparison section. This secn applies the proper commands to ː locomotive brake and throttle conıls. Locomotive performance is conıuously checked to ascertain whether e train is responding according to the mmands.

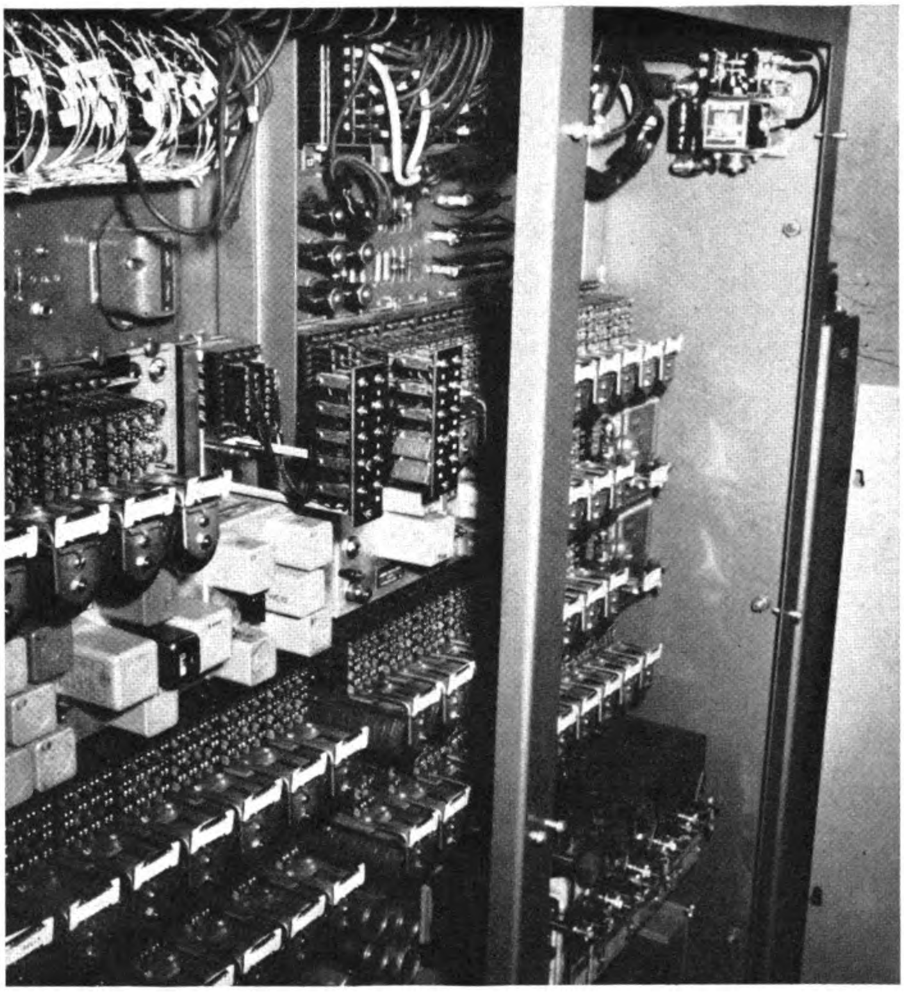
Train speed is maintained by cycling e power application up or down. For ample, for maintaining 30 mph, the wer is reduced at 30.5 mph. If the ıin reduces speed at 29.5, additional ıwer is applied and the cycle is reıated. However, if the power is reıced on a train operating at 30.5 mph ıd its speed increases to 32 mph (due downgrade), service braking is apied to reduce the speed to 30 mph. ıe cycle is then repeated.

Continuously variable control is proded on the locomotive for the inching ıeed. This control, which is via a odulated-carrier signal picked up om the high frequency track circuits, very precise. It controls train speeds on a continuously variable basis—beveen ⅛ and ⅜ mph ± one-hundredth ph. The regular running speeds are aintained within ½ mph.

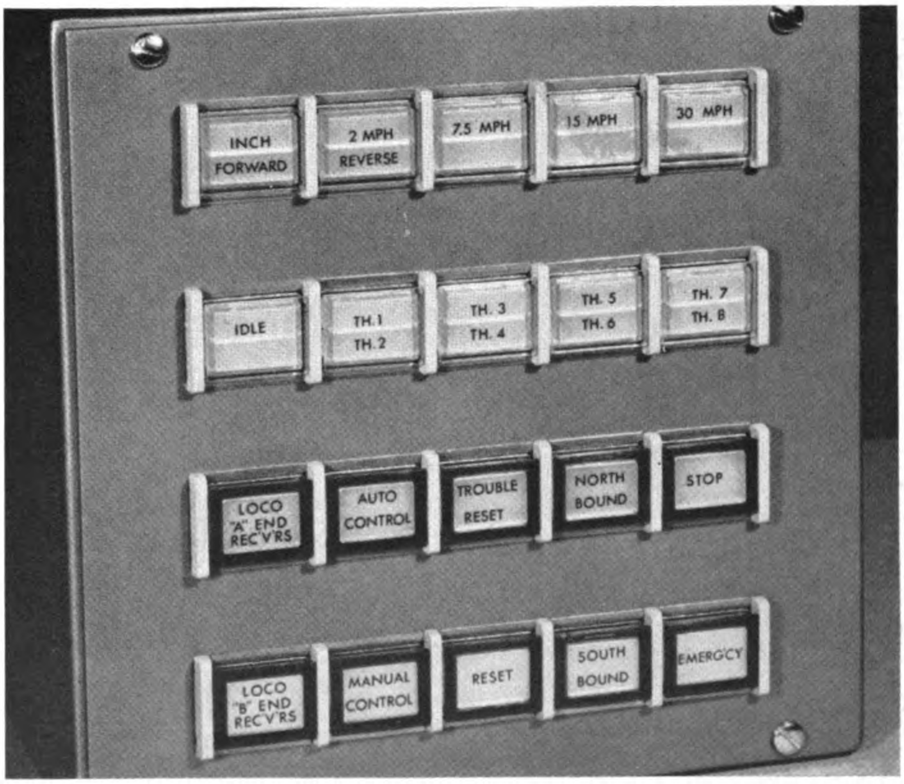
The brake equipment on the crewss train is electro-pneumatic straight r. In the shuttling operation brake ıuipment controls respond to coded ımmands to apply or release brakes. ı other words, the brakes are either l on or all off. In inching or at low ıeed during loading or dumping, the ıecial 960-cycle, tone-modulated code ːtuates brake controls that are suffient to hold the brake shoes against ıe wheels, creating a dragging action ıat permits precise inching.

The manual-automatic changeover anel is used to put the locomotive ack in ATO after it has been on manal control (when refueling or servicıg).

The system is designed on fail-safe rinciples. Any failure of the continous command stream causes a stop. ikewise, a central indicating and conol console, located in the dumper uilding, provides complete facilities ɔr normal override of all automatic perations as well as indications of ːain positions and system status. **RSC**



ATO equipment rack in the short hood of the locomotive carries the decoding and command control equipment, and features many plug-in units.



Manual-automatic changeover panel, also in the short hood, is used to put the locomotive back in automatic operation after it has been off ATO.