SHUTTLE AUTOMATION

A fully automated train was placed in shuttle service January 4, 1962, by the New York City Transit Authority between Grand Central Station and Times Square Station. The automation system provides completely automatic operation of the train's doors, motoring, and braking, and also includes an automatic dispatching system to cause the train to operate in accordance with a predetermined time schedule.

The system is comprised of wayside track and detection equipment, a dispatcher's control machine with an associated automatic train dispatcher, and train-carried control equipment.

The wayside equipment gives commands to the train and checks that the train obeys these commands. The equipment consists of relay circuits which apply electrical pulses to the rails and which establish the direction of train movement, timing sections which check train speed and accordingly control wayside train stops, and ultrasonic detectors which detect train position at the station stop.

A dispatcher's control panel (located at the Grand Central end) is used for supervisory control of train operation. Indications are displayed on this panel of train position, proper arrival, berthing, departure, etc. Controls are provided for the selection of automatic or manual control, for placing the train in emergency, for delaying train departure, etc. The automatic dispatcher unit maintains train operation in accordance with a fixed schedule.

The train-carried equipment includes (1) a continuous inductive train control system for receiving commands from the wayside, (2) a frequency-responsive speed governor for electronically determining actual train speed, (3) a relay logic network to compare the operating command with train

performance, (4) other relay circuits to determine train direction and to operate the doors, headlights, tail lights, side destination signs, etc., and (5) a control panel to place the train in either automatic or manual operation.

Figure 1 shows a simplified track plan of the installation at the Grand Central Station end of the Shuttle. The movements of the train are controlled from the wayside by coded a-c current sent through the running rails. The code consists of a-c energy at 91 2/3 cycles per second, interrupted 75, 180, or 270 times per minute. The code rate, as well as a lack of code, determines the command given to the train. The code is transmitted toward the movement of the train in order to check the integrity of the route in the train's path, and also to permit reception of the code by receivers mounted on the lead car ahead of the wheels and close to the rails. The code is converted to relay operation which gives commands to the train to indicate the desired speed, door operation, etc.

To explain automatic train operation, assume that the train is standing over the door control track loops in Grand Central Station. A 75 code, applied to the track loops, is being received by the train. With this code present, the doors are open on the platform side, and the brakes are applied. When the schedule calls for the train to leave, the automatic dispatcher removes the 75 code from the track loop and applies a 270 code to track circuit 1683T under the lead end of the train. The car doors are closed and locked, and direction is established on both ends of the train so that the end receiving the 270 code will lead, and the other end will trail. The 270 code causes the brakes to release after the doors are closed and locked, and also causes the train to accelerate to 30 mph. Power can only be applied if all the doors on the train are closed and locked. Should any door be partially open at any time or at any point, power is removed, and a full service brake application

is made. The train maintains the 30-mph speed between stations by repeated power and coasting cycles. As the train continues toward Times Square Station, it continues to receive the 270 code until approaching the station.

The brakes are applied in emergency should train speed fall below 1 1/2 mph between stations. This condition could occur, for example, because of a third rail power failure. Such emergency braking will occur even though a proceed code is being received. A brake application would also result should the train exceed 32 mph in the 270 code zone or 7 mph in the 180 code zone. This brake application will be released when the train speed has been properly reduced.

Assume now that a train is approaching Grand Central Station. When it occupies track circuit 1683T, the 180 code is received instead of the 270 code. The presence of the 180 code causes the application of the dynamic brakes and the air brakes until the speed is reduced to 16 mph. The air brakes are then released, while trapped air maintained in the brake cylinders and minimum dynamic braking continue to further reduce the speed to 5.6 mph. This speed is maintained by repeated power and coasting cycles. Grade time sections are used to determine that the train properly reduces speed through the 180 code zone. If the speed is proper, these timing sections act to clear train stops that are located alongside the track. Should train speed be excessive, these stops would not be cleared, and they would cause an emergency brake application.

When the train enters track circuit 1663T, no code is received from the rails, which causes the air brakes to be applied to stop the train over the door control track loops. Accurate positioning of the train over these loops is checked by the ultrasonic detection system. Upon detection, this system completes the wayside door control circuits to permit application of the 75 code to the track loops. The doors cannot operate unless: (1) the 75 code

is received, (2) the train speed is below 1 1/2 mph, and (3) a full service brake application is made.

A block diagram of the train-carried automation equipment is shown in Figure 2. The receivers, which are influenced by the track circuit current, provide a signal which can be interpreted by the equipment. The signal from the receivers is passed through a filter to ensure that only the information contained in the desired 91 2/3-cps frequency will be used. The train control amplifier amplifies the signal and produces rectified a-c to operate code-responsive relay CR. This relay pulses at the code rate being received from the rails. Car battery energy is fed through contacts on the CR relay to operate one of three decoders - the one which is tuned to the rate of the received code. The output of the selected decoder operates its associated relay, which in turn indicates to the train what action it should take. A 270 code means accelerate to 30 mph and maintain this speed; a 180 code means reduce speed to 5.6 mph and maintain this speed; absence of code means stop; and a 75 code means doors open.

The speed governor includes an axle generator which is mounted on the truck journal box so that the rotating element is driven by the axle. This generator produces an a-c voltage with a frequency proportional to the speed of the train. The output of the axle generator is fed to the speed governor section of the amplifilter where it is amplified, passed through the speed filter which is set for the frequency that corresponds to the speed being detected, further amplified, and then applied to the governor relays.

The output of the axle generator is also fed to the motion detection section of the amplifilter. This section enables the train to coast under governor control should a condition occur which prevents motoring, and also prevents the doors from opening if train speed is above 2 mph.

In the end result, the commands given to the train are compared with actual speed. Thus, the decoder relays and the governor relays operate the control relays which, in turn, actuate the train motors, brakes, doors, etc.

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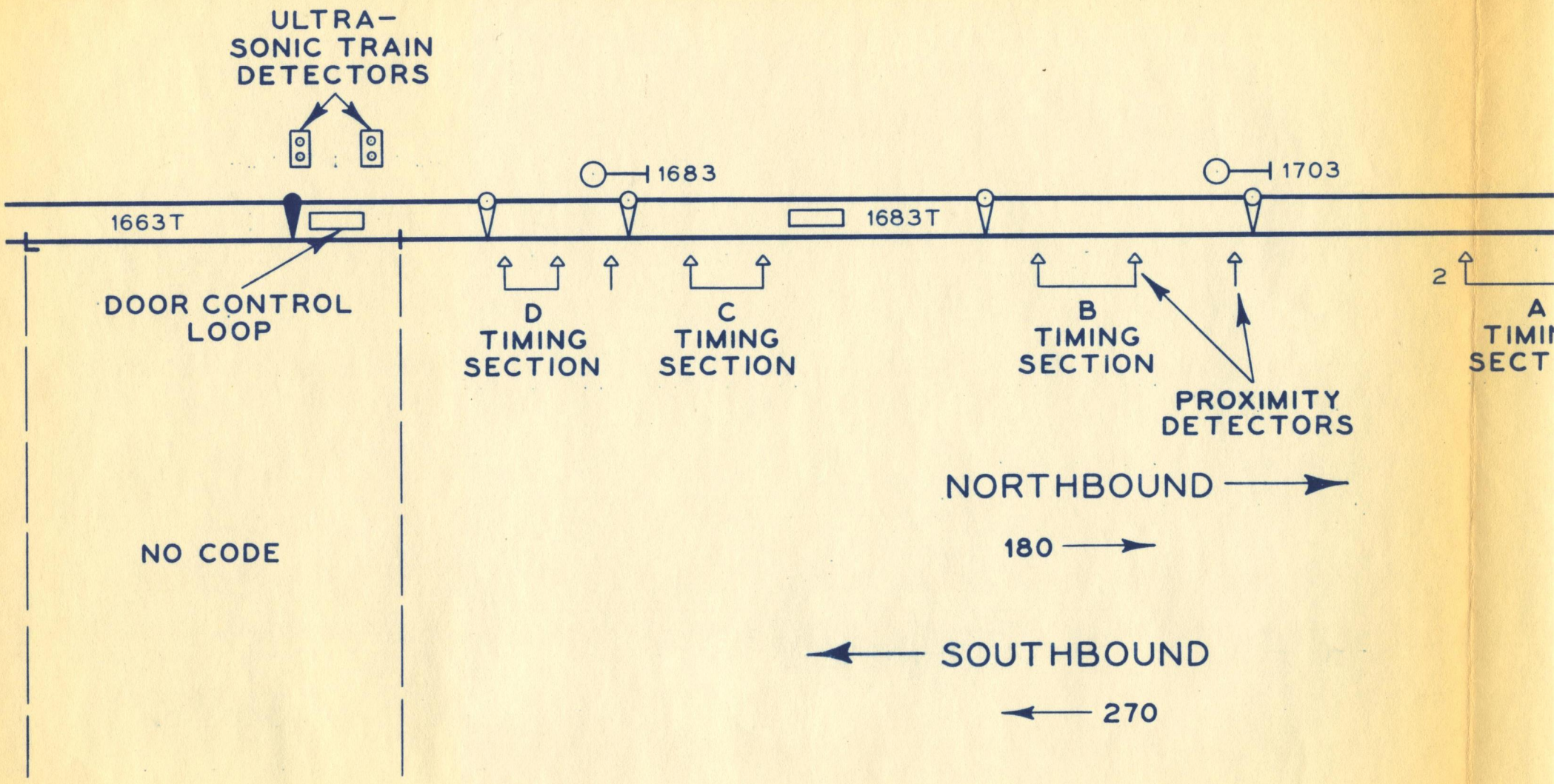
ULTRA-
SONIC TRAIN
DETECTORS
1683
1703
1663T
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DOOR CONTROL
LOOP
D
TIMING
SECTION
C
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SECTION
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2
A
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NORTHBOUND
180
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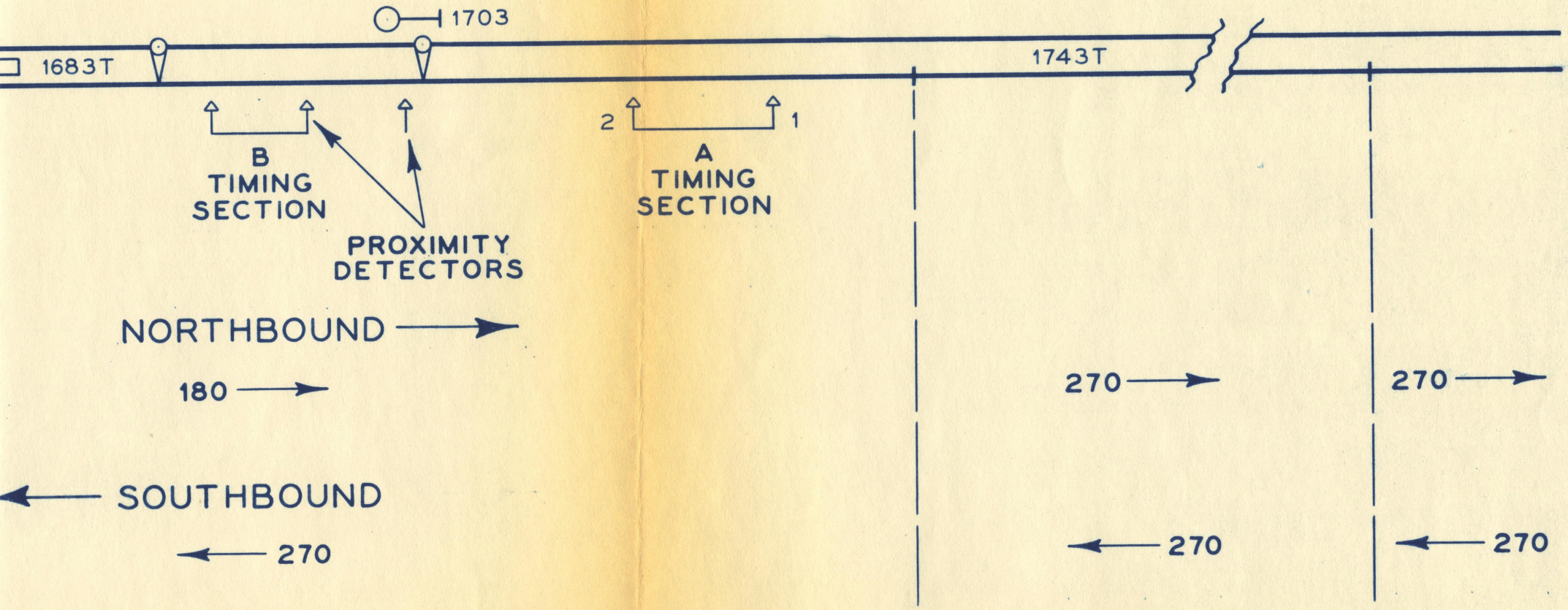
SOUTHBOUND
270


1703
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TIMING
SECTION
PROXIMITY
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2
1
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TIMING
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NORTHBOUND
180
270
270
SOUTHBOUND
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270
270

FIG. 1

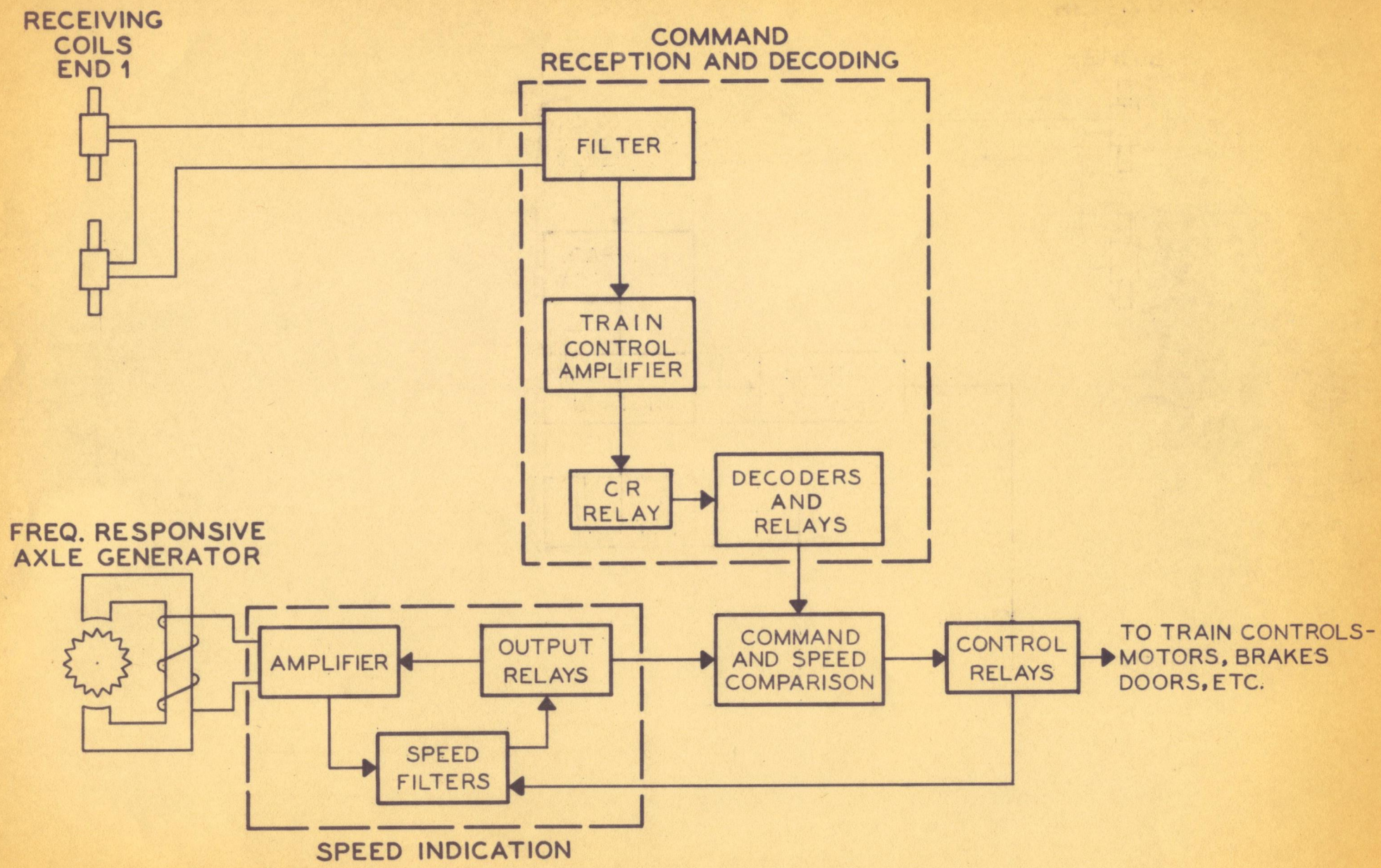
RECEIVING COILS END 1
COMMAND RECEPTION AND DECODING
FILTER
TRAIN CONTROL AMPLIFIER
CR RELAY
DECODERS AND RELAYS
FREQ. RESPONSIVE AXLE GENERATOR
AMPLIFIER
OUTPUT RELAYS
COMMAND AND SPEED COMPARISON
CONTROL RELAYS
TO TRAIN CONTROLS- MOTORS, BRAKES DOORS, ETC.
SPEED FILTERS
SPEED INDICATION

FIG. 2