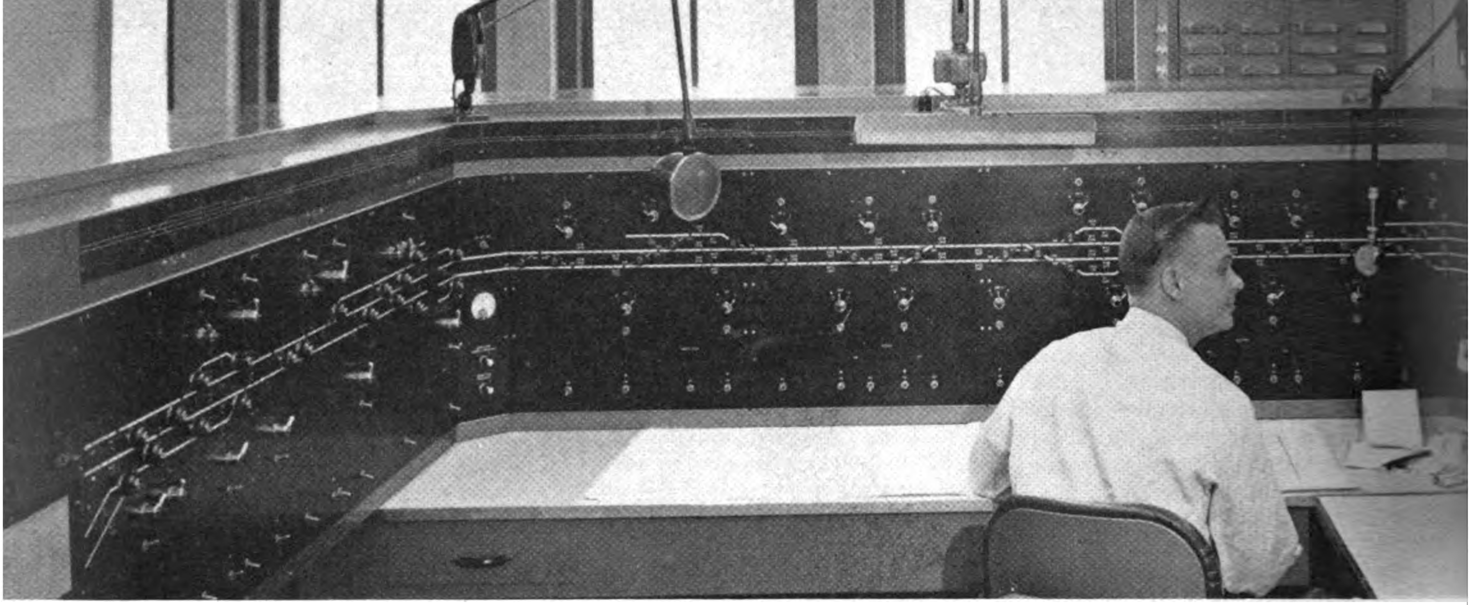

One of the CTC control machines that was moved from Erie, Pa., to Cleveland, Ohio

NYC moves CTC point o

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New York Central moved two CTC control machines to a point far from the controlled territory and put them to work through leased telephone voice circuits without interrupting train service.

The machines control CTC on the New York Central's double-track mainline from Buffalo, N.Y. to Collinwood, Ohio, near Cleveland, a distance of about 170 miles. When CTC was first installed in 1956, division headquarters and CTC controls were at Erie, Pa., near the midpoint. In a division consolidation in 1957, the new division headquarters was moved to Cleveland. At that time, moving the CTC controls to Cleveland was not feasible, so some of the division offices remained at Erie. In 1963, through the use of commercial telephone circuits, such a move became practical. As a result, consolidation of the Lake division offices was completed in late 1963 by moving the remaining Erie offices, including the CTC machines, to Cleveland.

NYC is presently in the process of installing an integrated data processing system and long distance communication system, using American Telephone & Telegraph circuits obtained under the Telpak tariff. Telpak provides a large number of channels which the signal devartment can now make use of wherever feasible for CTC operation and data telemetering, such as for hotbox detectors.

CTC on the Lake division is divided between two control machines and two dispatchers, one for the east end and one for the west. The east end machine covers 24 control points, the west end covers 17. All field locations and existing pole line facilities are unaffected by the machine relocation except for the former control office, which is now a repeater location. All connections to the field still emanate from this point in the form of two-wire code lines as before. But now the code lines connect not to the control machine equipment itself but to the repeaters, which in turn are connected to the control machine by the 100 mile "extension cord" provided by the Telpak circuits.

The control system is Syncroscan, built by the General Railway Signal Co. The Syncroscan system requires transmission of three separate information forms. Controls to operate field functions are transmitted over the code line as a sequence of positive and negative pulses of DC energy, originating and terminating in banks of stepper relays. Providing indications to the operator involves two separate audio frequency carriers. A synchronizing signal is transmitted continuously by the control office, which scans all field locations and establishes the necessary time division by which each field location transmits back to the control office in its turn a carrier with information on the status of all indicated functions at that location. Carrier frequencies used are 4.5, 6.5, 8.5, and 10.5 kc, two for the east machine and two for the west.

The Telpak circuits through which these machines are now operating are voice circuits having a relatively flat transmission response over a spectrum from 400 to 2,500 cps. This required conversion of all three signals to fit into the given range. DC controls are carried by a low frequency shift (FSK) carrier. The transmitter is keyed by the same stepper that formerly pulsed the DC code line supply. The output of the receiver in Erie operates relays which apply positive and negative DC energy to the code line from local power supplies.

The synchronizing and indication carriers had to be converted to voice frequencies to fit the pass band of Telpak. This was done by means of regenerative carrier repeaters, in which the incoming carrier with its high and low frequency shift is fed to a receiver circuit. The receiver output consists of DC pulses representing the frequency shifts; these pulses are then used as gates to key the transmitter portion to a high or low shift about the new center frequency.

The Telpak circuits used for Syncroscan transmission are 4-wire channels. One such channel is the equivalent of one pair of wires for each direction, since the eastbound and westbound paths, although considered part of the same channel, are completely independent. Two such channels are in use, one for each control machine. The eastbound circuit in each channel carries the FSK control carrier and

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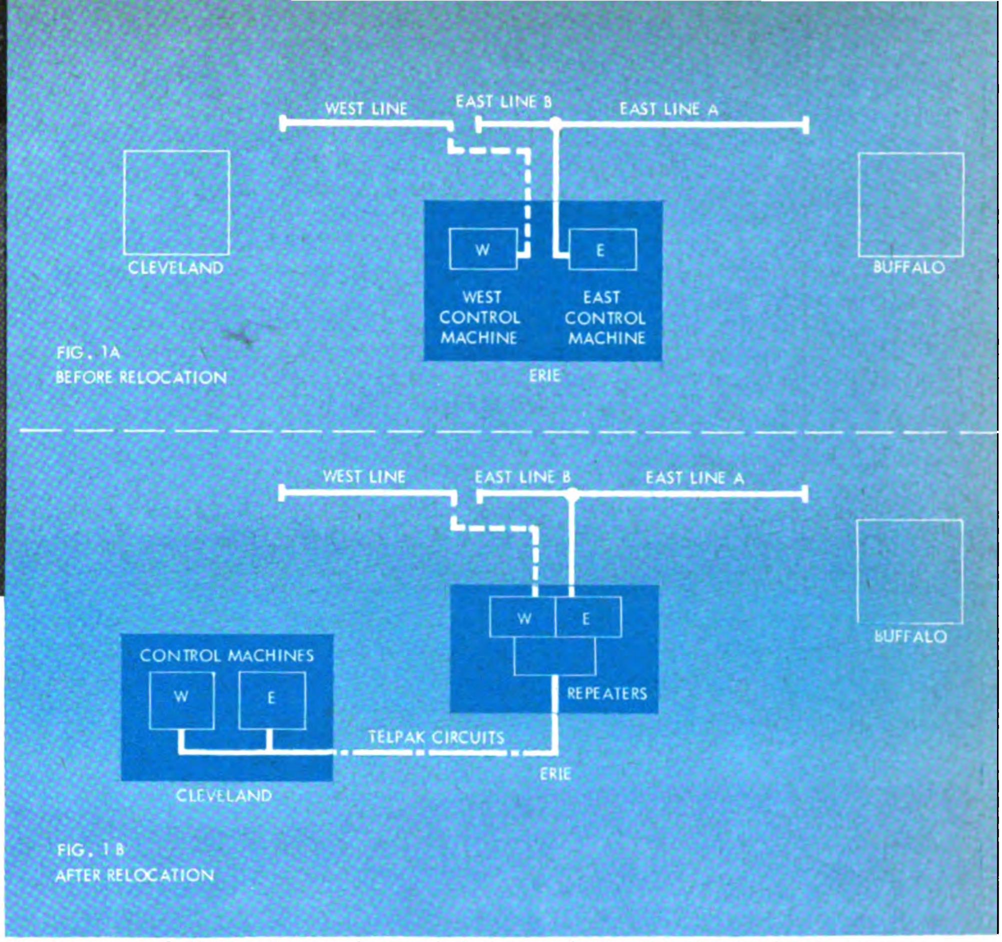
the syncronizing carrier to Erie. The westbound circuit carries the indication carrier back to Cleveland. Since the circuits are independent, the synchronizing and indication carriers for one machine are operated at the same frequency through Telpak. However, the two machines are operated at different frequencies so that, in case one of the Telpak circuits fails, both machines may be operated together through the remaining channel.

Transferring from one Telpak channel to the other is a simple matter of operating a relay at each end of the circuit. The relay at the control end is operated directly by 28 volts DC through a transfer switch on the control machine. The relay at Erie is operated by another Telpak circuit, this one a telegraph-type circuit in which energy is applied to external circuits at the remote end when the terminals at the control end are keyed together. Keying is accomplished by contacts on the transfer relay at Cleveland, and the energy output at Erie is applied to the coil of a transfer relay. Similar arrangements are made for transfer to standby carrier equipment. Standby equipment is provided for all transmitters, receivers, repeaters, filters, and power supplies. In the event of failure of any one of these units, the entire operation is transferred to the standby equipment at both Erie and Cleveland by throwing a single carrier transfer switch on the control panel. The transfer relays in Erie are energized by a keyed Telpak circuit in the same manner as used for Telpak channel transfer.



Arrangement of CTC territory and controls before and after the CTC machines move.

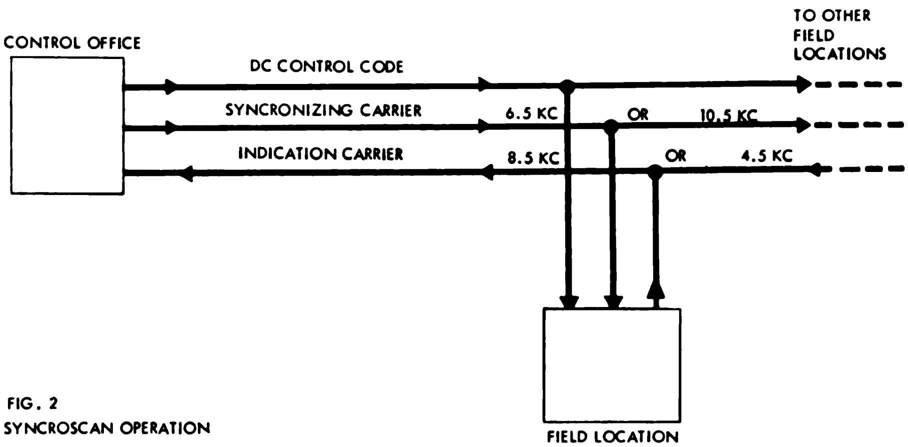


Diagram of the Syncroscan control and indication system network.

Along with the CTC control machine, eight hotbox detector recorders were also relocated from Erie to Cleveland and are operated over voice frequency circuits. Indications from the various detector locations are telemetered into Erie over the CTC code lines, as before. The output of the relatively high frequency (16 kc and up) receivers in Erie consists of a group of FM tones in the 900 to 2,400 cycle range, one tone for each rail. These tones, instead of going directly into demodulators as before, are now fed into Telpak circuits for transmission to Cleveland where they are demodulated and the outputs used to drive the pen recorders.

Physical problems in moving the control machines involved breaking them apart into pieces small enough to be handled and moved through the necessary doorways. Each machine was separated into five sections of roughly the same size and weight, and the sections were separately mounted on wood bases equipped with large rubber casters. All wires through each break point were individually cut and run through plug connectors, months in advance of the move. All the wires running into the machine from external equipment, including power, were broken through plug connectors. Complete disassembly of each machine took only a few minutes, and reassembly at Cleveland took only a few minutes once the sections were placed in their new locations. The actual moving of the pieces was done by truck. A van was rented for each machine, and the machine sections were carefully set and secured against the side walls. The only vertical move of concern was one flight of steps leading down from the old control office in Erie. This part was handled by a block and tackle arrangement anchored to the wall of the building and planks over the steps for the casters to roll on. All other vertical moves were made via elevators or ramps on the carefully selected route.

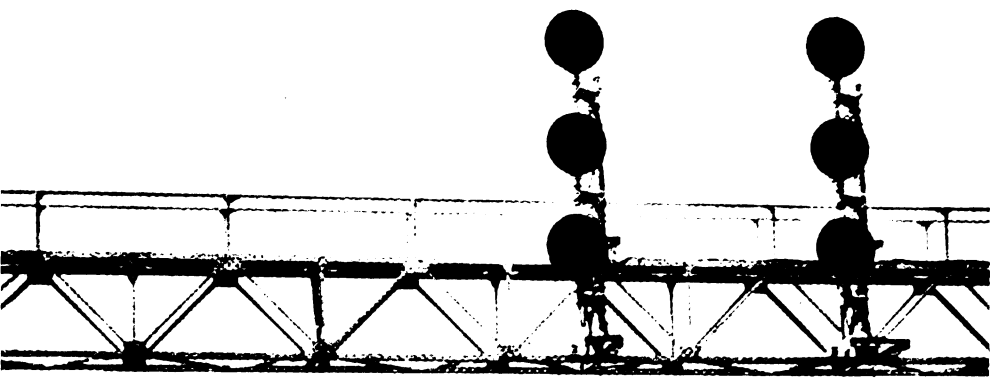
The two machines were moved one at a time in two successive weeks to reduce the territory put out of service at one time. During the 12 to 16 hours that each machine was out of service, operation of the division was handled by signal operators at eight key control points under telephone instructions from the dispatcher. Each of these manned locations was equipped with an "emergency control panel" providing the operator with a track diagram of his control point and pushbutton controls for operating power switches and clearing signals. Unmanned control points were equipped with special slave circuits which would clear a signal when the control point in the rear had cleared. All crossovers and turnouts at the unmanned locations were set for straight moves, and left locked. The moves were carried out on days when traffic on the division is ordinarily light, so very little interruption of service resulted from the reduced flexibility of operation.

Most of the new equipment as well as the Telpak circuits were tested and in full operation for a week or more before the move. While the control machines were still in Erie, the new low frequency carrier equipment was installed in the machines and the carrier signals were fed from Erie to Cleveland and back to Erie through the Telpak circuits, then through the repeaters. This left only the small amount of rack wiring in Cleveland untried, and no serious problems were encountered on moving day.

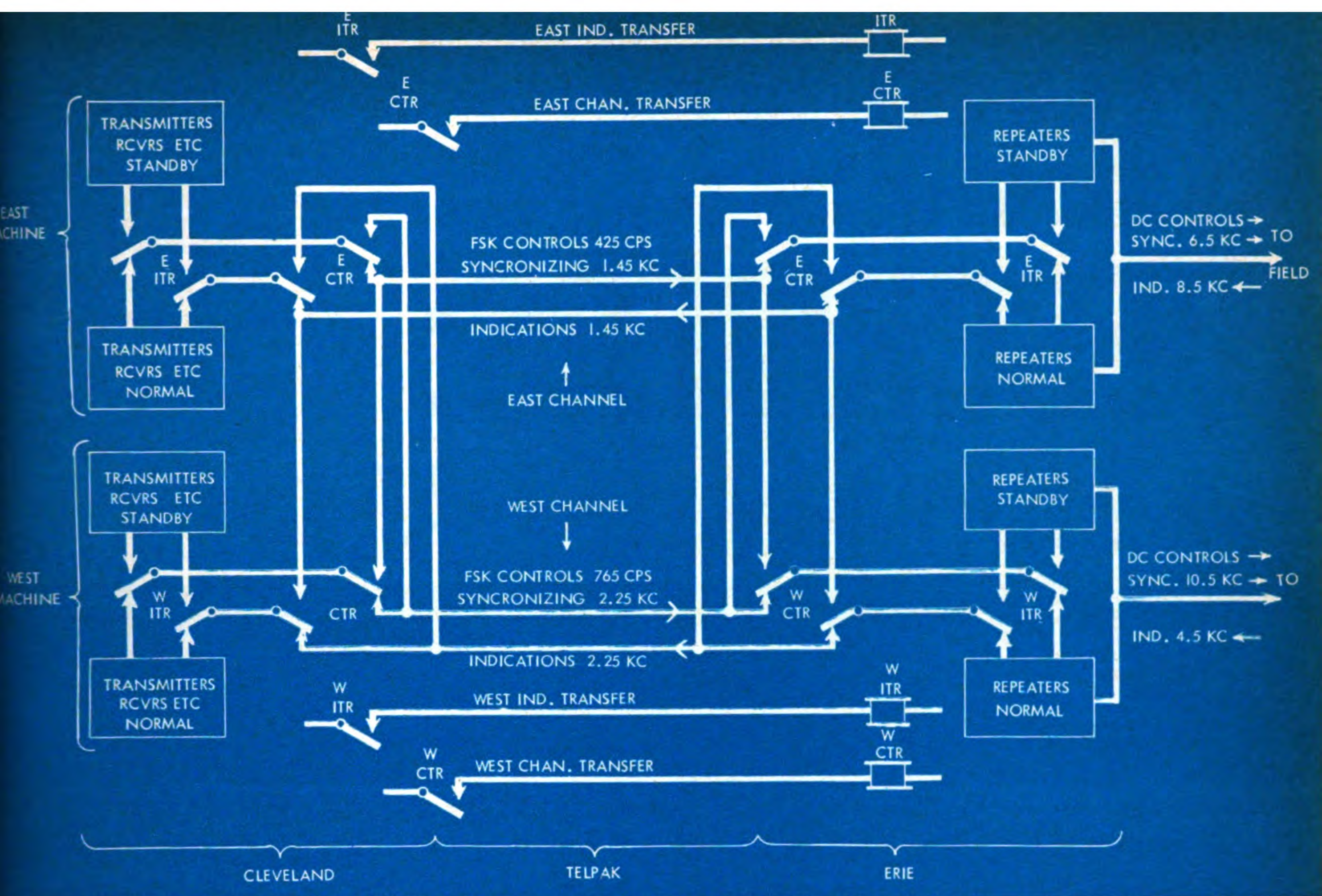
The only major technical problem encountered was in the design of the carrier equipment for the low frequency. The indication system operates on a pattern of 120 pulses per second, with spacing between pulses approximately equal to pulse duration. This makes the pulses about four milliseconds wide. On a carrier of 1,450 cps, this allows about five cycles of carrier to form a pulse, and the discriminators must be quite fast to catch the shift. Resulting variations in spacing and width of the pulses were largely eliminated by extensive use of reshaping circuits.

Maintenance and trouble analysis are a little more involved now than before the move. Formerly, if the dispatcher reported faulty indications, a comparison of the symptoms with the incoming signal could usually diagnose the problem. Now the incoming signals at the control office are being formed at the repeaters in Erie, and do not always reflect what is being received from the field. Some kinds of trouble require having a man at Erie to work with both the office and the field location and comparing notes to determine which of the three locations is the source of the trouble. In addition, the possibility of failure of the Telpak circuits introduces another factor in maintenance. If a failure being checked by railroad maintenance people turns out to be in the Telpak circuits, a call for service must be made to the telephone company. This adds another call time to the possible delays resulting from the interruption.

From the technical standpoint, the use of commercial leased telephone circuits for railroad CTC operation appears quite feasible. Economically the leased circuits are at least competitive with railroad-owned pole line, and depending on local conditions may be substantially lower in overall cost. For applications where continuous operation is of utmost importance as in CTC machine operation, the use of standby circuits channeled over different routes reduces the probability of total failure. It does not eliminate the possibility because regardless of routing, certain equipment is common to both channels. On the whole, though, the operation has been successful and other applications will be made. RS&C



This CTC territory is now controlled from machines at Cleveland.



Arrangement of Telpak channels, carrier frequencies and transfer facilities (above).

Eight hotbox detector recorders were relocated from Erie to Cleveland (below).