Appendix E

CHRONOLOGY OF TRAIN CONTROL DEVELOPMENT

The history of train control technology in rail rapid transit is interwoven with railroad engineering. Most of the train control techniques applied in rail rapid transit have their origin in railroading, from which they are either borrowed directly or adapted to the special circumstances of the urban setting. For this reason, many train control engineers consider ATC in rail rapid transit simply an extension of the field of railroad signaling. However, there are some distinct differences, both in the technology and its application. The similarities and differences are evident in the chronology of train control development presented here.

The development of signaling and train control technology may be separated into two periods, with 1920 as the dividing point. Before 1920 the major areas of technological advance were interlocking control and block signaling (manual and automatic). After 1920, the demand for moving heavier traffic at higher speeds and with increased safety led to major developments such as centralized traffic control, continuous cab signaling, coded track circuits, and automatic train control. Generally, innovative signaling and train control technology for rail rapid transit was derived from railroads and lagged behind railroad application by about 10 years. There were some notable exceptions; the development of automatic junction operation and automatic train dispatching was pioneered in rail rapid transit. Very recently, since roughly 1960, there has been some experimentation with techniques and equipment solely for rail rapid transit and small people-mover systems.

The major source of this material is American Railway Signaling Principles and Practices, Chapter l—History and Development of Railway Signaling, published by the Association of American Railroads, Signal Section, 1954. Supplementary information, particularly on rail rapid transit technology in recent years, was assembled from various sources, including manufacturer's brochures, local transit agency reports, and technical journals.

1832 The first fixed signal system in America was installed on the New Castle & Frenchtown RR, The signals were ball-shaped objects mounted on masts at 3-mile intervals. The signals were raised and lowered by a signalman to indicate permissible speed—low meaning stop and stay and high meaning proceed at full speed, The latter indication gave rise to the expression "highballing."

1843 The first mechanical interlocking was installed at Bricklayer's Arms Junction in England. It was a simple machine operated by a signalman who worked the switches with his hands and the signals with his feet.

1851 Morse code electric telegraph was first used in train operation for sending train orders on the New York & Erie RR.

1853 The Philadelphia & Reading RR installed signal towers for giving information to approaching trains on the occupancy of the track in advance.

1853 Open-circuit manual block signaling was first used in England.

1860 Gate signals were initiated in America. A stop indication was displayed by placing a red banner or disc on top of the gate during the day. A red light was displayed at night.

1863 Closed-circuit (fail-safe) manual block signaling, using the space interval method of operation, was first employed in America on the United New Jersey Canal & RR Co. between Kensington, Pa. (Philadelphia), and Trenton, N.J.

1866 The first automatic electric block system was installed on the New Haven System at Meriden, Corm. Hall enclosed disc signals, open circuit, were operated by track instruments.

1868 The Pennsylvania RR used a type of train order signal which was under the control of the train dispatcher who could set it in the stop-danger position at any remote station by means of a selective device operated over the regular Morse telegraph circuit.

1870 The first interlocking machine in America was installed at Top-of-the-Hill, a junction at Trenton, N. J., on the Camden and Amboy Division of the Pennsylvania RR.

1871 A system of automatic block signals, comparable with presently used equipment, was installed on the New York & Harlem RR and the Eastern RR.

1872 The first installation of closed d.c. track circuit, invented by Dr. William Robinson, was made at Kinzua, Pa., on the Philadelphia & Erie RR.

1873 The Robinson closed-circuit track block for switch protection was first put into use on the Philadelphia & Erie RR.

1876 The first power interlocking of the Burn pneumatic type was put in use on the Pennsylvania RR at Mantua "Y," West Philadelphia, Pa.

1876 The Boston & Lowell and the Boston & Providence RRs introduced the Robinson electromechanical signal for **automatic** blocking, controlled by direct current track circuits.

1880 The first automatic train stop was placed in trial service on the Middle Division of the Pennsylvania RR. A glass tube in the train air line located on the locomotive near the rails was designed to be broken by a "track trip" set in operating position when the signals were in the stop position.

1881 The first interlocking of the hydraulic type was installed by the Union Switch & Signal Co. at Wellington, Ohio, for a crossing of the Wheeling & Lake Erie Ry. with the Cleveland, Cincinnati, Chicago & St. Louis Ry.

1885 The "Dutch Clock" device for establishing time intervals (headways) between trains was in use on the New York, New Haven & Hartford RR and the New York Central & Hudson River RR. When operated automatically by a treadle device on the rail, the passing train released a pointer which started to move around a dial divided into three segments each representing 5 minutes. The pointer movement was controlled by an escapement so that it moved across the dial in a period of 15 minutes. Headway for the train ahead was thus indicated up to 15 minutes.

1885 The first electric detector locking for interlocked track switches was installed by the Pennsylvania RR at the Pittsburgh, Pa., terminal by using depression trips to ground the indication circuit.

1889 The first electric interlocking employing dynamic indication, invented by John D. Taylor, was installed at East Norwood, Ohio, at the crossing of the Baltimore & Ohio Southwestern RR and the Cincinnati and Northern RR.

1893 The first low-voltage, direct-current, motor-operated automatic semaphore block signals were installed on the Central RR of New Jersey in Black Dan's Cut, east of Phillipsburg, N.J. They were two-position lower-quandrant signals with the motor and driving chain outside the mast.

1900 The first three-block indication was installed on the Pennsylvania RR between Altoona and Cresson, Pa. The signals were two-position, lower-quadrant, home and distant automatic semaphores,

1900 In Acton Town, England, an illuminated track diagram was first used in connection with resignaling on the District Ry. due to electrification, It dispensed with separate track indicators and brought together all track occupancy information on the plan of tracks and signals, thereby facilitating the work of the signalman handling traffic.

1901 The Taylor Signal Co. put in service the first electric interlocking embodying the "dynamic indication" principle, at Eau

Claire, Wis., on the Chicago, St. Paul, Minneapolis & Omaha Ry.

1901 The Boston Elevated installed special polarized d.c. track relays. This was the first attempt to operate track circuits on a railroad where propulsion power was supplied by electricity and the rails were used as the medium for current return.

1901 The Boston Elevated made the first permanent installation of an automatic train stop system, which consisted of mechanical wayside trips engaging brake control apparatus on the moving car.

1903 The North Shore RR of California made the first installation of a.c. track circuits for automatic block signals.

1906 The first signal system with a.c. track circuits on a road using a.c. propulsion power was installed on the New York, New Haven & Hartford RR, The track circuits were the two-rail type, 60 Hz, with impedance bonds. Propulsion current was 25 Hz.

1907 The first automatic interlocking for the protection of a railroad crossing was installed at Chester, Va., at a crossing of the Tidewater & Western Ry. with the Virginia Railway, Power & Light Co.

1909 The Erie RR installed automatic signaling for train operation by signal indication on a two-track division, 139.7 miles in length, which directed trains to: (1) stop and hold main track, (2) take siding, (3) proceed on main track regardless of superior trains.

1911 The absolute permissive block system (APB), developed by the General Railway Signal Co., was first installed on the Toronto, Hamilton & Buffalo RR between Kinnear and Vinemount, Ontario, Canada, using direct-current semaphore signals.

1912 Train movements on the Chesapeake & Ohio Ry. were directed for the first time by signal indication without written train orders.

1912 Cab signals were first used on an electric railway, the Indianapolis & Cincinnati Traction Co.

1914 The cam controller for control of power application to d.c. propulsion motors was first used in the Chicago Rapid Transit co.

1915 The American Railway Association adopted rules which permitted train operation on single track by controlled manual block signal indications, superseding timetable and train orders.

1919 The Buffalo, Rochester & Pittsburgh Ry. made the first trial installation of the General Railway Signal Co. intermittent inductive train stop system. This system used magnetic induction to transfer signals from wayside controls to train equipment.

1920 The first installation of automatic speed control in the US. was that of the Regan Safety Device Co. intermittent electrical contact ramp-type train control system on the Chicago, Rock Island & Pacific RR between Blue Island and Joliet, Ill.

1923 The Pennsylvania RR placed in service, experimentally, the first installation anywhere of the continuous inductive cab signal and train control system coveting 43.5 miles of single track and 3.4 miles of two-track, between Lewistown and Sunbury, Pa. It was the first instance where vacuum tubes were used for purposes other than in communication circuits. This installation also was the first time that cab signals were used in lieu of wayside signals for operating trains by signal indication.

1925 The first permanent installation of cab signals without wayside automatic block signals was made on the Atchison, Topeka & Santa Fe Ry., between Chillicothe, Ill., and Ft. Madison, Iowa. The equipment was a Union Switch & Signal Co. three-speed continuous inductive-type train control device.

1926 The Illinois Central RR was the first to equip an operating division with automatic train stop and two-indication

continuous cab signals without wayside automatic block signals,

1927 The first General Railway Signal Co. centralized traffic control system was installed on the New York Central RR between Stanley and Berwick, Ohio. The first dual-control electric switch machines, which provided for either hand or electric operation, were introduced on this installation,

1930 The first use of the all-relay interlocking principle, as a substitute for indication parts and magnets at the levers of a large interlocking machine equipped with mechanical locking, was at Cleveland Union Terminal, Ohio,

1931 The New York Central RR installed a system of four~block indication signals on a line equipped with automatic block signals in heavy suburban traffic territory.

1932 The Philadelphia subways installed a modified type of the three-wire circuit code scheme of centralized traffic control.

1933 The Pennsylvania RR was granted permission by the ICC to convert all its locomotives equipped with the coded continuous train stop system to the coded continuous cab signal system with whistle and acknowledger. This was done with the understanding that the Pennsylvania RR would voluntarily extend cab signal territory to include most of its main line trackage.

1934 The first installation of coded track circuits on steam-operated territory was made between Lewistone and Mt. Union, Pa., on 20 miles of four-track main line on the Pennsylvania RR, The average length of track circuit was 5,201 feet. Energy was coded storage battery for three and four-indication wayside signals, with coded 100 Hz a.c. superimposed for continuous cab signals,

1937 The first installation of a relay-type interlocking with push-button automatic selection of routes and positioning of switches and signals, General Railway Signal Co. Type “N-X” (entrance-exit), was made at Girard Junction, Ohio, on the New York Central RR.

1939 A four-indication, four-speed coded, continuous train control system was installed on suburban cars of the Key System, Southern Pacific and Sacramento Northern Railroads operating over the San Francisco-Oakland Bay Bridge, California, The system was designed to handle 10-car multiple-unit trains operating on a l-minute headway, The installation included an N–X interlocking system with a train describer and automatic operation of a single switch.

1939 The first application of coded detector track circuits in interlocking was made by the Norfolk & Western Ry.

1940 The first installation of coded track circuits for continuous cab signaling without wayside automatic signals in steam territory, developed by the Union Switch & Signal Co., was made between Conpit and Kiskiminetas Junctions, Pa., on the Pennsylvania RR,

1940 The Pennsylvania RR installed a centralized traffic control system between Harmony and Effingham, Ill., using the Union Switch & Signal Co, two-wire, 35-station time code type for the first time on a multiple-connected line circuit in which the line wires were continuous throughout the territory, and which provided for the coordination of the code circuit and communication circuits over the same line wires, This was the first installation of a centralized traffic control system to employ a two-wire code line circuit in which all the field locations were connected in multiple across the line wires,

1940 The first installation of reversible coded track circuits in single-track territory with centralized traffic control was made between Machias and Hubbard, N.Y., on the Pennsylvania RR.

1940 The first installation of absolute permissive block (APB) signaling with three and four indications with coded track

circuits was made on the Norfolk & Western Ry., between Petersburg and Evergreen, Va.

1943 The first installation of coded track circuits using polar reverse codes with three-indication signaling for either-direction operation was made on the St. Louis Southwestern Ry.

1944 The first installation of normally deenergized coded track circuits for centralized traffic control on single track was placed in service between Laredo and Polo, Me., on the Chicago, Milwaukee, St. Paul & Pacific RR.

1946 The Pennsylvania RR demonstrated the feasibility of centralized traffic control operation over commercial communication circuits, including beamed radio. The test was made over approximately 1,130 miles of Western Union carrier telegraph circuit including about 90 miles of beamed radio. This was the first time beamed radio was used for this purpose.

1948 The first use of automatic train dispatching in rail rapid transit was by the Philadelphia Rapid Transit Co. (now SEPTA). The device employed a perforated opaque tape driven by a clock mechanism. A beam of light scanning the tape triggered a photoelectric cell that automatically activated starting lights at terminals.

1949 The Chicago Transit Authority initiated experiments in the use of radar for train detection and separation assurance.

1951 The Pennsylvania RR installed a three-speed continuous inductive train control system in which the limits were 20 miles per hour with no code, 30 miles per hour with 75 code, 45 miles per hour with 120 code, and no speed limit with 180 code.

1951 CTA began the use of automatic train dispatching with remote override capability from central locations. The system, which employs a mechanical clock, pen graph recorders of train movement, and line supervision, is still in operation.

1951 A portable radio, called "Dick Tracy," was first used by yard switchmen on the Southern Ry. in connection with coupling cars in the classification yard and transferring them to the departure yard.

1952 The Erie RR placed in service at Waterboro, N, Y., in connection with the establishment of a remotely controlled interlocking, a system of automatic train identification, This system automatically identifies the direction and the number of a train as it clears a manual block on a branch line.

1953 The first installation of cab signaling using transistors in place of vacuum tubes was placed in service on the New York, New Haven & Hartford RR by the General Railway Signal Co.

1953 The first installation using transistors instead of vacuum tubes in safety-type (vital circuit) carrier equipment was made on the Pennsylvania RR. The equipment was developed by the Union Switch & Signal Division of Westinghouse Air Brake Co.

1955 A crewless remote-controlled passenger train was demonstrated on the New York, New Haven & Hartford RR.

1959 The inductive train phone was first used in raiI rapid transit by the Chicago Transit Authority.

1961 A completely automatic subway train was placed in service on the shuttle run between Times Square and Grand Central Station in New York. A motorman was on board for emergencies, but he was not involved in normal operation of the train and often spent his time reading the newspaper,

1962 A crewless freight train operating system was tested on the Canadian National RR.

1964 Automatic train operation (ATO) equipment, intended for use in the BART system, was operationally tested at Thorndale on the Chicago Transit Authority North-South route.

1966 Four automatic train control systems for BART were demonstrated at the Diablo test track--one using the moving block concept, two using coded track circuits, and the other using a "trackwire" communications link and wayside control equipment.

1966 Fully automated vehicle operation and innovative methods of train control were demonstrated for the Transit Expressway (Skybus) system at South Park, Pa., by the Port Authority of Allegheny County (Pittsburgh).

1967 Audio-frequency track circuits in a rail rapid transit application were first placed in regular service by the Chicago Transit Authority.

1969 Revenue service was begun on the PATCO Lindenwold Line. After a manually initiated start, train operation is completely automatic until the doors are opened at the next station.

1971 An automatic people-mover system was placed in operation at the Tampa Airport. This system incorporates some of the ATC elements originally demonstrated at South Park,

1972 Four automatic people-mover systems were demonstrated at TRANSPO '72, Washington, D. C., under the auspices of the U.S. Department of Transportation.

1972 Revenue service was initiated on the Fremont-MacArthur portion of the BART system, Train operation, including start, berthing, and door operation, is entirely automatic but under the supervision of an onboard operator,

1973 The Satellite Transit System, featuring automatic crewless vehicle operation, was placed in service for passengers at the Seattle-Tacoma (Sea-Tac) Airport.

1974 The AIRTRANS system at Dallas/Ft. Worth Airport opened for service. Operating on 17 interconnected routes, AIRTRANS has automatic crewless trains to carry passengers, baggage, freight, and refuse within the airport complex.

1974 Demonstration of the Morgantown (W, Va,) PRT system was conducted, Small vehicles, operating on a fixed guideway, circulate under automatic control and without onboard operators,