Communication Engineering

'54-1

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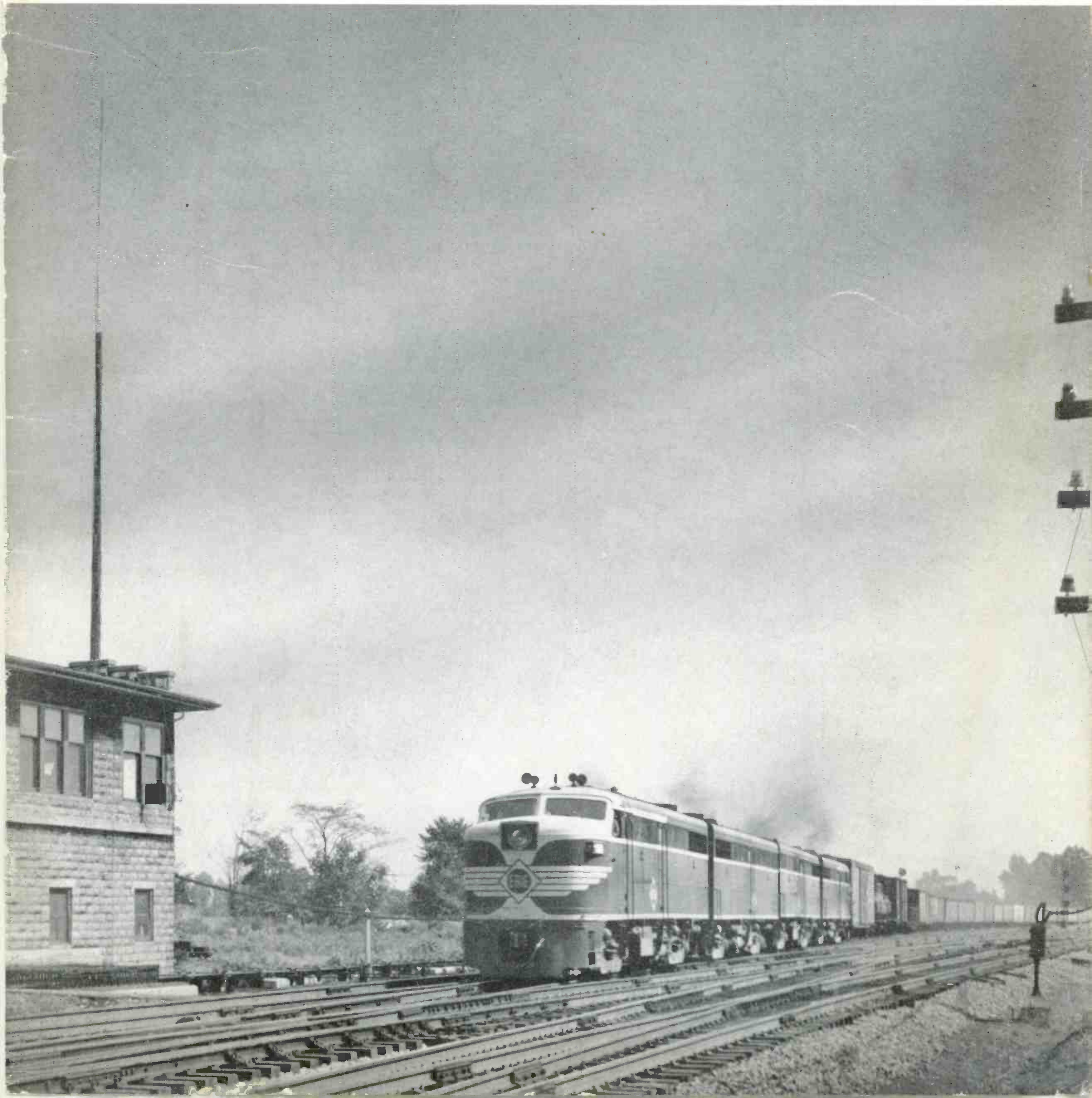


How THE NATION'S LEADING PIPELINES USE

PHILCO *MICROWAVE*

Philco Microwave is being used daily by the Nation's leading pipeline companies. These pipeline companies have selected microwave because: (1) it is an economical, reliable and expandable communications system eliminating costly and vulnerable wire lines, and (2) it provides them with private, dependable communications over long distances, cutting maintenance costs to a minimum.

Pipelines stretching over hundreds of miles can be operated and controlled from a single point by microwave. Pressure, rate of flow and tank level readings can be recorded automatically and relayed to headquarters or various points along the route. Philco Microwave carries telephone, teletype, control and telemetering channels . . . *and offers complete tie-in with VHF two-way radio systems and existing wire line facilities.*

Shown here are two of the many Philco Microwave systems that provide the nation's leading pipelines with modern and efficient communications.

From this central console headquarters at Kansas City, Missouri, the entire Platte pipeline and communication system can be controlled and monitored.

Platte Pipe Line Company's microwave system is over 1000 miles long . . . to provide every communication and control facility: voice channels, remote supervisory control, continuous or selective telemetering, teletype, alarm signaling and VHF radio. This entire microwave system was surveyed, designed and installed by Philco.

Typical Philco Pipeline Installations

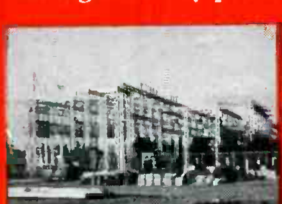
El Paso Natural Gas Company has 500 miles of Philco Microwave with an average distance of 50 miles between stations. This New Mexico to Arizona system consists of repeater and terminal stations, multiplexing equipment for system party line and VHF radio channels.

The longest microwave hop in the nation is this 81-mile El Paso hop from Mount Elden to Dilkon, Arizona . . . typical of the utilization of terrain advantage by Philco.

OTHER INDUSTRIES USING PHILCO MICROWAVE

Communication companies use Philco Microwave for telephone, telegraph and television transmission. Reliability, economy and quality of transmission make Philco Microwave ideal for their use.

Philco Microwave is being used by leading railroads for telephone, telegraph and train dispatching. Microwave is a private system, saves costly wire installations and simplifies right-of-way problems.



Utilities rely on Philco Microwave for the control of power stations, dispatching of repair trucks and communication. Dependable channels, unaffected by adverse weather, are a necessity for utility use.

For complete details, write to Dept. CE today!

PHILCO Famous for QUALITY the World Over

PHILCO CORPORATION

GOVERNMENT & INDUSTRIAL DIVISION PHILADELPHIA 44, PA.

ANNOUNCING

IMMEDIATE DELIVERY OF

PLATT 450-470

MOBILE RADIO

THE COMPLETE ANSWER TO A MOBILE SYSTEM WHERE LOWER FREQUENCIES CANNOT BE LICENSED!

MOBILE UNIT
FRONT or REAR MOUNT

BASE STATION
SINGLE PACKAGE
TRANSPORTABLE

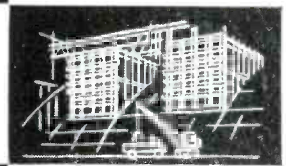
ALSO AVAILABLE
PLATT SETS COVERING
152-174 MC BAND
25-50 MC BAND

WRITE TODAY FOR COMPLETE INFORMATION

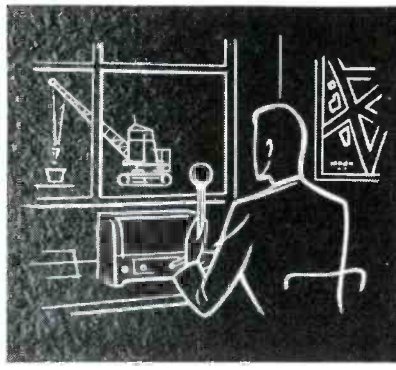
PLATT *Manufacturing Corp.*

489 BROOME STREET • NEW YORK 13 • NEW YORK

50 watt VHF TRANSMITTER

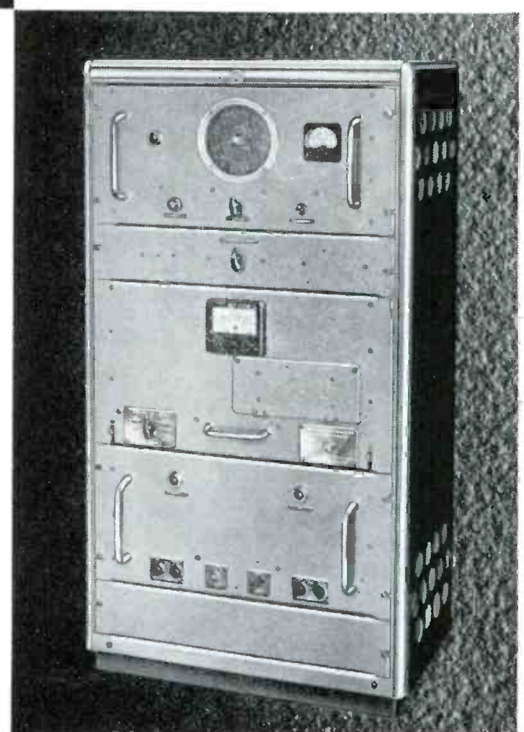


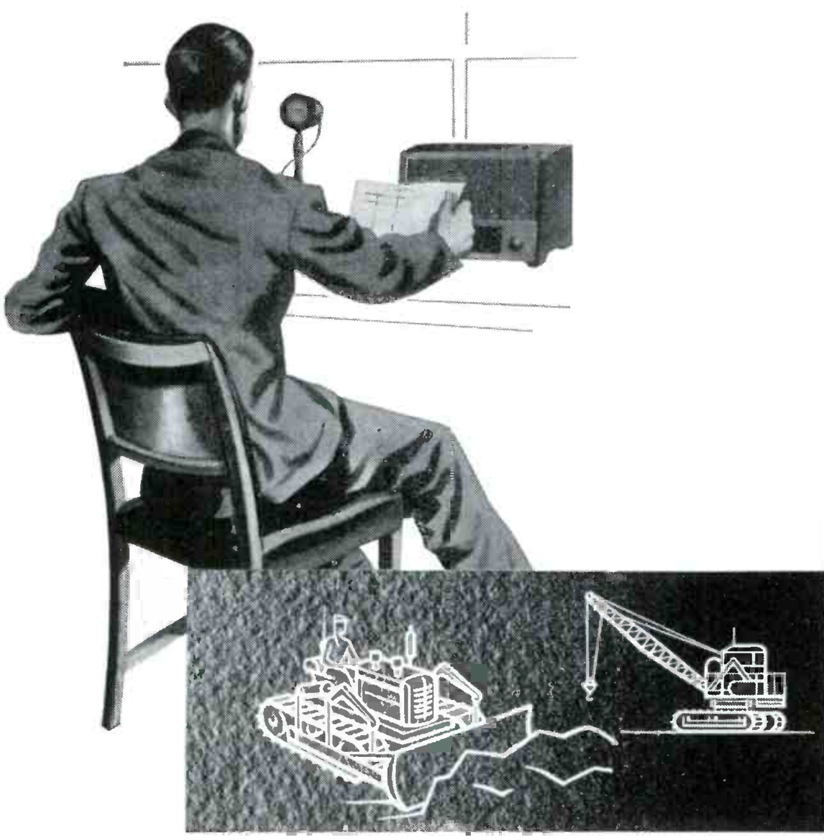
PTC 351 FOR RADIO CONTROL IN CIVIL ENGINEERING



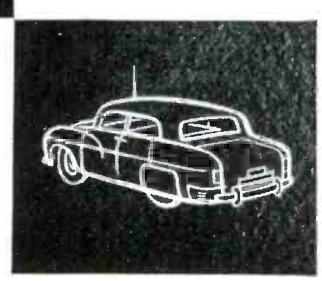
Of an advanced design using the latest techniques, the new Pye 50-watt V.H.F. Transmitter is ideal for use in normal fixed and mobile schemes where high powered transmitters are required. It may also be used for point-to-point radio-telephone links.

A further application is in the aeronautical band where the 50-watt transmitter, together with the standard Pye fixed receiver, provides one of the most efficient ground-to-air control stations at present available in the world.





Telecommunications



PYE LIMITED • CAMBRIDGE • ENGLAND

Communication Engineering

Formerly FM-TV and RADIO COMMUNICATION

VOL. 14 JANUARY - FEBRUARY, 1954 No. 1

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CPA AUDIT

CIRCULATION AUDITED BY HENRY R. SYKES CERTIFIED PUBLIC ACCOUNTANT SYKES, GIDDINGS & JOHNSON PITTSFIELD, MASSACHUSETTS

SYSTEMS DATA

FOLLOWING is a list of transmitters not included in the Table, because they will be operated outside the 30 to 50 and 152 to 174-mc. bands, for which applications were filed during December and January:

Police: 60 speedmeters on 2,455 mc.; 1 interzone CW transmitter on 1.722, 2 on 2. 804, and 2 on 7.935 mc.; 4 relays on 75 mc., 6 on 155 mc., 2 on 955 mc., 8 on 1,895 mc., and 20 on 6,585 mc.; 1 control transmitter on 958 mc., 1 on 458 mc., 2 on 74 mc., and 2 on 1895 mc.; 11 operational transmitters on 65 mc.

Fire: 1 relay on 453 mc., and 1 on 153 mc.; 1 control transmitter on 458 mc., and 2 on 154 mc.

Special Emergency: 1 relay transmitter on 453 mc., and 1 on 157 mc.; 1 control transmitter on 458 mc., and 2 on 162 mc.; 40 mobile units and 1 base transmitter on 3.190 mc.; 200 mobile units and 4 base transmitters on 458 mc.; 1 base transmitter on 2.726 mc.; 2 operational transmitters on 458 mc., and 1 on 3.201 mc.

Highway Maintenance: 2 relay transmitters on 454 mc., 1 on 161 mc., and 1 on 74 mc.; 5 control transmitters on 458 mc., and 1 on 75 mc.

Forestry Conservation: 2 base transmitters on 2.226 mc.; 4 relays on 173 mc., 1 on 159 mc., and 1 on 453 mc.; 1 control transmitter on 170 mc., and 1 on 453 mc.

Power Utility: 3 base transmitters on 456 mc.; 2 mobile relays on 37 mc.; 4 relay transmitters on 75 mc., 2 on 451 mc., 2 on 190 mc., 4 on 67 mc., and 1 on 953 mc.; 3 control transmitters on 456 mc., and 1 on 48 mc.; 10 operational transmitters on 1,900 mc., 1 on 169 mc., 2 on 6,625 mc., and 1 on 40.68 mc.; 1 mobile operational unit on 48 mc.

Pipeline Petroleum: 3 mobile units and 13 base transmitters on 2.292 mc.; 2 mobile units and 9 base transmitters on 4.638 mc.; 10 mobile units on 1.628 mc.; 50 mobile units and 6 base transmitters on 456 mc.; 15 mobile units and 1 base transmitter on 25 mc.; 5 base transmitters on 1,855 mc.; 5 relay transmitters on 75 mc.; 3 mobile and 1 base relay on 158 mc., and 2 base relays on 451 mc.; 5 control transmitters on 72 mc., 3 on 456 mc., and 10 on 153 mc.; 15 operational transmitters on 1,895 mc., 2 on 956 mc., 6 on 6,700 mc., and 2 on 75 mc.

Special Industrial: 11 mobile units and 6 base transmitters on 2.292 mc.; 80 mobile units and 3 base units on 27 mc.; 6 mobile and 1 base transmitter on 456 mc.; 6 relay transmitters on 75 mc., 5 on 960 mc., and 1 on 456 mc.; 6 control transmitters on 75 mc., 1 on 451 mc., and 10 on 960 mc.; 2 operational transmitters on 72 mc.

Relay Press: 110 mobile units and 3 base transmitters on 456 mc.

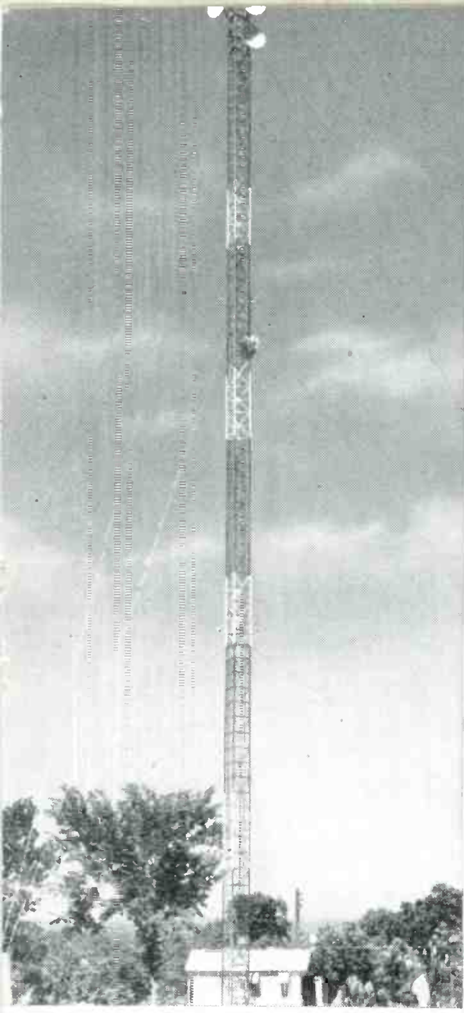
Taxicabs: 270 mobile units and 4 base transmitters on 457 mc.

Railroads: 4 mobile relays on 160 mc.

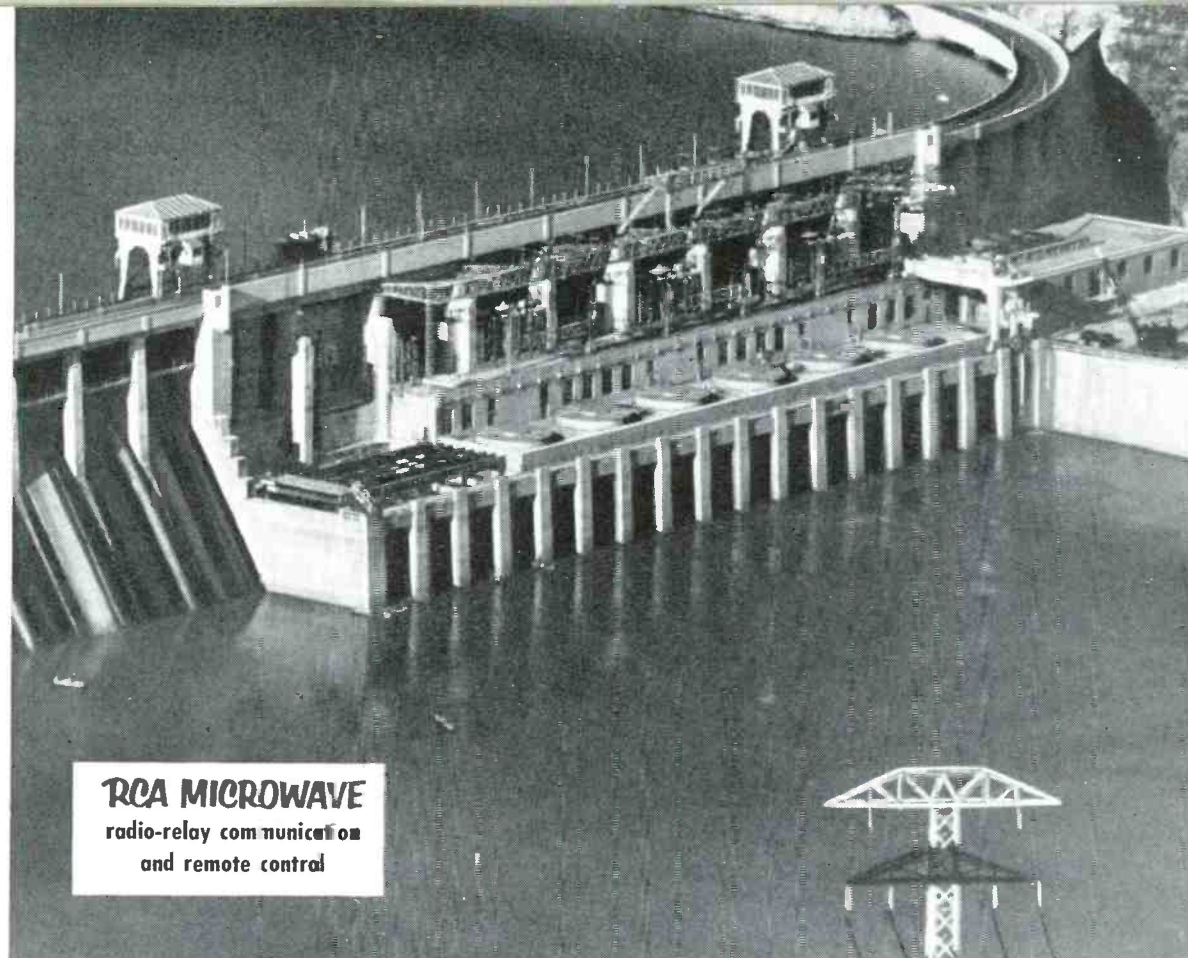
Auto Emergency: 80 mobile units and 3 base transmitters on 452 mc.

TABLE OF APPLICATIONS FILED OCTOBER 23, 1953 TO JANUARY 1, 1954

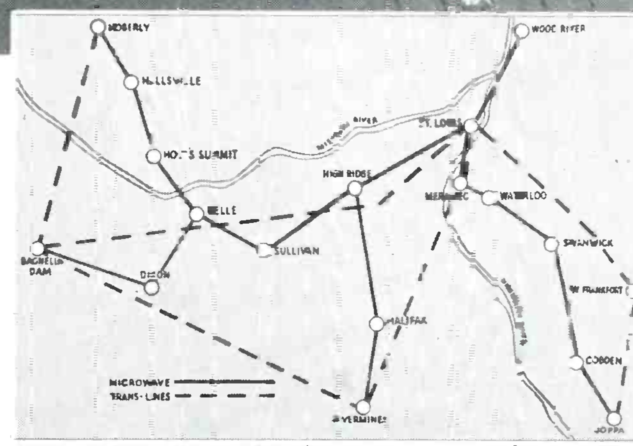
	TOTAL MOBILE	TOTAL BASE	TOTAL PORT.	30 to 50 mc. MOBILE	30 to 50 mc. BASE	30 to 50 mc. PORT.	152 to 174 mc. MOBILE	152 to 174 mc. BASE	152 to 174 mc. PORT.
Police	2,361	183	96	1,464	111	27	897	72	69
Fire	910	56	5	447	27	3	463	29	2
Special Emergency	229	103	—	154	87	—	75	16	—
Highway Maintenance	746	34	—	604	18	—	142	16	—
Forestry Conservation	158	36	—	108	17	—	50	19	—
Power Utility	1,726	81	—	663	49	—	1,063	32	—
Pipeline Petroleum	735	127	12	455	103	—	280	24	12
Special Industrial	2,561	240	16	1,718	178	1	843	62	15
Low-Power Industrial	—	1	566	—	—	77	—	1	489
Relay Press	45	1	—	—	—	—	45	1	—
Motion Pictures	—	—	—	—	—	—	—	—	—
Forest Products	107	11	—	95	9	—	12	2	—
Taxicabs	2,283	53	5	—	—	—	2,283	53	5
Railroads	507	30	40	—	—	—	507	30	40
Highway Trucks	871	63	—	836	63	—	35	—	—
Intercity Buses	—	1	—	—	1	—	—	—	—
Transit Utilities	31	3	—	31	3	—	—	—	—
Auto Emergency	207	28	—	207	28	—	—	—	—
Radio Paging	—	21	—	—	21	—	—	—	—
Common Carrier	549	6	—	85	1	—	464	5	—
Misc. Common Carrier	360	13	—	—	—	—	360	13	—
TOTALS	14,386	1,091	740	6,867	716	108	7,519	375	632



RCA Microwave radio relay installation at High Ridge, Mo. Towers are rugged, designed to withstand 100-mph winds under severe icing conditions.



Osage Hydroelectric Power Plant installation of Union Electric Company of Missouri, at Bagnell Dam, Mo.—serviced by RCA Microwave.



Union Electric Co. Microwave system stretches out 425 miles in 3 directions from St. Louis.

How UNION ELECTRIC solved today's communication problem

Two years ago Union Electric Company of Missouri ran into the communication problem which sooner or later confronts all growing utilities: their high-line carrier transmission system had become inadequate.

The 150 kc bandwidth, allotted for power line carrier operation, permits the use of only a relatively few channels which are not sufficient to meet all the requirements of a modern communications system. Direct wire lines were ruled out as too costly.

That prompted engineers to adopt Microwave, supplemented with mobile radio at major relay points. RCA Microwave provides channels for remote control of load dispatching, telemetering, teletype and voice communication. It results in close co-ordination of vehicles, field crews, executive and service personnel at outlying offices and stations. And, 70% of the RCA Microwave system is available for future expansion.

RCA Microwave can be interconnected with existing phone lines and switchboards. It uses familiar channeling circuits and readily available tubes. It provides as many channels as needed with minimum use of frequency space.

Now Union Electric has dependable, year-round communications over the full length of its operations. RCA "dish" antennas atop 100- to 300-foot towers, spaced 11 to 45 miles apart, send concentrated beams of radio energy from station to station. The radio beams follow a line-of-sight path—approximately parallel to the transmission lines.

You, too, can plan now for tomorrow's problems—prepare for your expanding communications needs before they develop. The booklet listed below provides quickly digested facts for future thinking, *with no obligation on your part.* Mail the coupon. *Remember,* only RCA can provide the nation-wide service facilities of the RCA Service Company.

RADIO CORPORATION of AMERICA
COMMUNICATIONS EQUIPMENT CAMDEN, N. J.

Dept. A-32, Building 15-1

Please send me your reprint describing Union Electric Microwave system, *"Microwave Relieves Overloaded Circuits."*

Name______________________ Title______________

Company____________________ Address______________

City______________ Zone______ State______________

☐ Have an RCA representative get in touch with me.

PRODUCT INFORMATION

Weatherproof Housings: For use on fire trucks, emergency mobile apparatus, and service and utility vehicles, weatherproof steel housings for Carfone and Fleetfone 2-way radio equipments are now available. Weighing about 50 lbs., the sturdy boxes have hasp latches on the covers which, when opened, expose top and one side of equipment. RCA Victor, Communication Equipment Section, Camden, N. J.

New Dynamotors: Model B615V Change-A-Volt dynamotor permits operation of 6-volt mobile radio equipments on vehicles with 12-volt electrical systems, is supplied with starting relay, switch and fuse block, and has an efficiency of 65%. Usable with transmitters of up to 30 watts. Complete specifications given in Bulletin 653A. For those interested in the complete line of Carter products, 28-page bulletin 753 is available on request. Also, a slide chart calculator for computing efficiency and regulation of any rotary power supply will be sent free on request. Carter Motor Company, 2641 North Maplewood Ave., Dept. 26, Chicago 47, Ill.

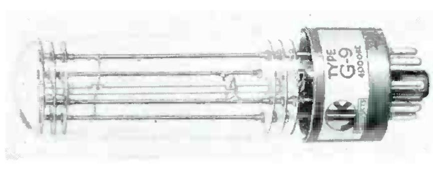
Mobile Equipment: Descriptive literature is available on the now-complete Platt line, consisting of 2, 10, 30, and 60-watt mobile and base units and 250 watt fixed stations in the 25 to 50, 152 to 174, and 450 to 470-mc. bands. Delivery is said to be immediate on equipment for the lower bands, and 60 days for high-band units. Platt Manufacturing Corp., 489 Broome Street, New York 13, N. Y.

Test Equipment: Type 232-A Glide Slope signal generator, shown here, is said to provide for the first time in a single instrument complete testing and calibration facilities for glide-slope receiving equipment, as used in the CAA instru-

ment landing system. RF and IF signal voltages are available for accurate study, alignment, and calibration, and internal modulation for simulation of on-and off-course signals. Other new components are type 590-A inductors for use in types 170-A and 190-A Q-meters, for the range from 20 to 230 mc., and the type 513-A Q standard inductor for accurate calibration. Inquiries should be addressed to Henry J. Lang, Boonton Radio Corp., Boonton, N. J.

1953 Catalog Edition: The 18th edition of *Radio's Master* has just been distributed, numbering 100,000 copies. It is claimed that the 1370 pages list 90% of the electronic industry's parts and equipment output; complete descriptions, specifications, and prices are accompanied by more than 8,000 illustrations. Systematically organized in 18 sections for fast location of desired components. United Catalog Publishers, Inc., 110 Lafayette Street, New York 13, N. Y.

Octal-Base Crystals: The G-9 series of flexure-mode crystals, hermetically sealed in an evacuated glass holder with octal base, are available for the range from 4

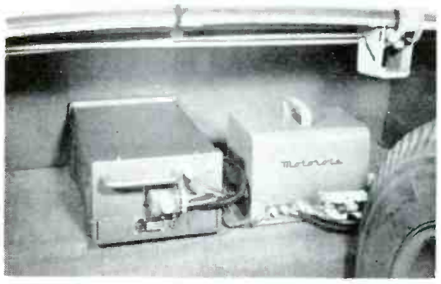


to 80 kc. Operating range is −40 to +70° C.; capacity ratio Co/C is said to be very high. The James Knights Company, Sandwich, Ill.

Connector Bulletin: Series XL low-level audio connectors is described completely in 4-page bulletin XL8-1953. Dimensional sketches, sectional drawings, and detailed technical information are given for 17 assemblies and two insert arrangements. All connectors in this series are equipped with latch locks. Cannon Electric Advertising Dept., 3209 Humboldt Street, Los Angeles 31, Calif.

Remote Switching Unit: The PCU-2 pulse counting unit responds to and channelizes telephone dial-actuated pulses to perform selective switching operations at a remote point. Transmission medium can be any that will accommodate audio tones or DC telegraph signals. Can be used to select any one of 10 telemetering circuits for transmission over a single circuit, or controlling any equipment adaptable to electrical control. The Hammarlund Manufacturing Company, Inc., 460 West 34th Street, New York 1, N. Y.

12 to 6-Volt Converters: Two small 12 to 6-volt converter units have been designed to furnish from 10 to 30 and from 10 to 50 amperes at an efficiency of 80%. Heavy-duty 16-contact vibrators are used. Overall dimensions are 7 by



9¼ by 6¾ ins., so that either unit can be mounted under the dashboard or in the luggage compartment. Motorola Communications & Electronics Division, 4545 West Augusta Boulevard, Chicago 51, Ill.

Vibrator Converters: Series 3200 vibrator converters, designed to supply 115 volts AC at 60 cycles and 375 volt-amperes, are described in Bulletin EB-3200. Complete technical specifications and performance curves are given. Intended primarily for railroad operation, these units can be obtained for 32, 64, or 120 volts DC primary power. Also catalog 200D contains the complete line of C-D capacitors in its 36 pages; free on request. Cornell-Dubilier Electric Corp., South Plainfield, N. J.

Communication Antennas: Bulletin 118-A describes fixed-station omnidirectional and Yagi antennas and accessories for 148 to 174 and 450 to 470-mc. Available free of charge on request to the Andrew Corp., 363 East 75th Street, Chicago 19, Ill.

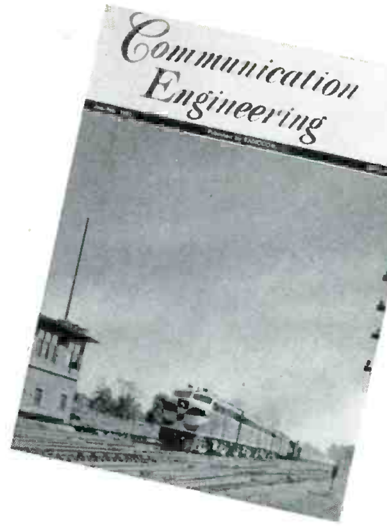
.5 to 50-Mc. Unit Oscillator: Type 1211-A unit oscillator covers the range from .5 to 50 mc. in two logarithmic ranges, with an output of 2 watts up to 5 mc. and at least .2 watt above. Frequency is indicated directly on a 6-in. dial, and approximate increments of frequency expressed in percentage are indicated on drive dial. Voltage divider output control; frequency calibration accuracy 2% at no load. General Radio Company, Cambridge, Mass.

Gold-Plated Connectors: Amphenol AN connectors are now supplied with an additional outer plating of gold on the contacts, in addition to the previous silver plate. This assures good contact performance and easy soldering even after long periods of storage under corrosive conditions. American Phenolic Corp., 1830 South 54th Avenue, Chicago 50, Ill.

Continued on page 12

THIS MONTH'S COVER

Railroad radio is one of the fastest-growing in the mobile communication services, although one of the least publicized. And contrary to what might be expected, there is more variety in railroad radio systems engineering than in most other services. Beginning on page 26, radio engineer Warren J. Young describes the Erie Railroad mainline installation, one of whose base stations is shown on the cover.



COMPANIES & PEOPLE

Dr. R. A. Heising: Awarded the Armstrong medal by the Radio Club of America at its 44th annual banquet. In 1914 he joined Western Electric, where his work led to construction of the first transmitter to carry a human voice across seas and continents. He invented the system of modulation which bears his name. Other activities include research on carrier current and piezoelectrics. He retired recently after 39 years of service at the Bell Telephone Laboratories.

New Professional Group: IRE has organized a Professional Group on Engineering Management, currently sponsoring a course entitled "Engineering Management in the Electronics Industry." Seminars limited to 40 persons began Nov. 6 and will include 15 meetings, under the chairmanship of J. W. Jarmie, of the Electronic Engineering Company of California.

John P. Tansey: Appointed national service manager of Motorola's Communication division. Formerly service contract manager, Mr. Tansey replaces Fred Schnell, who is now staff assistant to the vice-president.

Walter Widlar: Died suddenly on November 25 of a heart attack, at the age of 45. He was sales manager of the Bird Electronic Corp.

Plant Addition: Insuline Corp. of America, Long Island City, N. Y., recently added 281,000 square feet of space by purchasing a four-story factory in Manchester, N. H. The new facilities will increase TV and auto antenna production about 10 times, as well as quadrupling manufacturing facilities for cabinets, racks, and chassis. Insuline Corp. will maintain its New York factory and administrative offices at 36-02 35th Avenue, Long Island City.

Roy F. Allison: Resigned as editor of Communication Engineering Magazine to take a position as associate editor of *High Fidelity* Magazine.

Helipot Expands: Helipot of California opened a new Eastern plant of 14,000 square feet last month in Mountainside, New Jersey. This plant will produce precision potentiometers and turns-counting Duodials; the building will also house the eastern showrooms and offices of the Beckman Division of Beckman Instruments, Inc.

Stromberg - Carlson Appointments: Arthur Gibson has been named corporate secretary of the company. Mr. Gibson has been with Stromberg-Carlson since 1912; for the last 5 years, he has been general manager of the Telephone Division. John H. Voss, formerly chief telephone engineer, was appointed to replace Mr. Gibson. Mr. Voss has been with the company since 1946.

Collins in Canada: The Collins Radio Company of Cedar Rapids, Iowa, has organized a subsidiary, Collins Radio Company of Canada, Ltd., at 74 Sparks

Continued on page 10

MEETINGS and EVENTS

APRIL 24,
CINCINNATI SECTION IRE CONFERENCE
Cincinnati, Ohio

MAY 4 - 6,
ELECTRONICS COMPONENTS SYMPOSIUM
U.S.D.I. Auditorium, Washington, D. C.

MAY 10 - 12,
AIRBORNE ELECTRONICS CONVENTION
Dayton Biltmore Hotel, Dayton, Ohio

MAY 17 - 20,
ELECTRONIC PARTS SHOW
Conrad Hilton Hotel, Chicago

Power Gain of 1000 at UHF

EIMAC 3K50,000LF
Length 49 inches
Weight 48 pounds

Eimac 3K50,000L Klystrons in typical CW operation give 10KW power output with only 10 watts drive

High power, high efficiency, ultra-high frequency Eimac type 3K50,000L klystrons, widely heralded for UHF-TV, are proving outstanding for CW. Typical CW operation of these versatile klystrons shows 40% efficiency while delivering 10 kw output with only 10 watts drive—a power gain of 30 db., or 1000 times. Furthermore service at frequencies above and below the UHF-TV band is being obtained through flexibility provided by the externally tuned cavities of Eimac klystrons.

● ***For information about Eimac type 3K50,000L klystrons contact our Application Engineering department.***

TYPICAL OPERATION
3K50,000L Klystrons

	CW	TV
D-C Beam Current	1.65	2.15 amps
D-C Beam Voltage	15	17.2 kv
Driving Power	10	55* watts
Power Output	10	12* kw
Efficiency	40%	32%*

*Peak synchronizing level (80% of saturation power)

3K50,000L KLYSTRONS
FOR UHF-TV

TYPE	FREQUENCIES
3K50,000LA	470-580 mc
3K50,000LF	580-720 mc
3K50,000LK	720-890 mc

Eimac

EITEL-McCULLOUGH, INC
SAN BRUNO • CALIFORNIA

COMPANIES & PEOPLE

(Continued from page 8)

Street, Ottawa, Ontario. Primary production will be communication and navigation equipment for the Canadian Department of Defense Production; the sale of Collins commercial equipment in Canada will be promoted also. W. S. Kendall, formerly sales manager of Marshall-Wells Co., Ltd., will manage the new company.

Dr. P. S. Christaldi: Promoted to manager of the Instrument Division of Allen B. DuMont Laboratories, Inc., replacing Rudolf Feldt who has resigned. Dr. Christaldi has been with Du Mont since 1938, in later years as chief engineer and engineering manager of the Instrument Division.

Dr. Alfred N. Goldsmith: Given Founders Award by IRE. He is a co-founder of the Institute and is currently the editor of *Proceedings of the I. R. E.* Born in New York in 1899, he received a Ph.D. from Columbia University and in 1923 became permanent professor of Electrical Engineering at CCNY. He has been with GE, Marconi Wireless Telephone Company, and RCA.

Name Change: Workshop Associates, the Norwood, Mass., Division of the Gabriel Company, will henceforth be known as the Gabriel Electronics Division.

Stanley D. Crane: Appointed director of engineering and research for the Special Products Division of Raytheon Manufacturing Company. Mr. Crane has been with the company since 1944 as chief engineer of the Special Products Division.

Tower Plant Addition: Rohn Manufacturing Company has just completed a 5,000-square foot addition to its main plant at Peoria, Illinois. The company manufactures towers for communication and radio antennas.

Link Bought: Link Radio Corp. of 125 West 17th Street, New York City, announced recently the transfer of stockholding interests to Murray Platt, who was elected president. A complete reorganization is planned. Mr. Platt is also president of Platt Manufacturing Corp. of 489 Broome Street, New York City. The entire engineering and production facilities of the Link and Platt organizations will now be combined.

WCEMA Elections: At the December 1953 WCEMA meeting E. P. Gertsch of Gertsch Products was elected chairman for 1954. R. G. Leitner of Packard-Bell vice chairman, and Gramer Yarborough of American Microphone Company, secretary-treasurer.

Scarce Materials Released: The regulatory measure "Designation of Scarce Materials 1" has been revoked by the BDSA. This measure specified as scarce the alloying materials chromium cobalt, columbium, tantalum, molybdenum, and nickel, as well as diamond grinding wheels. BDSA officials said that continuation of this designation is no longer warranted.

1954 IRE Officers: William R. Hewlett of Hewlett-Packard Company was elected president of the IRE, succeeding Dr. James W. McRae of the Sandia Corp. Maurice J. H. Ponte of Compagnie Generale de Telegraphie Sans Fil, Paris, succeeds S. R. Kantebet of the Government of India Overseas Communications as vice-president. New directors for 1954-1956 are: Axel G. Jensen of Bell Telephone Laboratories, Inc., and George Rappaport of Aircraft Radiation Laboratory, Dayton.

Charles F. Stromeyer: Promoted to executive vice-president of CBS-Hytron, a division of the Columbia Broadcasting System. He joined Hytron in 1942 as chief engineer and has been assistant to the president and vice-president in charge of manufacturing and engineering.

New RCA Plant: Dedicated recently in Moorestown, New Jersey at Borton Landing Road and Marne Highway, this one-story plant of 145,000 square feet will be devoted to the conception, development, and design of all types of ground and marine radar equipment.

C. G. Barker: New distribution manager of the National Company, Inc., of Malden, Mass. Prior to this he was vice-president in charge of sales for Magnecord, Inc., of which he was one of four original founders.

Martial A. Honnell: Elected vice-president and chief engineer of Measurements Corp., Boonton, New Jersey. He was formerly professor of electrical engineering and electronics at Georgia Institute of Technology.

Dr. Virgil E. Bottom: Appointed development physicist in charge of Solid State Devices Development Group of Motorola, Inc. at Phoenix, Arizona. He heads a group of engineers developing transistors. Previously he was professor of physics and director of piezoelectricity at Colorado A. & M. College.

NEW PRODUCTS

(Continued from page 7)

Fleet-Radio Control: Electrocall control devices are now available for installation in mobile units, as well as fully-automatic coding units for base-station use. With this equipment, the dispatcher can select any one of the mobile units under his control for private conversation without disturbing other fleet units. Contained in a housing 2½ by 3 by 7 ins., the decoding device controls the output stage of the associated mobile receiver and, according to the manufacturer, provides a 14% reduction in battery drain. Lectrolab Manufacturing Company, 2996 Middlefield Road, Palo Alto, Calif.

Tower Lighting Controls: Three antenna tower lighting control units, housed in compact indoor-mounting cabinets, are designed to meet FCC specifications for unattended tower lighting. Models LC-100, 200, and 300 are suitable for towers up to 150 ft., 150 to 300 ft., and 300 to 450 ft. respectively. All contain photoelectric controls to turn lights on and off, and alarm panels to warn of lamp or power supply failure; models LC-200 and LC-300 contain flasher panels for beacon lamps as well. Hughey and Phillips, Inc., 3300 No. San Francisco Blvd., Burbank, Calif.

Bantam Crystal: The Bantam BX crystal provides precision control from 15 to 100 kc. in subminiature size; this hermetically-sealed unit has same performance characteristics as MIL types CR-23 or CR-32. Can be wired to sub-miniature socket or soldered to PC terminal board.

Bulletin 46, giving complete information, is available on request to Bliley Electric Company Sales Department, Union Station Bldg., Erie, Pa.

Precision Dynamometer: Two models of inexpensive dynamometers are available for checking relay contact force, microswitches, and other small torque and force applications. Small models measure from 5 to 15, 5 to 30, 10 to 50, 20 to 100, and 25 to 150 grams; large models from 25 to 250, 50 to 100, and 100 to 1,000 grams in each direction. Pamphlet describing them can be obtained from the George Scherr Company, 200 Lafayette Street, New York 12, N. Y.

900-Mc. Helix: Model H-960 helical beam antenna, giving 15 db. gain in the 890 to 960-mc. band, is now in production. Available in either left or right-hand polarization, the units are 4 ins. in diameter and 30 ins. long, are rigidly mounted on 16-in. square ground plate. Mark Products Company, 3547-49 Montrose Avenue, Chicago 18, Ill.

VHF Interpolator: Model AM-1 interpolator, when supplied with a standard 100-kc. signal and used with auxiliary 1 to 2-mc. measuring equipment, measures or generates frequencies from 20 to 1,000

mc. with an accuracy of better than 1 part in 10 million, depending on accuracy of 100-kc. source. Rack or cabinet-mounted unit is 19 by 10½ by 14 ins. Gertsch Products, Inc., 11846-48 Mississippi Avenue, Los Angeles 25, Calif.

Tubes and Diodes: Literature is available on the following components:

Amperex Electronic Corp., 230 Duffy Avenue, Hicksville, Long Island, N. Y. — 5894/AX-9903, twin tetrode, power amplifier, modulator, and multiplier, 80 watts at 200 mc. and 50 watts at 470 mc.; 6360, twin tetrode, class C amplifier, oscillator, multiplier, and modulator, 16 watts at 200 mc.; rectifier, thyratron, and ignitron selection chart showing peak inverse voltage and average forward current for all Amperex tubes, free of charge.

General Electric Company, Tube Department, Schnectady, N. Y. — GL-6386, five-star miniature receiving tube for remote-cutoff cascode applications, useful for RF, IF, and mixer service. Major price reductions announced on 23 of 32 available five-star tubes.

Lewis and Kaufman Ltd., 126 El Rancho Avenue, Los Gatos, Calif. — 3C24/24G, medium-mu triode, 25 watts plate dissipation, amplifier, modulator, oscillator with maximum ratings to 60 mc.

RCA Victor, Tube Department, Harrison, N. J. — RCA-6263 and RCA-6264, UHF pencil-type triodes, 13 watts plate dissipation, full ratings to 500 mc., reduced ratings to 1,700 mc., mu of 27 and 40, respectively; 6 crystal diodes, germanium point-contact types sealed in glass, RCA-1N34-A, -1N38-A, -1N54-A, -1N55-A, -1N56-A, -1N58-A.

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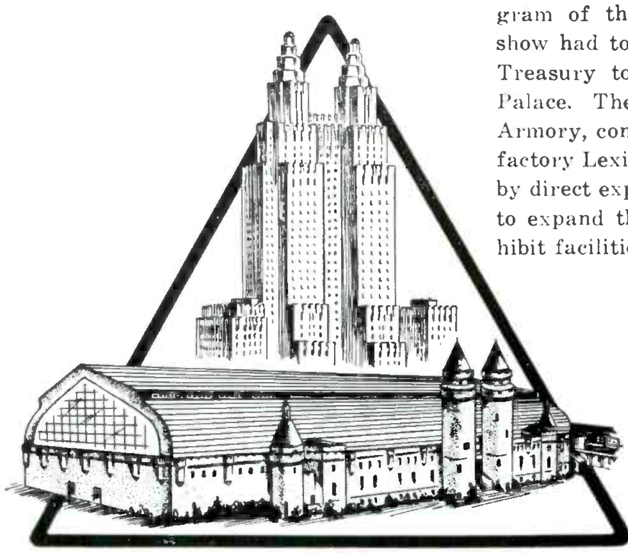

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Using Radio Links and Relays

TYPICAL EXAMPLES OF HOW RADIO RELAYS AND LINKS CAN BE USED TO ADVANTAGE IN TWO-WAY SYSTEMS — *By* G. E. DODRILL AND J. F. ATKINSON*

THE purpose of this paper is to describe various types and combinations of radio relay systems, and the conditions under which they may be authorized for operation. FCC definitions and rules applicable to relay station operations can be found in Rules parts 11.3 and 11.7.

Fixed Relay Stations: The remotely located radio station may be operated from the office either by a telephone line or by a radio relay link. In the latter case the relay station would extend the range of communications from the office to the mobile units in the system area. The type of relay station most often used for this purpose is called a fixed relay station. A fixed relay station receives radio signals directed to it from any source and retransmits them automatically on a fixed service frequency for reception at one or more fixed points. It is classified by the FCC as an operational fixed station in the fixed service.

Mobile Relay Stations: Another type of relay station, called a mobile relay, is used primarily to extend the range of communication between mobile units. A mobile relay station is a base station (a station in the mobile service not intended for operation while in motion) authorized primarily to retransmit automatically on a mobile service frequency those communications originated primarily by mobile stations, and may be located at the office or at a remote location.

Two mobile service frequencies are required for a mobile relay installation. All mobile units transmit on one frequency and receive on the second. The mobile relay station receives the mobile transmissions and repeats them automatically and simultaneously on the second frequency. Receivers in the office and in the mobile units are all tuned to this second mobile service frequency.

If the mobile relay is not located at the office, the control transmitter at the office may operate on the same frequency as the associated mobile units, or it may operate on a fixed service frequency. The use of the mobile service frequency by such control stations is subject to the condition that harmful interference not be caused to other mobile units operating in the area. If the control station operates on the frequency of the mobile units, the mobile relay will repeat all messages received on that frequency regardless of whether it is from mobile units or from the office. Thus, any mobile unit may talk via the mobile relay to any other associated mobile unit or office within radio range of the same relay.

Frequencies Used: Fixed relay stations utilize fixed-service frequencies in the 72- to 76-mc., 450- to 460-mc.,[1] 950 to 960-mc., or higher microwave bands. Mobile relay stations utilize mobile service frequencies in the 30 to 50-mc., 152 to 162-mc., and 450 to 460-mc. bands. Mobile service frequencies are those assigned by the FCC for communication between mobile stations and between mobile and base stations.

When fixed-service frequencies are to be used, the 72 to 76-mc. frequencies are preferred, particularly for non-line-of-sight paths. However, the use of 72 to 76-mc. frequencies within 100 miles of TV stations using channels 4 or 5 is not recommended if other fixed-service frequencies can be used satisfactorily. TV Channel 4 is next to the lower side of the 72 to 76-mc. band, and Channel 5 is adjacent to the upper side. Under present FCC Rules, it is necessary to make a showing to the FCC for stations located within 55 miles of TV stations using Channels 4 or 5 that no interference will be caused to the reception of Channels 4 or 5.

*Electrical Engineers, Rural Electrification Administration, United States Dept. of Agriculture, Washington, D. C. This paper was presented at the 1953 IRE National Meeting of the Professional Group on Vehicular Communication, Hotel Somerset, Boston.

[1]The 450-460 mc. frequencies are actually mobile-service frequencies, but they may be used as fixed-service frequencies with certain limitations as outlined in section 11.254 of the FCC Rules.

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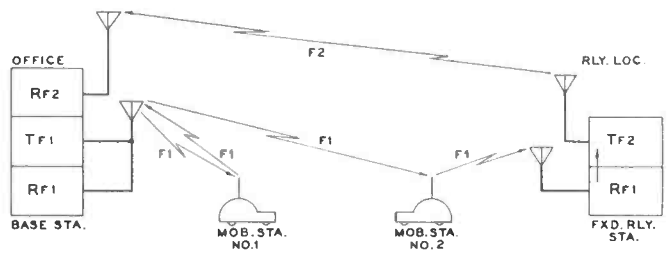

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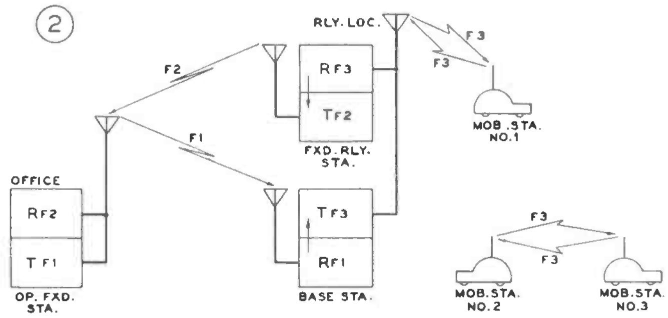

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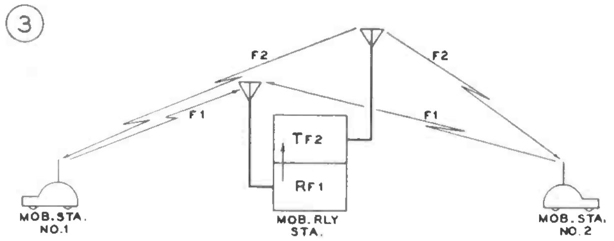

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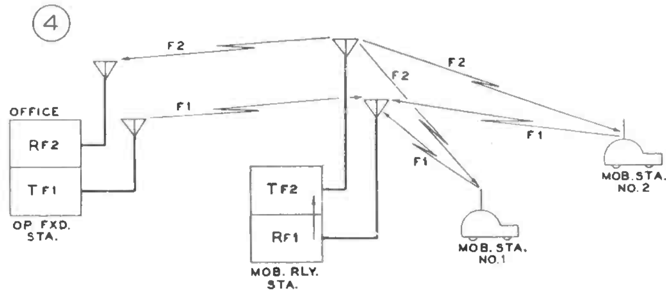

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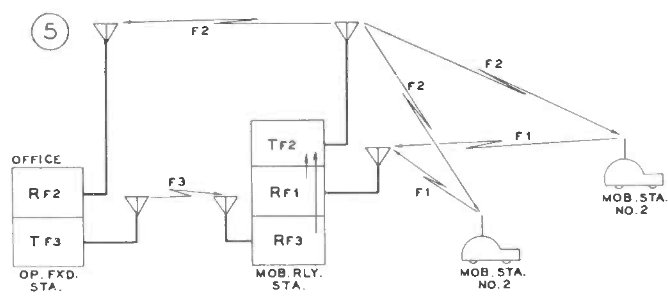

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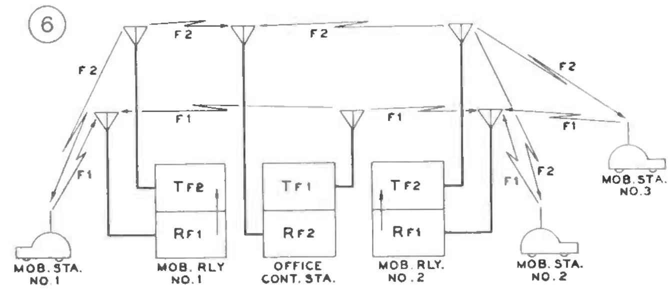

Coded Trigger Signals: In order to protect other stations operating within the service area of a mobile relay station from undue interference that might be caused from frequent activation of a relay transmitter by undesired signals, the FCC requires the use of a coded trigger signal where such interference is likely to exist. A trigger signal is required when 1) the mobile unit's frequency is below 50 mc., and where distant skip signals could cause the repeater to operate, or 2) there are other stations within a 75-mile radius of the mobile repeater operating on the same frequency as the mobile relay transmitter. The coded signal requirement may be waived if the mobile service frequency which activates the mobile relay is above 50 mc. and the stations operating within a 75-mile radius of the mobile relay on the same frequency do not object to the relay operating on a regular basis.

Point-to-Point Operations: Mobile relay licensees having more than one business office can transmit messages between these offices through the mobile relay, provided the conditions are met as specified in paragraph 11.151 of the FCC Rules. Such transmissions are permissible when 1) the communication is related directly to the safety of life or protection of property, or 2) the message to be transmitted is of immediate importance to mobile units, or 3) when wire line communication facilities between such stations are inoperative, economically impracticable, or unavailable from communications common carrier sources. The temporary unavailability of a busy wire-line circuit is not considered to be sufficient reason for such communication. The transmissions permitted under 2) or 3) must be essential to the efficient operation of the system.

Relaying Schemes: The diagrams on the following pages illustrate various arrangements of fixed and mobile relay installations.

Fig. 1 shows a one-way talk-back relay. The talk-back relay may have application where talk-out range is considerably greater than talk-back range, because of higher power at the base-station transmitter or high ambient noise level at the base station. F1 is any mobile service frequency and F2 is any fixed relay station frequency.

The system shown in Fig. 2 uses a fixed relay station and direct mobile-to-mobile operation. The fixed relay station and the control station provide a radio link between the office and the remotely located base station. Mobile stations communicate with the office through the relay link and with each other directly. Only one mobile service frequency, F3, is used. F1 and F2 are any two fixed-service frequencies.

Fig. 3 depicts the simplest form of mobile relay operation. The station may be located at the office, or remotely located and operated from the office through a telephone pair. Messages can originate from the office as well as from the mobile units. Two mobile service frequencies are used.

Fig. 4 shows a mobile relay station remotely located and controlled from the office by means of a mobile service frequency. Mobile stations communicate with each other through the mobile relay station using two mobile service frequencies. The relay station also repeats messages transmitted from the office on a mobile frequency.

In Fig. 5 is diagrammed a similar setup except that a fixed service frequency is used to control the mobile relay station. The fixed service frequency provides a positive means for the office to gain control of the mobile relay transmitter.

Fig. 6 shows a system of one office and two mobile relays, with only two mobile service frequencies used. Mobile units can communicate with each other provided they are within range of the same mobile relay station. They can communicate with the office through the nearest mobile relay. The office can communicate with any mobile station within range of either mobile relay station. Mobile units within range of mobile relay station No. 1 can communicate with each other simultaneously and without interference while mobile units within range of mobile relay station No. 2 are communicating with each other. The office transmits on the mobile frequency. It may be desirable for the office or mobile units to use a coded trigger signal to activate the desired mobile relay.

The system shown in Fig. 7 is virtually the same; the only difference between it and that in Fig. 6 is that a fixed service frequency is used by the office to trigger the relays.

In Fig. 8 is outlined a system of two mobile relay stations used for communication between two offices; only two mobile service frequencies are required. Office No. 1 can communicate with Office No. 2 through mobile relay station No. 1. Both offices can communicate with any mobile unit within

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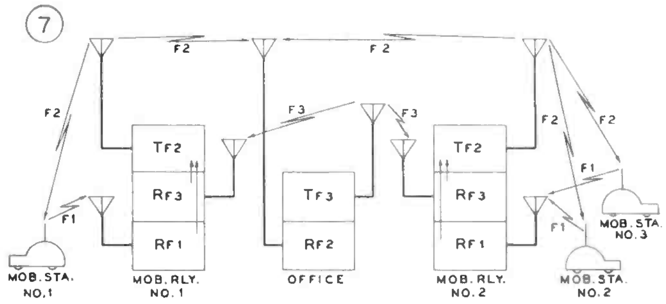

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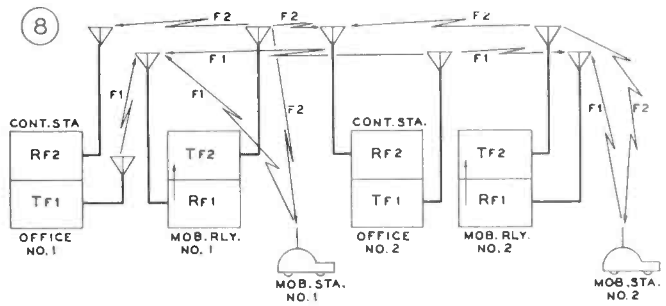

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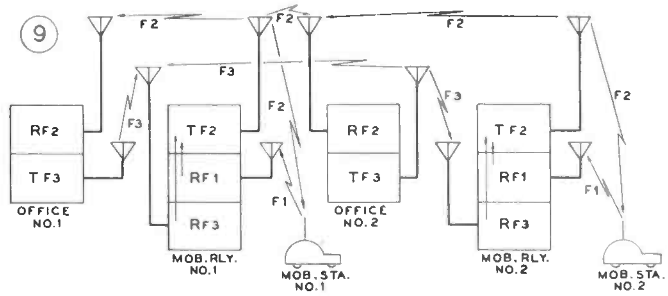

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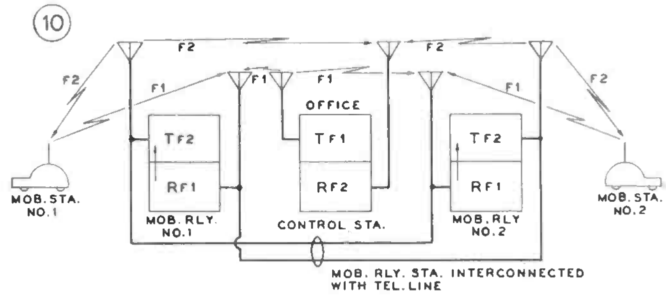

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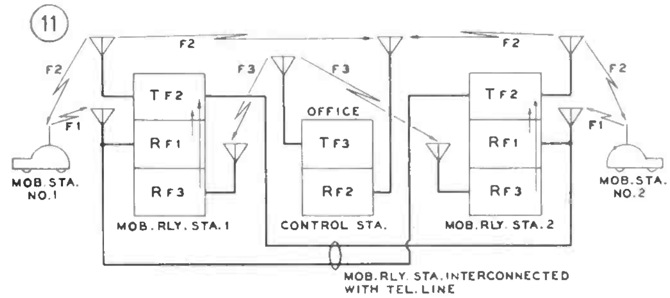

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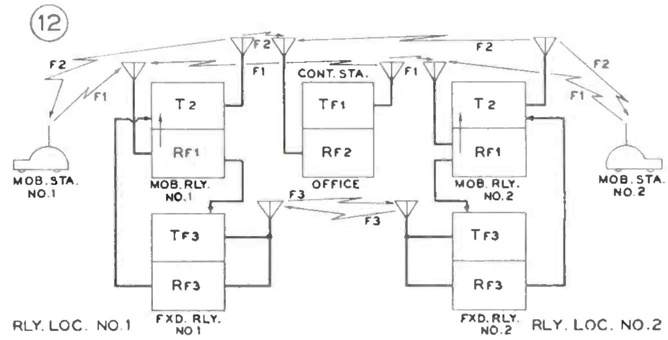
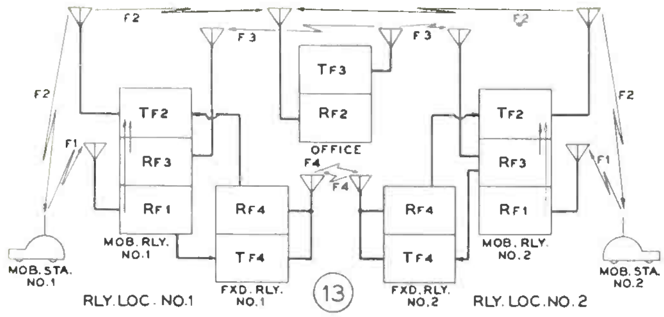
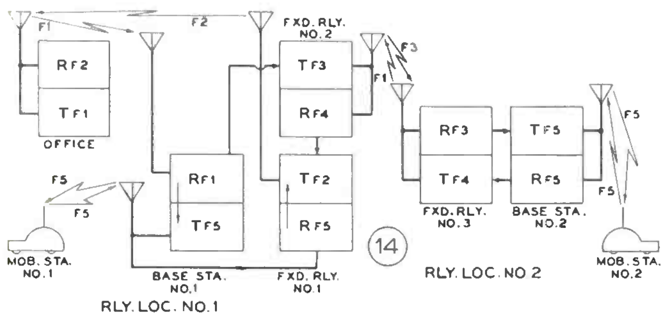
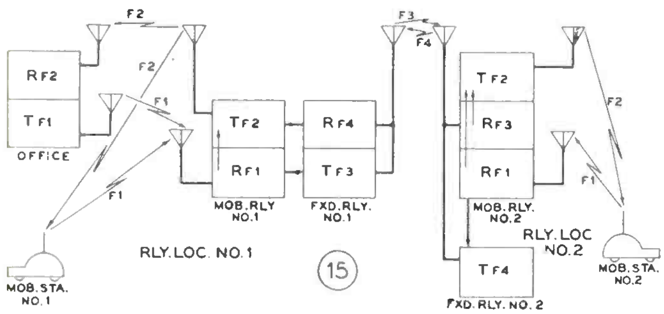
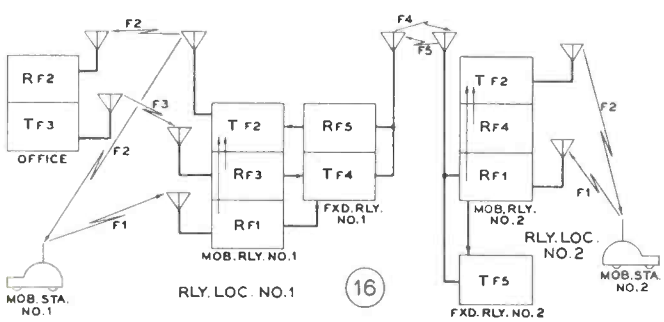
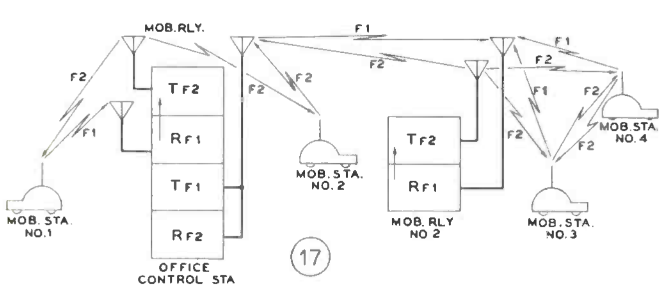


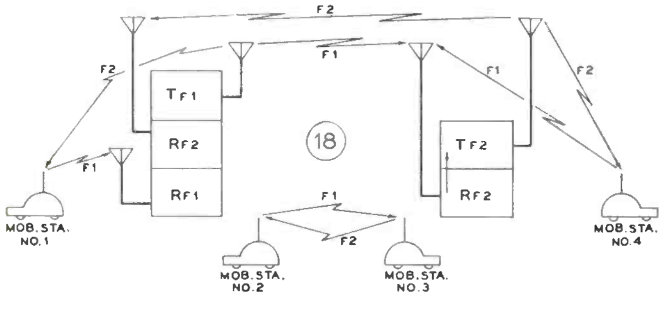












range of mobile relay station No. 1. Office No. 2 can also communicate with any mobile unit within range of mobile relay station No. 2. Mobile units within range of the same mobile relay station can communicate with each other. It is usual practice for the office or mobile units to use a coded trigger signal for activation of the desired relay.

Fig. 9 shows the same type of system except that the offices transmit on a fixed service frequency to the mobile relays, thus gaining more positive control.

Two mobile service frequencies are used in the system shown in Fig. 10, consisting of one office and two mobile relay stations. The relays are connected with telephone lines, so that communication is furnished between all mobile units within range of either relay station.

Fig. 11 shows the same type of system, except that a fixed service frequency is used by the office transmitter.

The system diagrammed in Fig. 12 is basically the same as that in Fig. 10, except that here a point-to-point radio link replaces the telephone link for interconnection of the two mobile relay stations.

Fig. 13 depicts the same basic system with another fixed service frequency used by the office to transmit to the relay stations. Thus, two fixed and two mobile frequencies are required in this system.

Fig. 14 shows two base stations interconnected with a fixed radio link to provide communications between the office and all mobile units. Relay locations are within radio range of each other but one is beyond direct radio range of the office. The office can communicate with mobile unit No. 1 through a radio link using two fixed service frequencies to base station No. 1, and thence to mobile unit No. 1 on a mobile service frequency. The office can communicate with mobile unit No. 2 through the additional fixed relay stations Nos. 2 and 3 and base station No. 2. Four fixed service frequencies and one mobile service frequency, F5, are utilized in this system.

Two mobile relay stations are shown in Fig. 15 interconnected with a fixed radio link to provide communications between office and all mobile units, and mobile-to-mobile communications between all mobile units. The office transmits on the mobile frequency. The office can communicate with mobile unit No. 1 through mobile relay station No. 1, and with mobile unit No. 2 through mobile relay station No. 1, thence to fixed relay station No. 1 and fixed relay station No. 2, and thence through mobile relay station No. 2. Mobile unit No. 1 can communicate with mobile unit No. 2 through mobile relay stations Nos. 1 and 2 linked by fixed relay stations Nos. 1 and 2. Relay locations are within radio range of each other but one is beyond radio range of the office. Two mobile service frequencies, F1 and F2, and two fixed service frequencies are used.

Fig. 16 shows basically the same system as that in Fig. 15 except that another fixed service frequency is used for transmission from the office. This practice, as before, assures positive control of the mobile relay station.

In Fig. 17 is diagrammed a combination operational fixed control and mobile relay station, with a second mobile relay station to provide extended mobile-to-mobile communications over a greater area. Mobile units can transmit on two frequencies. The office can communicate with mobile units by one or more methods. For example, it can communicate with mobile unit No. 1 through mobile relay station No. 1 operating as a two-frequency base station, and with mobile unit No. 2 on a simplex basis by use of a second receiver. The office can communicate with mobile units Nos. 3 and 4 through its operational fixed control station and mobile relay station No. 2. Mobile units Nos. 3 and 4 can communicate with each other through mobile relay station No. 2 or when within direct radio range they can communicate on a simplex basis, leaving the mobile relay stations available to handle extended-range mobile-to-mobile communications. Mobile relay station No. 1 functions as such only when unattended or when extended-range mobile-to-mobile communications are desired by mobile units within range of this station. Two mobile service frequencies are used. The office can monitor the simplex transmissions when they are within range.

In Fig. 18, the base station at the office is used intermittently as an operational fixed control station and as a mobile relay station. Mobile units can receive on two frequencies. The office can communicate with mobile units through the mobile relay or directly when they are within range. Mobile units Nos. 2 and 3 can communicate directly on a simplex basis, leaving the mobile relay station available to handle extended-range simplex transmissions when they are within range.

Minimum-Cost Equipment Assemblies

HOW TO CHOOSE THE MOST ECONOMICAL COMBINATION OF BASE ANTENNA, TOWER, TRANSMITTER, AND LINE FOR REQUIRED RANGE — *By* L. R. KRAHE*

A major consideration in the design of a mobile communication system is the proper choice of various equipment items to achieve the desired results at the least cost. For any given system, the best answer can be obtained only by a detailed analysis of all the possible combinations of equipment available which will meet that system's requirements. This is ordinarily tedious at best.

This is a report on a study which was made in an attempt to arrive at some basic, general conclusions which would apply to all, or most all, fixed stations in the 150- and 450-mc. bands.

Basic Considerations: The common objective of all stations is a satisfactory output signal. The four major items necessary to put that signal out are a transmitter, a length of transmission line, an antenna, and a tower or other supporting structure. Each is available in several "sizes," with the more expensive items (higher-power transmitters, lower-loss lines, higher-gain antennas, and taller towers) contributing toward a better signal output.

The problem in the individual case then becomes: Which combination of transmitter, line, antenna, and tower that produces enough signal is the least expensive?; the general problem becomes: How do the four compare on a signal-versus-dollar basis?

A straightforward method of analyzing the problem would be to take some typical examples of each item on the market and put them together in all the possible combinations. The results should give the desired comparison. This was the method used.

For transmitters, 30-watt and 250-watt units were used in the 150-mc. study, and 40-watt and 250-watt units in the 450-mc. study. For tower heights 100-ft., 200-ft., and 400-ft. examples were used in the study for each band. A unipole antenna, a medium-gain (3 db) antenna, and a high-gain (6-db) antenna were used for the 150-mc. studies. The 450-mc. antennas were the same except that gain figures for the second and third were 4 and 7 db, respectively.

In each band three sizes of coaxial transmission line were considered: RG-17/U, 7/8-in. air-dielectric, and 1 5/8-in. low-loss air-dielectric.

Although 400-ft. towers and 1 5/8-in. coaxial cable are seldom used in communication work, it was felt necessary to include them in this study so that all variables were considered over a large range. Thus, the effects on the output signal of low and high-power transmitters; low, medium, and high towers; zero-gain, medium-gain, and high-gain antennas; and high, medium, and low-loss transmission lines are studied.

With the variables stated, next must be considered exact conditions under which the signal-vs.-dollar comparisons should be made.

For the dollar figures, it would seem logical to compare total cost over several years, in order to take operating costs into account. Five years was chosen as a reasonable length of time for operation comparisons and for the complete amortization of all capital investments.

The total cost of each case then consists of the sum of the prices of one transmitter, one tower (complete with lights as necessary), one length of transmission line (with adaptors and hangers), one antenna, all freight, erection, and installation costs, and tube replacement, electricity, and tower maintenance costs for five years.

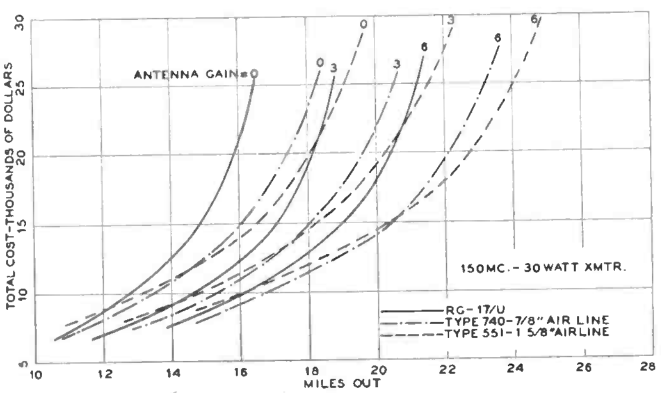
Not included, as not bearing on this study, are costs of the mobile equipment, any audio or remote equipment, operators' wages, building costs, and the like.

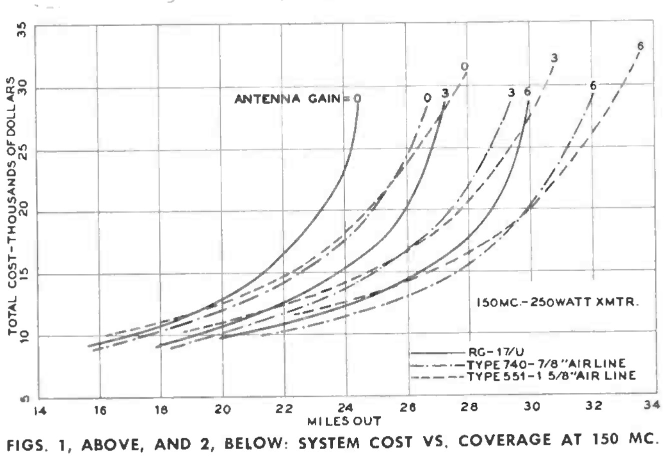
Although the signals produced could be compared on several bases, perhaps the most realistic would be an area-served basis, or miles out to the level of satisfactory operation. Standard propagation curves, assuming average ground conductivity and flat terrain, were used to calculate distances to the five-microvolt level at 150 mc. and the two-microvolt level at 450 mc. Both figures represent receiver terminal voltages assuming a whip antenna on the mobile unit. The five and two-microvolt figures are rounded off from the power level curve necessary for satisfactory operation published by Young.[1]

Although discussion thus far has been concerned with talk-out range only, experience has shown that talk-back range is often the limiting factor in the operation of a mobile communications system. Since a higher tower, lower-loss line, or a higher-gain antenna increases talk-back range as well as talk-out range, but boosts in fixed-station transmitter power do not increase talk-back range at all, it would seem logical to separate the cases as to transmitter power, and to make inter-comparisons only with certain reservations.

On this basis, the results of the study are listed in Tables I through IV, and plotted in Figs. 1 through 4.

*Chief, Advance Development Group, Antenna Research and Development Center, Andrew Corporation, Orland Park, Ill.





FIGS. 1, ABOVE, AND 2, BELOW: SYSTEM COST VS. COVERAGE AT 150 MC.

[1] *Bell System Technical Journal*, November, 1952, p. 1071.

TABLE I

150-MC. CASE SUMMARIES — 30-WATT TRANSMITTER

Case	Cmbntn.	Cost	db	Miles	Case	Cmbntn.	Cost	db	Miles
1	100-0-A	$5,100	0.0	11.0	15	200-3-C	$10,900	9.7	17.2
2	100-0-B	5,200	0.6	11.3	16	200-6-A	10,400	10.7	18.0
3	100-0C	5,900	1.0	11.5	17	200-6-B	10,500	12.1	19.2
4	100-3-A	5,400	3.0	12.7	18	200-6-C	11,700	12.7	19.7
5	100-3-B	5,500	3.6	13.0	19	400-0-A	21,400	8.5	16.3
6	100-3-C	6,200	4.0	13.3	20	400-0-B	21,500	10.7	18.0
7	100-6-A	6,200	6.0	14.5	21	400-0-C	24,200	12.2	19.3
8	100-6-B	6,300	6.6	15.0	22	400-3-A	21,700	11.5	18.7
9	100-6-C	7,000	7.0	15.2	23	400-3-B	21,800	13.7	20.5
10	200-0-A	9,300	4.7	13.7	24	400-3-C	24,500	15.2	21.8
11	200-0-B	9,500	6.1	14.6	25	400-6-A	22,800	14.5	21.2
12	200-0-C	10,500	6.7	15.1	26	400-6-B	23,000	16.7	23.2
13	200-3-A	9,700	7.7	15.7	27	400-6-C	25,600	18.2	24.5
14	200-3-B	9,900	9.1	16.7					

TABLE II

150-MC. CASE SUMMARIES — 250-WATT TRANSMITTER

Case	Cmbntn.	Cost	db	Miles	Case	Cmbntn.	Cost	db	Miles
28	100-0-A	$7,500	9.2	16.8	42	200-3-C	$13,300	18.9	25.3
29	100-0-B	7,600	9.8	17.3	43	200-6-A	12,800	19.9	26.3
30	100-0-C	8,300	10.2	17.6	44	200-6-B	12,900	21.3	27.5
31	100-3-A	7,800	12.2	19.3	45	200-6-C	14,100	21.7	27.8
32	100-3-B	7,900	12.8	19.8	46	400-0-A	23,800	17.7	24.2
33	100-3-C	8,600	13.2	20.1	47	400-0-B	23,900	19.9	26.3
34	100-6-A	8,600	15.2	21.8	48	400-0-C	26,600	21.3	27.5
35	100-6-B	8,700	15.B	22.4	49	400-3-A	24,100	20.7	27.0
36	100-6-C	9,400	16.2	22.7	50	400-3-B	24,200	22.9	29.0
37	200-0-A	11,700	13.9	20.7	51	400-3-C	26,900	24.4	30.3
38	200-0-B	11,900	15.3	21.9	52	400-6-A	25,200	23.7	29.8
39	200-0-C	12,900	15.9	22.5	53	400-6-B	25,400	25.9	31.7
40	200-3-A	12,100	16.9	23.4	54	400-6-C	28,000	27.4	33.0
41	200-3-B	12,300	18.3	24.6					

TABLE III

450-MC. CASE SUMMARIES — 40-WATT TRANSMITTER

Case	Cmbntn.	Cost	db	Miles	Case	Cmbntn.	Cost	db	Miles
61	100-0-A	$5,000	0.0	13.8	75	200-4-C	$10,600	11.7	21.7
62	100-0-B	5,100	1.6	14.7	76	200-7-A	9,700	10.3	20.6
63	100-0-C	5,800	2.3	15.2	77	200-7-B	9,900	13.4	23.2
64	100-4-A	5,100	4.0	16.2	78	200-7-C	11,000	14.7	24.2
65	100-4-B	5,300	5.6	17.2	79	400-0-A	21,400	4.6	16.6
66	100-4-C	5,900	6.3	17.7	80	400-0-B	21,700	10.4	20.7
67	100-7-A	5,500	7.0	18.2	81	400-0-C	24,100	12.8	22.7
68	100-7-B	5,600	8.6	19.3	82	400-4-A	21,500	8.6	19.3
69	100-7-C	6,300	9.3	19.9	83	400-4-B	21,800	14.4	23.9
70	200-0-A	9,200	3.3	15.7	84	400-4-C	24,300	16.8	25.8
71	200-0-B	9,400	6.4	17.8	85	400-7-A	21,900	11.6	21.6
72	200-0-C	10,500	7.7	18.7	86	400-7-B	22,300	17.4	26.3
73	200-4-A	9,400	7.3	18.4	87	400-7-C	24,700	19.8	28.3
74	200-4-B	9,500	10.4	20.7					

TABLE IV

450-MC. CASE SUMMARIES — 250-WATT TRANSMITTER

Case	Cmbntn.	Cost	db	Miles	Case	Cmbntn.	Cost	db	Miles
88	100-0-A	$8,200	8.0	18.9	102	200-4-C	$13,800	19.7	28.2
89	100-0-B	8,400	9.6	20.1	103	200-7-A	12,900	18.3	27.1
90	100-0-C	9,100	10.3	20.6	104	200-7-B	13,200	21.4	29.5
91	100-4-A	8,300	12.0	22.0	105	200-7-C	14,200	22.7	30.5
92	100-4-B	8,500	13.6	23.3	106	400-0-A	24,600	12.6	22.4
93	100-4-C	9,200	14.3	23.8	107	400-0-B	24,900	18.4	27.2
94	100-7-A	8,700	15.0	24.4	108	400-0-C	27,300	20.8	29.1
95	100-7-B	8,900	16.6	25.6	109	400-4-A	24,700	16.6	25.6
96	100-7-C	9,500	17.3	26.3	110	400-4-B	25,000	22.4	30.3
97	200-0-A	12,400	11.3	21.4	111	400-4-C	27,500	24.8	32.2
98	200-0-B	12,600	14.4	24.0	112	400-7-A	25,200	19.6	28.0
99	200-0-C	13,700	15.7	25.0	113	400-7-B	25,500	25.4	32.6
100	200-4-A	12,600	15.3	24.7	114	400-7-C	27,800	27.8	34.4
101	200-4-B	12,800	18.4	27.2					

The case summaries list, in order, a case number for easy reference, a three-part code to indicate which elements were used, the total cost rounded off to the nearest one hundred dollars, a relative signal level in db, and the operating radius in miles to the previously specified levels (five microvolts at 150 mc. and two microvolts at 450 mc. at the receiver terminals). The code is rather simple; the first number is the tower height in feet, the second is the antenna gain in decibels, and the third is the line type (A means RG-17/U; B means 7/8-in. air-dielectric, C means 1 5/8-in. air-dielectric).

The db level was calculated to permit comparisons on other bases if desired. For each frequency the zero level is that signal resulting from the combination of the lower-power transmitter, the shortest tower, the no-gain antenna, and the most lossy transmission line. Higher-tower contributions to the db gain were computed by the rule of thumb that doubling the height provides 3 db more signal, taking into account that the transmission line length has increased. The effects of the antennas and lower-loss lines are obvious, except that in each case a short horizontal run of line at the bottom is included.

Since the analysis of a number of plotted points is made much easier by drawing one or more curves, or families of curves, this was done here. Of the three variables in each plot, the tower height is the only factor in any given installation which can be set at *any* value between the arbitrary points used here. Accordingly, it makes sense to plot the points as nine curves of varying tower height (one for each combination of line and antenna). Even though tower height does not appear on any scale, it can be approximated from the 100, 200, and 400-ft. point locations on the particular curve of interest. The lowest curve represents the most economical combination, of course.

Interpretation: Before analyzing the curves, mention must be made of the reverse curves shown for RG-17/U at 450 mc., Figs. 3 and 4, which are not necessarily indicated by the plotted points. Obviously, since the gain due to increasing antenna height is very closely approximated[2] by the logarithmic formula

$$G_A = 20 \log h2/h1, \quad (1)$$

and the extra line loss is a linear function

$$L = a\ (h_2 - h_1), \quad (2)$$

there exists a point at which the extra line loss becomes *more* than the extra gain due to height. Beyond that point, a higher antenna actually puts out a lower relative signal.

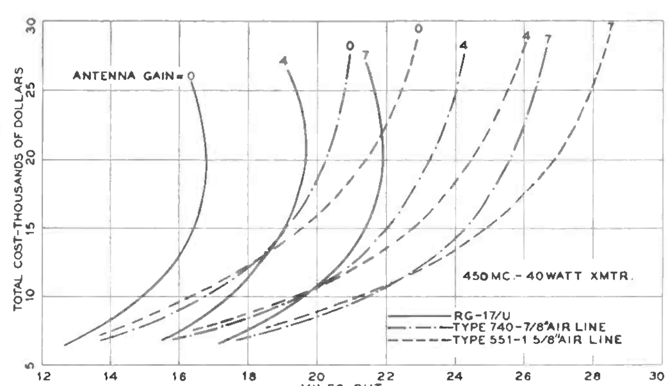
Using (1) and (2), the following formula is easily developed:

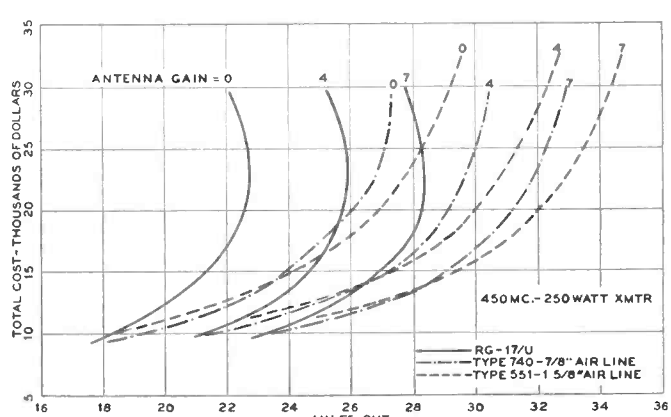
$$H = 868/a$$

where H is the height in feet at which maximum output signal occurs (for any transmitter or antenna) and a is the attenuation in db per 100 feet of the transmission line in question at the frequency involved. For RG-17/U at 450 mc., the limiting height is approximately 380 feet. For higher-loss lines the height is correspondingly less, and vice versa. In this analysis the distances of all the RG-17/U points at 450 mc. for a 380-ft. tower were calculated and used to determine the shape

Continued on page 36

[2]Until free-space conditions are realized, when gain does not increase with height.





FIGS. 3, ABOVE, AND 4, BELOW: CURVES FOR THE 54 CASES AT 450 MC.

Should Radio Equipment Be Leased?

DETAILED DISCUSSION OF THE POSSIBLE CONSEQUENCES IF THE LEASED RADIO EQUIPMENT PROGRAM IS SUCCESSFUL — *By* WALTER B. WILLIAMS*

APCO was the first national organization to condemn the action of what it calls "outside commercial interests" in offering and attempting to purchase communication equipment of privately-owned systems and subsequently leasing the equipment to the original owners on a fee basis. Because the question of privately-owned vs. leased equipment is of vital concern to all in the communication field, we asked APCO for a full discussion of the issues involved. President Walter B. Williams replied to the effect that such a discussion was to be published in the APCO Bulletin, *and that he considered this article ideal for our purposes. After seeing it we agreed, and we think readers will also.*

THE most important single act of the 1953 APCO Conference in Detroit was the formal adoption of Resolution No. 1. Aimed at the demonstrated intent of "outside commercial interests" to operate in the public safety field of radio communications, the language and intent of this Resolution are clear, and it represents at the national level the culmination of an agitation which has been rampant in APCO circles for at least six years.

During this period considerable name-calling has ensued, the personal qualities of fine gentlemen have been assailed and, in general, the communications art has suffered from a lack of understanding of the issues involved. A glance at the various Chapter reports over the period indicated will verify these remarks, and further, point inevitably to the need for an open discussion on the subject of private ownership of radio communications systems of the several law enforcement agencies throughout the land.

The purpose of the article, then, is to focus these issues into an expression which will clear the air, so to speak, and permit all law enforcement administrators, as well as communications men, to know the *status quo*. Many, for example, are asking, "What's it all about?" "Who are these outside commercial interests, and how do they affect me?" This is an attempt to answer such questions.

The Resolution: In the drafting of Resolution No. 1, the Resolutions Committee is to be congratulated on the excellent thinking which marked the composition of the resolution. Principally aimed at the American Telephone and Telegraph Company, and its many state and regional affiliates, the Committee found the opportunity to wave an admonishing finger at any and all "outside commercial interests" who might be looking with a covetous eye at the tremendous income in the law enforcement communications field.

In other words, the APCO Conference was asked if it would condone the release of the primary, last-ditch communications facilities of law enforcement to a second party, or parties, whose interest is primarily pecuniary, and whose devotion, in matters of maintenance, would be divided because of previous commitments to other not-so-essential services. The Resolutions Committee has done its job well.

The 1953 Conference, formally convened with the largest and most representative attendance on record, answered this question with a thundering majority vote approving the adoption of Resolution No. 1. Now let's look at these "outside commercial interests."

AT&T and its Affiliates: As early as 1947 Bell Telephone Company representatives announced the company's policy with regard to police radio communications. This statement was made clearly, and it left no doubt that it was their intention to sell their radio services to police as well as to taxicab services, utilities, and many others.

This announcement provoked no outburst of wrath on the part of the APCO membership nor, for that matter, did it appear to have evoked considerable thought. There were a few, however who heard well, and pigeon-holed the news in the general category of things certain to come.

At first it was considered that this was a local policy. As time progressed, however, persistent rumor plus an occasional fact suggested the existence of an active AT&T policy with regard to the public safety radio services. Apparently, this new policy was an extension of the then new urban-highway radiotelephone service for the general public, and it evinced a definite interest in the whole field of mobile radio communications.

In the meantime the subject was claiming the closest attention of the APCO Chapters. Two, Ohio and Florida, passed resolutions condemning the operations of Bell, which is synonomous with AT&T. The others, perhaps more moderate, took no formal action — confining themselves to discussing the issue from the information at hand. This information, it must be realized, was of purely local nature.

The proverbial lid blew off in 1953, when it was revealed that the Pacific Telephone and Telegraph Company (AT&T) had entered a bid to buy outright the radio communications facilities of the California Highway Patrol, and to lease these back, on a unit fee basis to their former owner.[1]

To all outside the AT&T, this occurrence confirmed almost beyond a doubt the existence of an aggressive, nationwide policy with regard to police, as well as to all other mobile radio communications services. The remaining small shadow of doubt was disseminated by Dr. Austin Bailey, the AT&T representative on the Future panel at the 1953 APCO Conference.[2] Definitely, AT&T and its affiliates are in the radio communications business. This includes the public safety services, and "any others who want our services."[2]

In rebuttal to some critics it must be said that AT&T has violated no concept of business ethics in pursuing its plan. Nor, as far as the writer is aware, has it violated any law of the land in attempting to take over public safety communications. Clearly, they are within their rights whether they are "requested" to bid or the opportunity to bid is created by discerning sales engineers.

Why, then, the uproar? The answer is simple: APCO opposes the attempt by any and all private operators to invade the police radio field of communications.

It is important to realize that this decision on the part of AT&T embraces the whole gamut of publicly-owned communications — radio communications in all its aspects — overhead lines, underground cables, switchboards, police patrol boxes, fire alarm boxes, and so on. Further, the policy requires that all maintenance work be done by employees in the AT&T structure.

The writer is pleased to note that APCO is not alone in this opposition, and that the results of the decision formed the

*President, APCO Inc., 18108 Strasburg, Detroit 5, Mich. This article appeared also in the *APCO Bulletin* for November, 1953.

[1]See Letter Box, June 1953 APCO Bulletin.
[2]See October 1953 APCO Bulletin. Proceedings, page 86.

principal topic of another major public-service employee convention in 1953.[3]

Now, for the moment, let's divert the searchlight from AT&T and talk about the other "outside commercial interests."

The echoes of the thundering affirmative vote adopting Resolution No. 1 were still reverberating around the Conference meeting room when questions arose concerning the identity of the "interests" noted in the resolution. While there was no floor discussion on this point, post-meeting small talk revealed a feeling that timidity had precluded the outright mention of AT&T in the resolution. This was not true, of course.

On the other hand the Resolutions Committee and its advisors, with a sure finger on the pulse of public safety communications, found the opportunity to warn any possible combine aiming to take over these communications in a commercial operation. Thus, feeling that they did not *know* the names of all other such groups, or companies, the Committee took the expedient of not naming any outright.

Since that time, though, events have occurred which indicate that AT&T will not be without competition in its projected encroachment in the public service communication field — especially radio communications. Let's continue with the "interests."

Motorola, Inc.: In a paid advertisement in the APCO Bulletin, addressed to the APCO membership, Daniel E. Noble, Vice President of the Communications and Electronics Division of Motorola, Inc. publicly announced his company's policy with regard to "Lease and Maintenance Contracts."[4]

Several readings of this advertisement have convinced the writer that the position of Motorola in this matter is a defensive one, but one which will be pursued by their sales engineers and official Motorola Service Stations throughout the country. In essense, this official pronouncement by Mr. Noble puts Motorola into competition with AT&T, because Motorola is now offering to the public safety and all other mobile radio fields the same "service" which is being offered by AT&T through its affiliates.

At this time the writer is not fully acquainted with the nature and terms of the Motorola C. & E. Division contractual agreements. It is obvious, however, that they will depend to some considerable extent upon independent engineers and technicians to carry out their maintenance obligations.

On this last point, in due fairness to the other "outside interests," it must be said that the implications involved in the Motorola service contracts have been subjected to criticism by reliable APCO people. As before, this writer has no information on the point other than that just noted. But it is evident that Motorola, by its public pronouncement, is included within the intent of Resolution No. 1.

There are, of course, others which are subjects of the resolution. But — lacking positive information in the form of announced policy, these cannot now be identified by name. Some are local, some are area-wide, others are national in scope. These people will maintain, will lease and maintain, or will sell outright and maintain, radio communications systems for the public safety services. Some are manufacturers of base and mobile radio communications equipment. They probably would much rather sell their equipment outright, and have their customers do their own maintenance, but they fall within the intent of Resolution No. 1.

At this point it is pertinent to comment on the overall attitude of these manufacturers toward the instigator of the lease-and-maintain policy — namely, AT&T. They are antagonistic and they are going to see to it that competition is offered.

This antagonism is based on two facts. First, there is no *need* for AT&T activity in the police field, such as there is in the urban-highway public radiotelephone service. Second, assuming any considerable success on the part of AT&T in pursuing its decision, these manufacturers must expect to have eventually their shares of the manufacture of radio equipment for this service sharply reduced.

For the reader not completely informed on this matter, AT&T is not making most of the radio equipment it uses. It is bought from independent manufacturers, leased to a third party, and maintained by them for the third party on a unit-fee basis which is included in the lease-maintenance contract.

It is unreasonable, therefore, to assume that AT&T would like to continue to pay to a manufacturer, or manufacturers, outside the structure a profit which should remain with AT&T.

APCO 1953 CONFERENCE RESOLUTION NO. 1

WHEREAS, it has come to the attention of the Associated Police Communication Officers (APCO) that certain Law Enforcement Agencies holding Federal radio licenses to operate Police Radio Systems have been approached by outside Commercial interests relative to the purchase of said licensees' radio communication equipment, and

WHEREAS, the intent of such purchase is specifically for the purpose of leasing such equipment back to the licensee on a unit fee monthly basis, and

WHEREAS, it is felt that such an arrangement will eventually result in the loss of the choice in the future to own, control, and operate police radio communication equipment on frequencies now specifically and exclusively allocated to the Public Safety Radio Services by the Federal Communications Commission, and

WHEREAS, this proposed turning over of police radio systems to outside commercial interests would place their design, maintenance and future engineering advancement into the hands of persons not directly responsible to or subject to the direct discipline of the head of the Law Enforcement Agency concerned, but instead would promote an impossible situation subject to work stoppages detrimental to the public interest and would involve people whose loyalty and devotion to duty is not primarily to the Public Safety Departments concerned,

BE IT THEREFORE RESOLVED, that the Associated Police Communication Officers now in session in Detroit, Michigan, strongly urge that the International Association of Chiefs of Police take cognizance of this nationwide and concerted commercial effort by these outside interests trying to inject themselves into this vital and sensitive internal function of our Law Enforcement Agencies and that its members resist this effort to the utmost of their ability and in the best interest of police administration.

It is reasonable, then, to expect that AT&T will manufacture eventually its own radio communications equipment.

Thus, assuming considerable success for the AT&T policy, the independent manufacturers must because of sheer inadequacy be witness to their own economic strangulation.

We believe that many AT&T employees are critical of the policy. They feel that it has opened a new road to bad public relations — a route whereon former public service friends meet AT&T people with a feeling of apprehension and distrust.

They feel further that the enormous expansion of AT&T's normal facilities, such as the urban-highway radiotelephone system, the coaxial cables for TV, and the long-distance dialing service has provided enough work and possible income for the foreseeable future. From this it would seem that the decision is unpopular within as well as without.

APCO and its Aims: APCO is an abbreviation standing for Associated Police Communication Officers, Inc. It was founded in 1935, and derives its active, voting membership from the personnel of federal, state, county, and municipal radio systems. The membership clause of its Constitution permits active membership to anyone connected with any agency concerned with law enforcement.

Thus, APCO members are found in the conservation, fire, and forestry services, as well as in police departments of all types. While the principal loyalty of APCO is devoted to the police services it does, because of its overall membership, maintain something more than a passive interest in those govern-

Continued on page 38

[3]IMSA Convention, October 1953.
[4]See September 1953 APCO Bulletin, page 2.

Hybrid Theory and Applications

OPERATING PRINCIPLES OF THE VARIOUS TYPES OF HYBRID JUNCTIONS, AND THEIR CHARACTERISTICS WHEN USED IN SPECIFIC APPLICATIONS*

In the early days of the telephone industry, the only source of power for the telephone was a battery. Transmission distance was limited because there was no way of rejuvenating the signals after they had become weak. With the advent of the vacuum tube it became possible to amplify the weak signals, and thereby extend the distance a conversation could be transmitted to several thousand miles. Because the vacuum tube was a one-way device and would work in only one direction of transmission, two amplifiers had to be employed. However, two amplifiers connected side-by-side to amplify in opposite directions on a two-wire line formed a loop that would oscillate or sing.

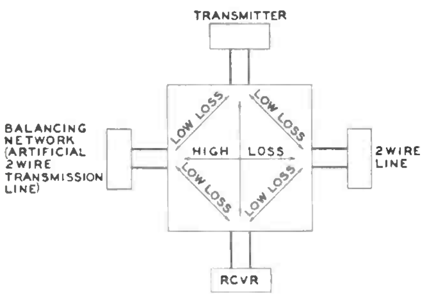


FIG. 1. ONE APPLICATION FOR A HYBRID

Some means was required to prevent the signals at one amplifier output from entering the input of the other amplifier, or the circuits for each direction had to be completely separated. The three-winding transformer was the first solution to this problem. When properly used, it prevented the output of one amplifier from entering the input of the other, and at the same time permitted easy passage of signals in either direction along the two-wire line. The three-winding transformer, when used for this purpose, came to be called a hybrid. Since that time, many devices and circuits have been developed that do essentially the same thing.

Although the name *hybrid* originally designated a specific type of three-winding transformer, it now often applies to any circuit or connecting device that combines the functions of providing low-attenuation paths between certain circuits, and isolation between other circuits. A hybrid junction between circuits may have one or more of a variety of names.

Any hybrid can be represented as a box having four or more sets of terminals. A signal entering the hybrid through any terminal pair will be divided within the hybrid and emerge from the two adjacent terminal pairs. Under ideal conditions a signal will be completely blocked from traveling directly across the hybrid to an opposite pair of terminals. Hybrid junctions, when properly designed, provide proper impedance matches between all connected circuits. Signal flow in a hybrid and typical terminal connections are shown in Fig. 1.

Many different circuit arrangements can perform the functions of a hybrid junction. Transformers, resistance networks, and impedance networks are the most common.

Transformer Hybrids: One of the oldest and most commonly-used connecting devices is the transformer hybrid. Several typical configurations are shown in Fig. 2. This may be a specially-built transformer or an arrangement of ordinary transformers interconnected to perform the hybrid function.

*This article appeared originally in *The Lenkurt Demodulator* for September, 1953.

Transformer hybrids are widely used in the telephone industry for both voice-frequency and carrier-frequency applications. A common use is in the junction of four-wire circuits with two-wire circuits. One such junction is in the subscriber set, where the four-wire transmitter and receiver circuits are joined by a hybrid. The hybrid permits easy passage of signals from the four-wire circuit to the two-wire circuit (and vice versa) but tends to prevent the passage of signals between wire pairs of the four-wire circuit.

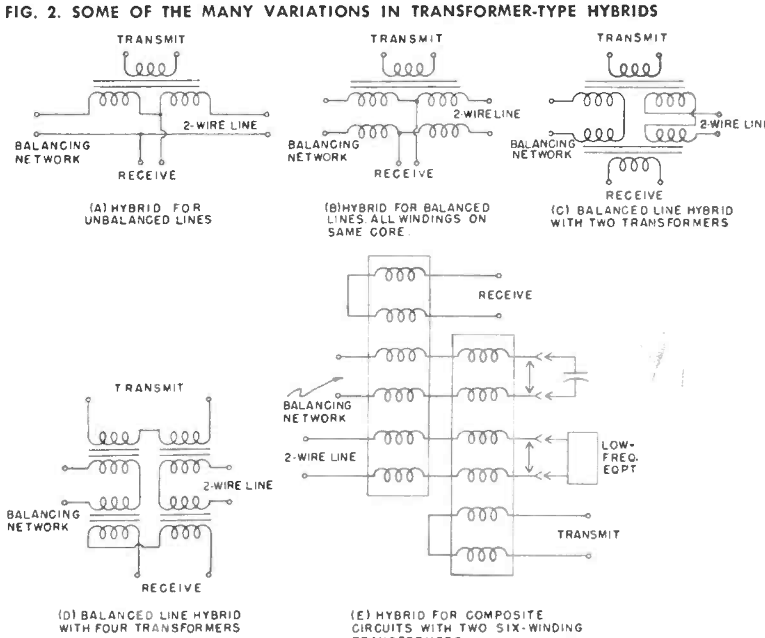
Construction of transformer hybrids to operate at frequencies above about 300 kc. is quite difficult. Inability to control couplings, iron loss, and interwinding capacitance are the frequency limiting factors.

Resistive Circuits: Resistance hybrids will, in many cases, do the same work as transformer hybrids with better operating characteristics. Because they can be made of noninductive elements, their operation is relatively independent of frequency. With careful construction and proper shielding, resistance hybrids operate satisfactorily at frequencies considerably above the upper limit of transformer hybrids. However, they have greater attenuation along the desired paths than do transformer hybrids. Two typical resistance hybrids appear in Fig. 3.

At frequencies near or in the microwave region, resistance hybrids are not practical because of the inductance and capacitance of resistors at these frequencies. There are, however, many devices suitable for use in the microwave region which are constructed of two-wire transmission lines, coaxial cables, or waveguides. They perform the same functions at microwave frequencies that conventional hybrids do in voice and carrier-frequency telephone systems.

Operating Considerations: Under ideal conditions, the hybrid is the perfect solution to many telephone and carrier problems involving the junction of circuits. Practically, the conditions under which a hybrid must operate are far from

FIG. 2. SOME OF THE MANY VARIATIONS IN TRANSFORMER-TYPE HYBRIDS



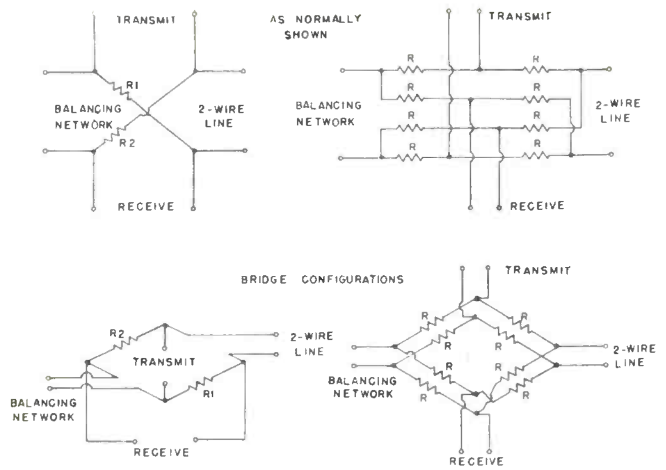


FIG. 3. TWO RESISTANCE HYBRID JUNCTIONS AND THEIR EQUIVALENTS

ideal. Among the problems that must be considered are hybrid loss, hybrid balance, cost, and space requirements.

The attenuation of a signal traveling from a transmitter through a transformer hybrid to the transmission line is about 3.5 db. Most of the loss occurs because the signal is divided into two parts as it enters the hybrid from the transmitter. Half the incoming signal is directed into the line and half is dissipated by the balancing network. Since reduction of signal by one-half corresponds to a 3-db difference in power, 3 db of the 3.5 db loss is accounted for. The other .5 db is dissipated in the core and windings of the hybrid.

Losses in resistance hybrids depend on the configuration. If all arms of a resistance hybrid are equal, the attenuation along desired signal paths will be 6 db. It is not necessary, however, for the hybrid resistances to be equal. If the line transmitter, receiver, and balancing network impedances are equal the two hybrid resistances may have different values depending upon the attenuation characteristics desired. The product of these two resistances must be equal to the square of the nominal resistance of the hybrid. As long as this condition is met the hybrid will be balanced, the impedance will remain constant, and the loss in any one direction can be made as small as desired. The loss in the other direction is then large. This is frequently an advantage in carrier applications because the incoming signal from the toll switchboard must often be attenuated to reach the carrier transmitter input at the proper level. To obtain this attenuation, a pad can be used in the input circuit of the carrier transmitter. By using the correct values of hybrid resistances, however, all the necessary attenuation can be provided within the hybrid itself. At the same time, received signals passing from the carrier terminal to the toll switchboard are attenuated less, thereby reducing the gain requirements of the carrier terminal receiver. The loss in any direction of transmission can be found from the graph, Fig. 4 if the hybrid resistances are known.

Hybrid Balance: Perhaps the most difficult problem to solve in the application of hybrids is that of balance, or impedance match at opposite pairs of terminals. A hybrid junction used between a two-wire circuit and a four-wire circuit requires a balancing network of impedances having the same characteristics as the two-wire line. To the extent that the line and balancing network impedances do not match, input signals from one side of the four-wire line pass directly across the hybrid to the other side and may cause singing or other undesired effects.

The impedance of a transmission line is subject in part to operating conditions and temperature, which may vary considerably over a period of time. It is, therefore, often impossible to determine accurately the impedance of the two-wire line from the hybrid. The best that can be done is to make the impedance of the balancing network an average between the extremes of impedance variation of the line. The problem is further complicated by the fact that the line impedance varies with frequency. To compensate for this effect, the balancing network must also be an impedance that varies with frequency in the same manner as the line impedance.

The terminating impedance of the two-wire line is especially important in the operation of the hybrid. If the two-wire line is not terminated in its characteristic or nominal impedance, energy traveling from the hybrid to the far end will be partially reflected from the far end back toward the hybrid. Reflected energy passes through the hybrid in the same manner as a normal incoming signal, and contributes to singing and echos. The amount of reflected energy received at the hybrid depends on the degree of mismatch at the far end and the attenuation of the line. To compensate for an unavoidable mismatch of impedances, the balancing network can be constructed to appear to the hybrid as a line having the same mismatch as the two-wire line. If the balancing network is so constructed, the reflection from the balancing network just cancels the reflection from the far end of the line and a better hybrid balance is obtained.

The problem of hybrid balance for a two-wire termination of a carrier terminal, though usually simple, may at times be very difficult. The drop from the carrier terminal to the toll switchboard is usually short, and is not in itself subect to impedance variations caused by the weather. The impedances of the loops or trunk extensions beyond the switchboard, however, vary frequently over a wide range of values. Under some conditions the switchboard and extension may even be open-circuited. Because of the extremely variable nature of the impedance of the voice frequency terminations, carrier systems are usually designed and operated such that voice-frequency re-

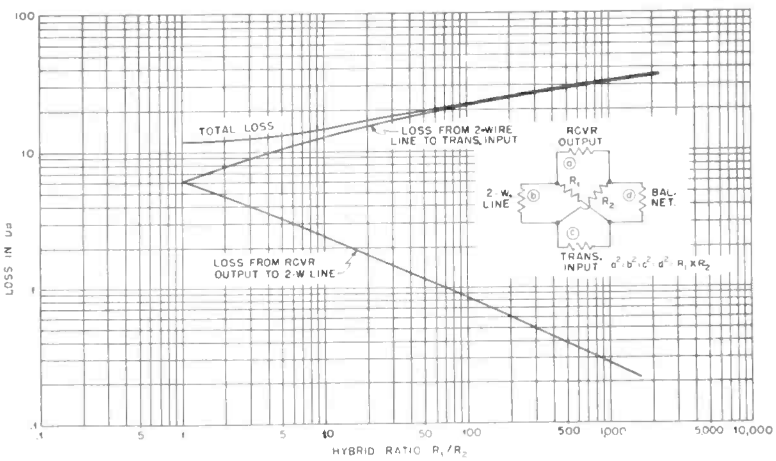


FIG. 4. HOW LOSSES VARY WITH HYBRID RATIO IN RESISTANCE HYBRID

ceived signals are about 3 db lower than voice-frequency transmitted signals. The effect of this method of operation is that even under the worst conditions of hybrid balance (short-circuited or open-circuited drop) the sum of the losses in the singing path is considerably greater than the sum of the gains. Singing under any condition is, therefore, unlikely. When the system is operated in this manner, stable operation can usually be obtained with a fixed compromise balancing network normally furnished with the hybrid.

When the facility to the toll switchboard is unusually long or the carrier system terminates in a two-wire extension of several miles, it may be necessary to operate the carrier terminal transmitter and receiver at higher gains. Under such conditions the sum of the gains in the singing path may exceed the sum of the losses and singing will occur unless a reasonable degree of hybrid balance is maintained. The required improvement in hybrid balance can often be obtained by the use of a complex impedance network that can be adjusted to balance accurately the line conditions encountered.

Cost and Space Factors: If two or more different hybrid types can be used to meet the same requirements, the cost and space elements become the determining factors in the selection of the proper hybrid to use. Resistance hybrids are generally less expensive and physically smaller than transformer hybrids, and are usually preferred where hybrid loss and longitudinal line balance are not important factors. Transformer hybrids are preferred for voice frequency repeaters and often for voice-frequency four-wire terminating sets because in these cases the lower loss of a transformer hybrid is an important factor.

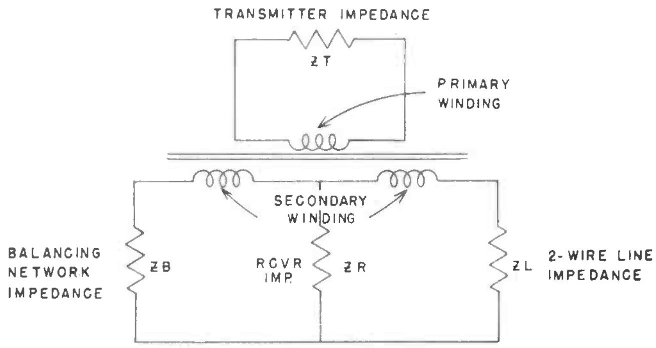


FIG. 5. OPERATION OF A SIMPLE TRANSFORMER-TYPE HYBRID JUNCTION

How a Hybrid Works: All hybrids utilize some type of annulling circuit. Most commonly-used circuit arrangements are modifications of the Wheatstone bridge.

The operation of a transformer hybrid can be understood by considering an elementary 3-winding transformer as shown in Fig. 5. In a 3-winding transformer used as a hybrid, the secondary windings are connected to a network of three impedances; the primary is connected to a single impedance. If the branch having the single impedance is considered to be the transmitter, and a signal voltage is connected in series with it, equal voltages will be induced in the two secondary coils. Also, if the impedance which represents the balancing network and the impedance that represents the two-wire line are equal, the current in the impedance representing the receiver, caused by one coil of the secondary, is exactly equal and opposite to the current caused by the other coil in the same impedance. The net effect of these equal and opposite currents is zero, and the total voltage across the receiver impedance is also zero. Therefore, any signal originating in the transmitter is blocked from the receiver by the hybrid transformer arrangement. One-half of any signal originating in the transmitter branch will be transmitted over the line and the other half will be lost in the balancing network.

Next consider the signal entering the hybrid from the two-wire line. Once inside the hybrid, the signal has two possible paths by which it can return to the other side of the line. One path is through the receiver impedance and the other path is through the balancing network. However, if the receiver impedance has the proper value (normally half the line impedance), the current will return only through the receiver impedance. This is because the voltage drops across the receiver impedance will be equal and opposite to the voltage induced in that part of the transformer secondary that is in series with the balancing network. Therefore, the net voltage applied to the balancing network is zero. To the two-wire line the transmitter and receiver impedances appear to be equal in series. Hence, the incoming signal power will be dissipated equally in the receiver and transmitter impedance. That portion absorbed by the transmitter serves no useful purpose and is lost.

Transformer hybrids, like resistance hybrids, can be constructed to divide the signal from the sending branch into unequal parts with more of the signal going to the two-wire line and less to the balancing network. This is accomplished by winding the two secondary coils with an unequal number of turns. To maintain balance under this condition, the balancing network impedance must be larger than the two-wire transmission line impedance. With this type of hybrid construction the energy received from the two-wire line will also divide unequally with more energy going to the transmitter branch and less going to the receiver.

The arrangement of coils shown in Fig. 5 is not satisfactory for use with a balanced line. A more suitable configuration, which operates on the same principle, consists of two secondary coils divided into four equal coils and installed on both sides of the line, Fig. 2B. This arrangement, with all windings on the same core, presents a balanced load to all circuits connected to the hybrid. Arrangements such as shown in Figs. 2C, 2D, and 2E employ two or more transformers with the windings connected to provide hybrid operation for balanced lines.

The transformer hybrid, Fig. 5, can be used also to join two sources of signal to a common line. Interactions between the two signal sources can be prevented by this means. It is used for this purpose in Lenkurt carrier equipment for combining two groups of carrier channels into a single group. If the two channel groups are connected to the line and balancing network terminals of the hybrid, then one-half of the energy contained in each group will appear across the transmitter terminal. The other half of the energy is dissipated in a resistor representing the receiver. Because the input groups are isolated from each other by the hybrid, actual loading between input groups is greatly reduced and supression requirements of the group band-pass filters can be relaxed.

Resistance hybrids are invariably some form of bridge circuit even though they frequently do not appear to be at first glance. A simple resistance hybrid, bridged network of resis-

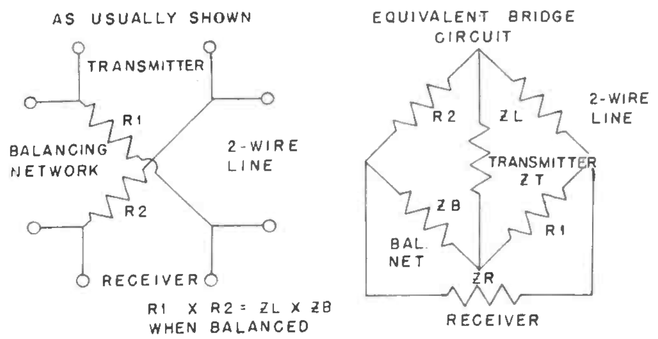


FIG. 6. CONVENTIONAL AND BRIDGE DRAWING OF A RESISTANCE HYBRID

tors, or simple lattice network is nothing more than the ordinary Wheatstone bridge. The different names are derived from the appearance of different schematic arrangements. There is no basic difference in their operation. Resistance hybrids are usually shown schematically in the form of a lattice because it is easier to show the terminal connections. Fig. 6 is a conventional diagram of a resistance hybrid and the same hybrid reduced to the familiar Wheatstone bridge circuit.

Like any other hybrid, proper results with the resistance network are dependent on hybrid balance. The hybrid will be balanced if all the legs are terminated with balanced impedances equal to its nominal or characteristic impedance. Impedance-matching transformers or networks can be used to achieve the matched condition if the receiver outputs or transmitter inputs have impedances different from the nominal impedance of the hybrid. When unbalanced circuits (one side grounded) are connected, isolation transformers must be used.

What's Wrong with Mobile Radio Sales

TWO-WAY RADIO SALESMEN MUST DO A MORE INTELLIGENT SELLING JOB TO MAINTAIN SALES AS MARKET GETS TOUGHER — *By* JEREMIAH COURTNEY*

DON'T let the title mislead you; I love salesmen. But in traveling about the country, I hear one common complaint: mobile radio salesmen of all manufacturers do precious little to sell the top management of a company on the values of radio.

In many companies, there is a large gap between the persons who want to use radio in different company activities and those at the top who have to okay the purchase order. The common gripe by those on the lower rungs of the company totem pole is that the mobile radio salesmen offer little help in getting that purchase order through top management.

Apparently, the mobile radio engineer-salesmen are not doing a high-level job of analyzing a particular company's operations in sufficient detail to convince its top management that radio can do a real job for their business. One case will be cited. The rest is left to the fertile imagination of those who continue to read.

The case in point is the radio use of the AAA auto clubs. They are prolific users of radio for emergency road service purposes. Here's how it works. You get a flat tire or you can't start your car, so you telephone the AAA club. The club radios the vehicle of a garage under contract with it to handle such calls; your car is soon rolling on its way.

Looks like radio was a natural for any auto club, doesn't it? Wrong. It wasn't when the clubs started using radio — because of the way the clubs were obliged to operate without radio.

How the AAA Works: Now, let's get inside the emergency road service business. The AAA member who got the flat tire mentioned before may make only a single emergency road service call a year. Some members go years without a single call. But when such a member does call, he wants service and the AAA's want to give it to him fast.

When is that member most likely to make his service call to the AAA club? Right — in bad weather periods, when every garage in town is taxed to capacity. Problem No. 1, unique to the emergency road service business is, therefore, getting service for members when all the rest of the motorist world wants service at the same time, and there is only a limited amount of equipment available to do the job.

Problem No. 2 is getting better service for the AAA member at such times than he could get for himself. This problem is not rendered any less formidable by reason of the fact that, as a volume purchaser, the AAA may be paying less for a service call than a non-member would pay for the same service.

What's the best way to solve those problems? Probably the way all the AAA clubs solved them: by getting a large number of contract garages each to handle a small number of calls. In that way, not too much burden would be placed on any single garage when the club needed its help.

The area each garage served under this arrangement was quite small because the garage could not be expected, in peak busy periods, to send a heavy wrecker ten or fifteen minutes away to answer a single call at the same volume rate as for a small pick-up truck on a nearby call. Equipment and labor were too costly to expect any garage to handle such outlying calls. Therefore, the area a garage could or would service had to be kept small. As the area served was reduced, so was the volume of AAA calls coming to any one service station. As one of the garage's smaller customers, this in turn magnified the AAA club problem of controlling the service rendered by the contract garages to their members during peak periods of greater need.

More important to this radio discussion, however, was the fact that if a garage handled only a relatively few calls per month, two-way radio did not pay off. Depreciation on a unit of mobile equipment costing $600 installed runs to about $10 a month. Maintenance runs about $7 a month on the same mobile unit. Considering just those two items, a garage would have to handle by radio 85 calls a month before the cost per call was reduced to even 20 cents. That in itself is not a small item of cost, and most of the contract garages were not handling an average of 85 AAA emergency road service calls each month. So radio was not a good deal for most AAA clubs.

Radio Can Help: But the more intrepid clubs that went into radio, notwithstanding, soon found how to integrate it into their business without (and that's the point) the help of radio salesmen. The Washington, D. C. club furnishes an excellent example. A year or so ago they had 80 contract garages serving the greater metropolitan D. C. area. These 80 garages operated 256 trucks of which 9 were radio-equipped. Today, the D. C. club has 17 contract garages serving the same area. These 17 garages operate 61 trucks of which 41 are radio-equipped.

What do these figures signify? They show that the D. C. club has reorganized its method of handling its emergency road service business so as to exploit the full advantages of two-way radio. They have made an 80% reduction in the number of AAA contract garages. This has permitted them to swing, roughly, four times as much business to each contract garage as before. The increase in the amount of business each garage handles has automatically assured the AAA clubs the control they need over the service rendered to their members in peak periods. They have become, overnight, very important customers.

Two-way radio alone has made this concentration of business feasible for the club and the garage, because the size of the area each garage covers is no longer important when the dispatcher can reach out by radio to any garage truck and re-assign it to another job upon completion of the first. The

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*Communications Counsel, American Automobile Association, 908 20th Street, N.W., Washington 6, D. C. Formerly FCC Assistant General Counsel.

Planning a Railroad Radio System

DESIGN, INSTALLATION, AND OPERATING FEATURES OF THE ERIE RAILROAD COMPANY'S TRAIN RADIO COMMUNICATION SYSTEM—*By* WARREN J. YOUNG*

RADIOTELEPHONE communication has become a vital part of American railroad transportation because it has increased the safety, dependability, and efficiency of railroad operation. The railroads needed communication between engine and caboose and between fixed points and moving trains even before the turn of the century; as early as 1914 the Lackawanna experimented with radiotelegraph, and had a Morse operator aboard one of their trains. Inability to overcome propagation vagaries and mutual interference with other stations forced the abandonment of this commendable effort. In 1921 the Communications Section of the Association of American Railroads assigned its committee on radio the task of working with prominent manufacturers to develop radio equipment applicable to trains. Some success was obtained, primarily with amplitude-modulated induction systems operating in the low-frequency range from approximately 70 to 180 kc. The impetus which the second world war gave to the development of VHF techniques, FM radio, and the entire electronic industry made possible the first really practicable application of radio in train communications.

In 1945 and 1946 the Erie Railroad conducted tests in its terminals and along its right-of-way on both AM and FM VHF radio, and also improved inductive carrier equipment. It is now one of the largest users of railroad radio, and the first and largest user of a comprehensive four-way train communication system over an entire main line. This article describes the installation and operation of that system.

Operational Considerations: The Erie is made up of a number of operating divisions, each approximately 100 miles in length, and train movements on these divisions are under 24-hour jurisdiction of train dispatchers. Along each division is a special wire, the telephone Dispatcher's Circuit, to which all important way offices and telephones at sidings are connected. Train orders given by the dispatcher over his telephone circuit to wayside offices are handed to the engine and train crew, or in emergencies, are transmitted directly to a crew member. There are many occasions in railroad operation, however, when the lack of direct communication on or with trains enroute may result in restricting the dispatcher's expeditious coordination of his train movements, or in preventing train crews from reporting promptly delays or hazardous conditions.

In freight service, particularly with trains of 100 to 150 cars, it is generally impossible without radio for the conductor to signal the engineer. When a conductor detects an unsafe condition such as a hot box (overheated bearing), shifted cargo, or dragging equipment, he is unable without radio to notify the engineer so that the train can be brought to a controlled stop. Therefore, to stop the train the conductor must open the air valve which applies the brakes over the entire train. If the engineer does not realize the situation and continues to apply power, the train may be pulled apart, cars may be derailed, or other damage might occur. In any event, it is necessary for the conductor to walk the entire length of the train in any kind of weather to talk with the engineer and determine the course of action. The passing of signals required to switch out a defective car is difficult and time consuming without radio, particularly with fog, inclement weather, and curves in mountainous terrain obscuring the engineer's view.

To determine if it would be economically feasible to install train radio, and to determine its efficacy in increasing safety and of reducing train delays, damage to equipment, and possible derailments, our operating department made analyses of dispatcher's train-sheet records for all train delays that could have been eliminated or substantially reduced by the use of radiotelephone. The record was made on certain divisions of the railroad which took into consideration heavy grades, weather conditions, and multiple and single tracks. Also considered were broken couplers and broken knuckles due to the application of air from the caboose, train stoppages and reverses for the purpose of detouring around preceding trains that were in trouble, and saving in elapsed time for disposal of cars with broken couplers, hot boxes, or other troubles. The study showed not only direct monetary savings but also intangible savings in reduced damage to equipment and contents of cars, retention of markets for perishable traffic, and better on-time arrival of scheduled freight trains. It showed the rapidity with which relief could be obtained in case of accidents at highway crossings. The study indicated, in short, that the actual monetary savings and the improvement in services and safety would justify the expenditure necessary for a main line installation. Accordingly, Erie's efforts were initiated primarily in that direction; radio service in yards and terminals was considered secondary.

As the result of similar tests and cost studies in its Marine operation, Erie had established radio service in the New York Harbor Lighterage area between the tug dispatcher and its fleet of tugs which handled more than 250 carfloats, barges, cranes, and other floating equipment. Westinghouse radio units were used. At the time, the transmitter complete with its power supply was mounted on one chassis and the receiver and its power supply was on a second chassis. As the radio repair shop is located near the service facilities for the tugs, transportation of the heavy units to and from the shop presents no problem from the standpoint of maintenance. It was felt, however, that these units were not suitable for a main line train system, so others had to be developed.

*Communications Engineer, Erie Railroad Company, Cleveland, Ohio. This paper was presented at the 1953 National Meeting, IRE Professional Group on Vehicular Communication, Hotel Somerset, Boston, Mass.

FIG. 1. VIEW OF THE 32-VOLT BATTERY COMPARTMENT AND GENERATOR

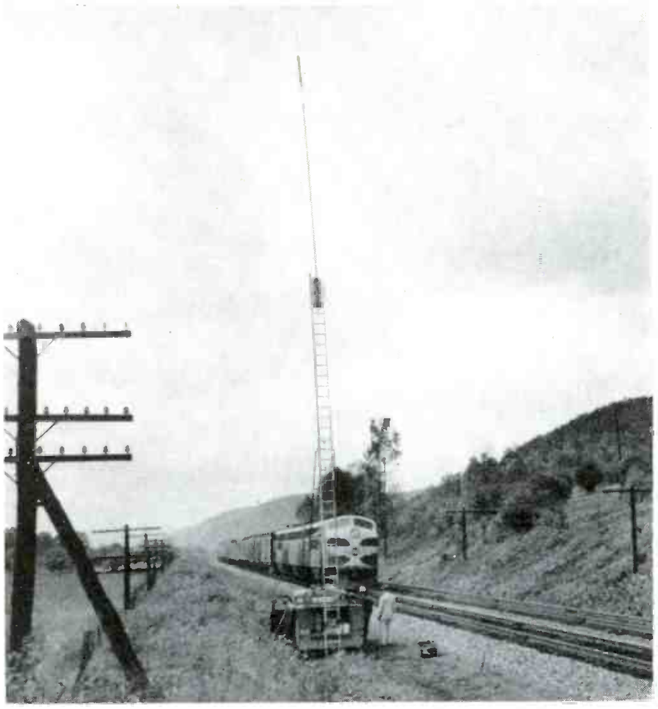

FIG. 2. TESTING A PROPOSED BASE-STATION SITE WITH MOBILE UNIT

In order to engineer a railroad radio system which would meet our particular requirements, extensive tests were made with the cooperation of manufacturers of both space radio and inductive systems. Transmission of induction frequencies is not limited to theoretical line-of-sight distance, as is VHF space radio. It does, however, require continuous and relatively close proximity of the wire lines usually found along railroad rights-of-way, to carry the current induced from the mobile transmitter to the line and from the line to the mobile receiver. Such lines are not always sufficiently close to the tracks. where topography is unfavorable and in congested areas and yards.

It is desirable that mobile equipment and base stations hear only the communications with which they are concerned. Most of these communications are division matters and it is important that the transmission be confined to that division. Controlling the coverage of induction signals is difficult. More space radio stations than induction stations may be required to provide adequate main-line coverage, but its advantages made space radio preferable for our purposes.

Tests of radio equipment installed on cabooses had shown that this equipment must be very well-built and shock-mounted in order to withstand the vibration and shocks encountered in such service. It was considered necessary also that the transmitter, receiver, and power supply be mounted on a separate chassis to reduce the unit weight. One manufacturer, Farnsworth, designed its equipment accordingly; these units were equipped with Cannon plugs so that they could be instantly installed or removed from the rack by personnel not trained in electronics. and were light in weight to facilitate handling and shipment from remote base stations to a centrally-located, well-equipped radio shop.

The original receivers tested were of the single-superheterodyne type, which tended toward instability. They were then redesigned; newer units are of the double-superheterodyne type, with both oscillators crystal-controlled.

Mobile Equipment: To simplify maintenance and reduce the required spare units, our system is designed so that the mobile equipment is interchangeable with that used in base stations. The power-supply unit requires 117 volts AC. Because the power available in diesels is 70 volts DC, a converter supplying well-regulated AC is installed in each locomotive. Normally, there is no power available on cabooses, so we equipped them with 32-volt 3-kw. axle-driven generators, which keep 32-volt banks of Edison cells charged. By this means power is available when the caboose is stopped. The cabooses were equipped also with rotary converters to change the 32 volts to 117 volts AC. Fig. 1 shows the generator and the opened battery compartment.

Dual-frequency transmitters and receivers are used on the mobile equipment. Normally, the diesels and cabooses stand by on the A band, which is 160.05 mc. If the A band is being used within range of a train on which the conductor wishes to communicate promptly with his engineman, he interrupts momentarily to instruct the engineman to switch to B band, 159.87 mc. Both the conductor and engineman then press a button on the control unit when the handset is off the hanger, which changes the equipment to B band. They can then talk without interfering with the A band conversation. When their communication is terminated, and they hang up their handsets, a microswitch is actuated which breaks a relay holding circuit and restores the transmitter and receiver to A band. With this system base stations and mobile units hear all communications within range. permitting safe and prompt coordination. When an emergency does arise, immediate protective action can be taken.

Base Stations: In order to assure continuous communication along the main line between Chicago and Jersey City, adequate overlap between adjacent base stations was necessary. The stations are located so as to provide a minimum signal of approximately five microvolts to the mobile receivers. Most are located on the railroad right-of-way; whenever possible, of course, we chose the highest points. A study of topographic maps enabled us to determine approximately the locations of stations and to prepare estimates for the system required, and also served as a guide for actual field tests. A radio truck, shown in Fig. 2. was used to determine the

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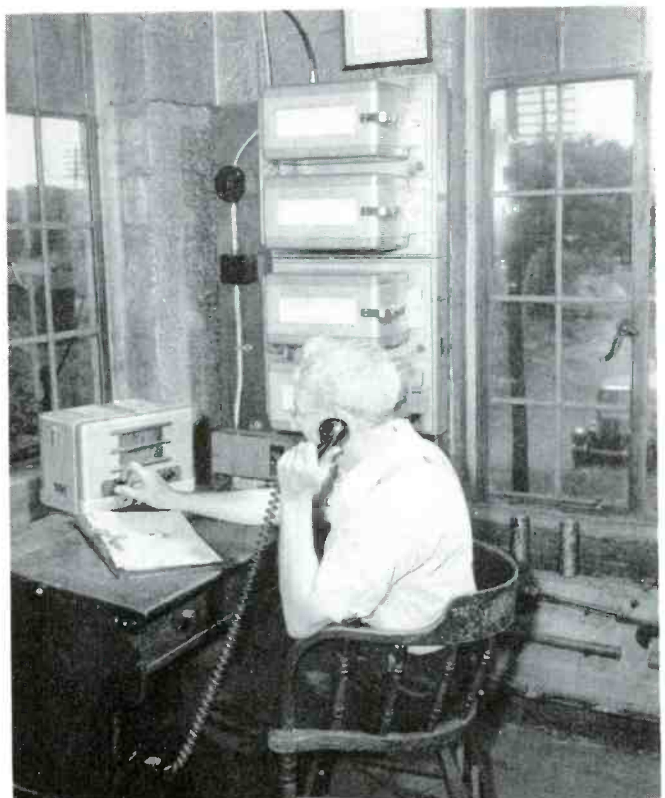


FIG. 3. LOCALLY-CONTROLLED ERIE BASE STATION AT FALCONER, N. Y.

Microwave Frequency Standards

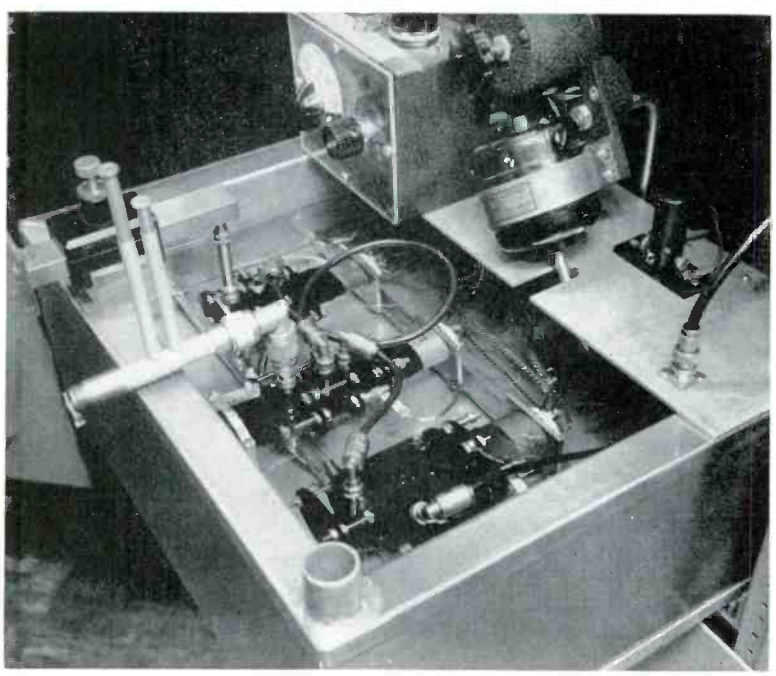
A COMPLETE DESCRIPTION OF THE PRESENT STATUS OF NBS MICROWAVE FREQUENCY MEASUREMENT TECHNIQUES, CURRENT DEVELOPMENT WORK

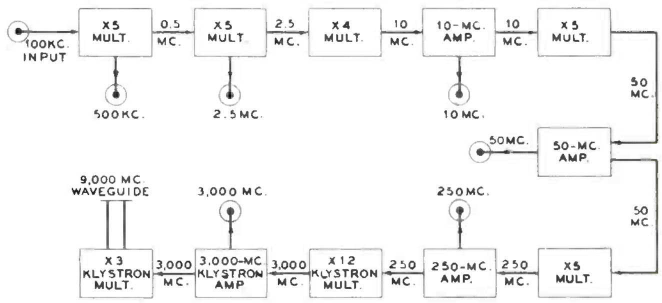
In order to keep pace with an ever-expanding utilization of the radio spectrum, the National Bureau of Standards maintains a program of research and development aimed to make available accurate standards of frequency measurement. Work on standards in the microwave spectrum is the responsibility of the NBS Microwave Frequency Standards group, under the direction of Dr. Harold Lyons and L. J. Rueger. The laboratory is equipped to operate between 300 and 40,000 mc. with completely standardized equipment,[1] and up to 75,000 mc. with instruments currently in the final stages of development. In addition to the broad research program in microwave principles and techniques, the laboratory calibrates the secondary microwave frequency standards used in science and industry.

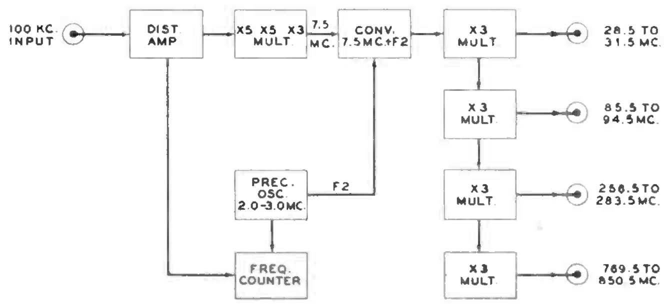
The signals used for calibration are derived directly from one of the stable 100-kc. oscillators maintained by the Bureau for time and frequency standards. Frequency of the driving oscillator is determined to better than 1 part in 1 billion by reference to the other NBS standard oscillators and with astronomical checks made by the Naval Observatory. The standard oscillators also control the operating frequencies of station WWV, Beltsville, Md. Because the 100-kc. signal must be multiplied up to thousands of megacycles, some difficulties arise because of noise and other small effects which tend to cause phase modulation in the frequency multiplier chain. In all, frequency and phase modulation produced is less than 1 part in 100 million at 300 mc., less than 1 part in 10 million at 24,000 mc., and less than 1 part in 100,000 at 54,000 mc. The increase in bandwidth at the highest frequency arises principally as a result of the low signal strength of the generating equipment at these levels. In special set-ups bandwidths of less than one part in 10 billion have been achieved. By comparison, resonant cavities and other secondary frequency standards are rarely dependable to better than 1 part in 10,000; although some cavities have been constructed that function consistently within 1 part in 100,000, the temperature, humidity, and pressure must be controlled carefully to obtain such performance.

[1] "Microwave Measurements Standards," *NBS Tech. News Bull.*, 32, 12 (Dec. 1948).

FIG. 2. CONSTANT-TEMPERATURE OIL BATH FOR KLYSTRON MULTIPLIERS







FIGS. 1, ABOVE, AND 3, BELOW. FIXED AND VARIABLE-FREQUENCY CHAINS

Signal Generation: The 100-kc. standard signals, from which the microwave frequencies are derived, are generated in a Meachan bridge oscillator circuit with a carefully hand-tailored 100-kc. crystal. They have short-time stability (10 minutes) of 1 part in ten billion and long-time stability (1 week) of 1 part in one billion. Two distinctly separate multiplier chains are employed to raise these to microwave frequencies: one is a fixed-frequency, and the other an adjustable-frequency standard. In both systems, unwanted sidebands or harmonics are suppressed 60 db at each stage of the chain. Conventional grid-controlled vacuum tubes multiply the frequencies up to several hundred megacycles, while fixed-frequency klystron multipliers yield frequencies up to 25,000 mc. Above this range crystal rectifiers are employed as harmonic generators, whose working frequencies are selected by transmission cavity filters.

The fixed-frequency standard, Fig. 1, has higher outputs than the variable system but is not as versatile. The 100-kc. reference source is multiplied in evenly-spaced intervals. Frequency mixing is accomplished at the end of the chain, the outputs of which provide coverage of the spectrum at very closely-spaced intervals. Strongest signals are obtained from the following mixing combinations: 10-mc. intervals through 5,000 mc., 50-mc. intervals through 25,000 mc., and 250-mc. intervals through 40,000 mc. Errors in transcribing and plotting data are minimized because the signals occur at evenly-spaced round numbers. Power available at the 10 and 50-mc. outputs is 5 watts; at the 250 and 3000-mc. outputs, 1 watt; and at the 9000-mc. output, 20 milliwatts. Stability and long life are obtained from the klystron amplifiers and multipliers by immersing them in a temperature-controlled oil bath, Fig. 2, and operating them well below maximum ratings. The klystrons are completely immersed in oil, which is kept gently agitated by a stirring motor. A sensitive control maintains the bath temperature to ±0.01°C. Outputs of the klystrons are fed into the calibrating system through matching sections of waveguide at the left.

Signals are generated in the adjustable-frequency standard, diagrammed in Fig. 3, by combining a fixed multiple of the 100-kc. source with the signal from a precision oscillator that is continuously adjustable between 2 and 3 mc. The combination frequency passes through multipliers tunable within a range of 10%. The adjustable range may be expanded to 100% by using the tenth harmonic of any output from the multiplier chain. Radio frequency power available to the harmonic generators is at least 2 watts at each output of the multiplier chain. Excellent efficiency in the generator and the detector systems permits the use of harmonics as high as the thirtieth for calibration purposes, and extends the range of the standard from 300 through 25,000 mc. Frequency mixing is accomplished near the beginning of the multiplier chain, which is advantageous because it maintains wide separation between adjacent harmonics. A major disadvantage of the system, however, stems from the fact that the very low difference intermodulation frequencies are multiplied in the chain together with the desired signal, which produces unwanted sidebands.

When relatively high standard-frequency power (about one milliwatt) is required, a frequency transfer process can be used with the normal loss of overall precision. Here, CW klystron oscillators are synchronized to a standard oscillator, and frequency modulation of the oscillators is minimized by using battery power and by operating the klystrons in a temperature-controlled oil bath, as described before.

Fig. 4 shows the rack-mounted microwave standard equipment. The system includes frequency multipliers, adjustable-frequency oscillators, and necessary metering and monitoring equipment. The adjustable-frequency standard occupies the two center racks. Two transmission-type wavemeters are shown mounted for a calibration: the meter at the left has been sent to the Bureau to be calibrated against the standard. Variations in output with change in meter setting are monitored on the visual analyzer mounted in the first rack. The system of panel jacks permits mixing many standard frequencies. Dolly-mounted racks at the right contain the electronic components of the Model II ammonia clock.

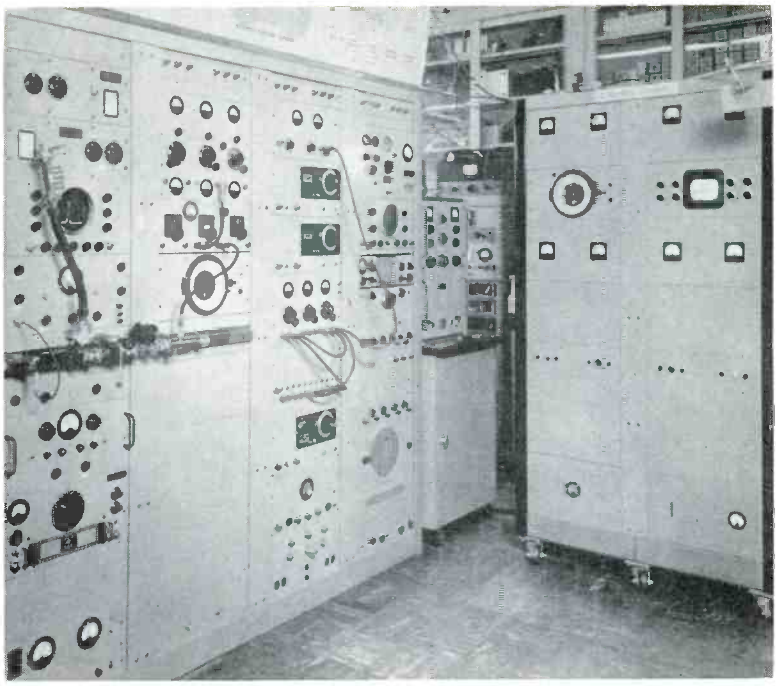


FIG. 4. FOUR RACKS ON LEFT WALL HOUSE BOTH MICROWAVE STANDARDS

Calibrating Secondary Standards: Frequency meters sent to the Bureau are calibrated, when possible, under normal operating conditions. For instance, if a meter has a built-in detector and indicator, sufficient power is used to operate the complete indicating system. Or, if the meter can be employed either as a transmission or a reaction device, the calibration covers both methods, and checks are made for any existing discrepancies between the two. Ambient room temperature of the calibration laboratory is maintained at 23° ±2°C, and the relative humidity to 50% ± 2%. Meters are permitted to reach equilibrium with room conditions before a calibration is made.

In Fig. 5 is shown a typical setup for calibration of a frequency meter by means of the fixed-frequency standard. The rack at the far right contains the local oscillator and associated power supplies; the rack to the left of the first contains the fixed standard. The RF components on the bench include, in a clockwise direction: directional coupler, matching

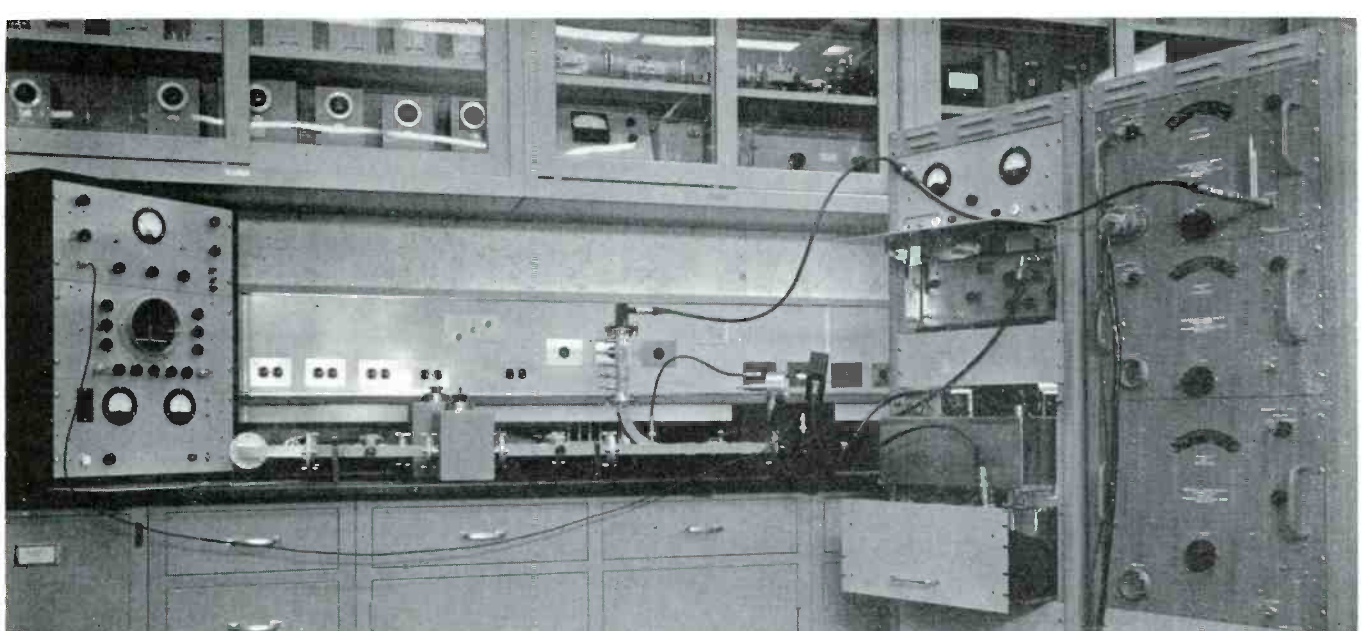


FIG. 5. EQUIPMENT FOR CALIBRATION OF A SECONDARY FREQUENCY STANDARD WITH THE FIXED PRIMARY STANDARD. LINEUP IS SHOWN IN FIG. 6

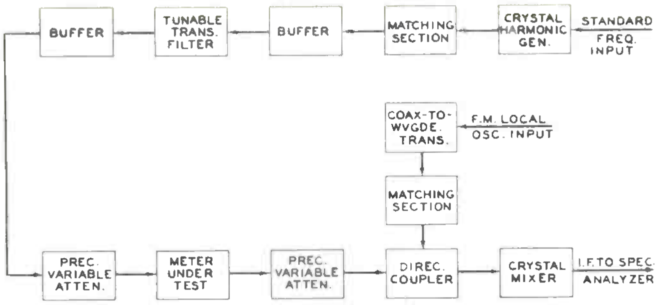


FIG. 6, ABOVE: TEST SETUP. FIG. 8, RIGHT: SOME HARMONIC GENERATORS

section and coaxial-to-waveguide transformer; variable attenuator; the frequency meter to be calibrated (similar to those in the shelves above); another attenuator; buffer; tunable transmission filter; another buffer and matching section; crystal harmonic generator; a connector for the standard; and a mixer (black box and cylinder) for mixing the standard signals. The output of the system, an intermediate frequency, is fed to the spectrum analyzer at the far left.

Fig. 6 is a block diagram of the setup. In the calibration procedure, the standard frequencies are applied to a crystal diode mixer, a non-linear device that generates all the sum-and-difference combinations of the signal present. The desired signal is selected and all others are rejected by a tunable transmission filter, which has been previously calibrated. The output of a frequency-modulated local oscillator is admitted to the converter crystal through a directional coupler, where it is mixed with the standard signal.

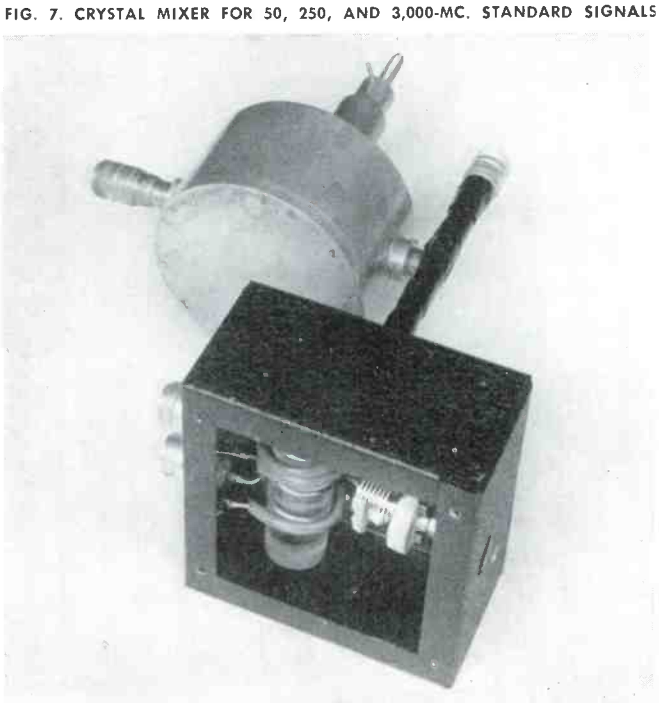
The intermediate frequency from the converter is fed to a spectrum analyzer and the matching sections are adjusted for maximum signal strength. Attenuators placed on either side of the meter to be calibrated are set to 10 db each, which effectively isolates the calibrating equipment and prevents reactive pulling of the meter.

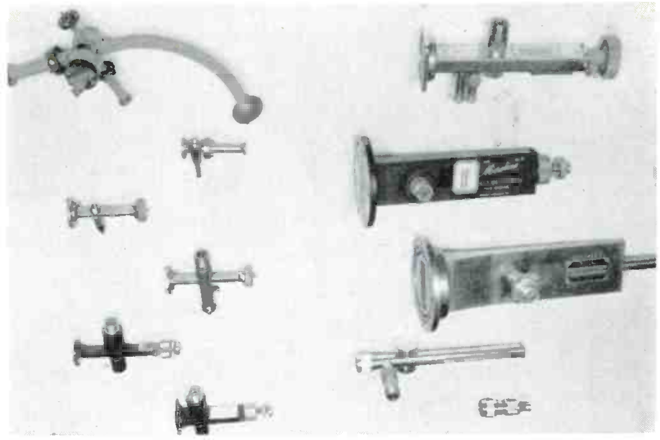
A close view of a crystal mixer is given in Fig. 7. By means of resonant circuits in series, three standard signals — 50, 250, and 3000 mc.—are applied simultaneously to the crystal converter. By extending these methods, additional frequencies can be added. The small box contains tuned circuits for the 50 and 250-mc. signals, and the cylinder is a cavity tuned to 3000 mc.

The frequency meter to be calibrated is set to resonance at each calibration frequency at least ten times. The divergence or spread of the readings at a given frequency is then a measure of the backlash or other mechanical defects of the drive and indicating mechanism. This spread is included in the calibration report as the tolerance to which readings are reproducible.

Although not included in a normal calibration, it is possible to measure the cavity temperature coefficient of frequency near room temperature and the approximate Q of the cavity.

FIG. 7. CRYSTAL MIXER FOR 50, 250, AND 3,000-MC. STANDARD SIGNALS





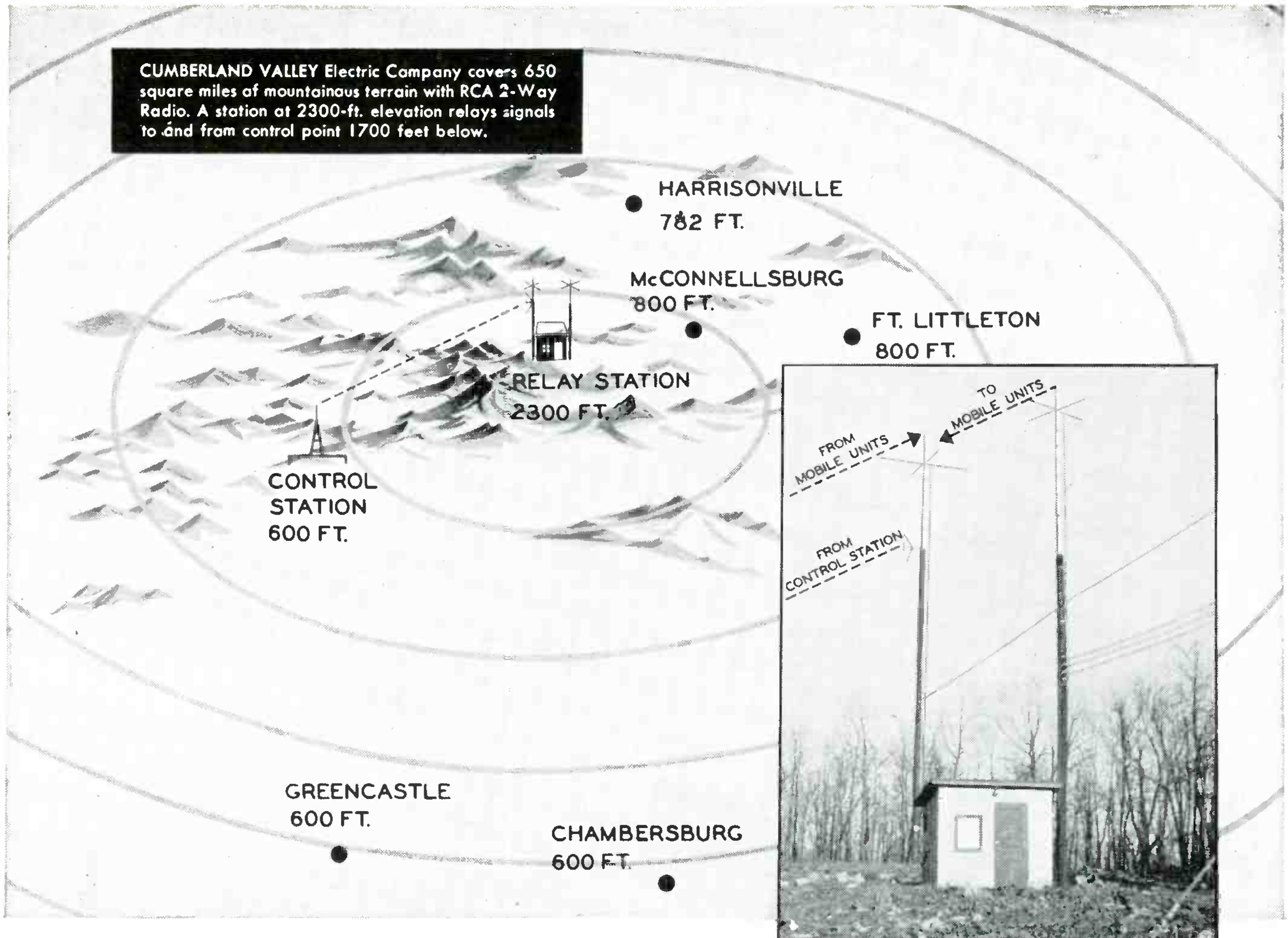
Microwave Signal Detection: Because the power of the harmonics used as standard-frequency signals is often as low as 1 microwatt, direct detection by means of a crystal diode and a sensitive current meter is usually impractical. In addition, the useful power at the detector is further reduced by a nominal insertion loss of 10 db for the transmission filter and 10 db each for the padding attenuators. Power available at the detector is then about 0.001 microwatt. Therefore, when a frequency meter with a built-in crystal detector is to be calibrated, a higher-power CW oscillator is used and is adjusted to the frequency of the standard signal. Amplification of the beat note beween the standard signal and a small portion of the oscillator output is sufficiently high to permit the adjustment of the oscillator to the same frequency as the standard-frequency signal, but precision is decreased approximately one order of magnitude. The remainder of the oscillator power is sufficient to permit the crystal current from the detector to be monitored with a microammeter.

When the type of calibration is such that the standard frequency signal can be passed through the meter to be calibrated, a sensitive receiver is used to detect the signal. In the frequency range from 300 to 750 mc. a double-superheterodyne panoramic receiver is employed; above 750 mc. a sensitive spectrum analyzer detects the signal.

Direct-reading local oscillators of the external-cavity reflex klystron type generate the signals from 750 to 11,000 mc. Above 11,000 mc., internal-cavity reflex klystrons, mounted directly on the waveguide connecting the meter to the standard, provide local oscillator power. Because the power of the local oscillator is much greater than that of the standard signal, the height of the pulse displayed is directly proportional to the power of the standard signal. The frequency meter being calibrated is tuned to resonance by observing the relative pulse height on the cathode ray tube of the analyzer. Voltage gains of 160 db are possible with the spectrum analyzer, which can accordingly detect microwave signals as low as 0.1 micromicrowatts.

Harmonic generators shown in Fig. 8 are arranged according to increasing frequency. Those in the column on the left operate from 300 mc., at the top, to 10,000 mc., at the bottom. Mounts in the right column from top to bottom operate from 10,000 to 75,000 mc. Some harmonic generators are modified crystal detectors used in the reverse direction; the shorting capacitances are removed, signals are inserted in the low-frequency side, and harmonics are recovered from the high-frequency side. The smallest unit (right column, second from bottom) generates signals as high as 75,000 mc.; that below it is capable of doubling frequencies from 26,000 to 40,000 mc., with an output from 52,000 to 80,000 mc.

Note: The fee for calibration of microwave frequency equipment is $33 to $42 for the first calibration point and $5 to $8 for each additional calibration point, depending on the type of equipment. More information is included in NBS Circular 483, obtainable for 25 cents from the Superintendent of Documents, U. S. Govt. Printing Office, Washington 25, D. C.



HILLTOP RELAY STATION receives signals from control station on 73.98 mc. and from mobile units on 48.54 mc. Station transmits on 37.58 mc.

RCA 2-Way Radio raises Cumberland Valley 1700 feet

VHF radio relay has recently converted a difficult piece of terrain into ideal radio territory for Cumberland Valley Electric Company, of Mercersburg, Pennsylvania.

Working with RCA communications men, Cumberland Valley engineers virtually lifted the utility's headquarters from its valley site, and placed it on a hilltop seven miles away. From this vantage point the company achieves unusual efficiency, over its 650 square-mile service area.

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Manufacturers Request New Service

COMMITTEE ON MANUFACTURERS RADIO USE, REPRESENTING THE SPECIAL INDUSTRIAL SERVICE LICENSEES, PETITIONS FOR RULES AND FREQUENCIES

On December 16, the Committee on Manufacturers Radio Use staged a demonstration at the Statler Hotel in Washington for FCC Commissioners and staff members, and presented a petition for establishment of a Manufacturers Radio Service. The petition requested 40 exclusive frequencies in addition to the shared frequencies now allocated to manufacturers, as well as point-to-point communication rights equivalent to those of other services. Host for the demonstration was the NAM.

Purpose of the demonstration was, of course, to show how important two-way radio has become to manufacturers, and that granting of the petition would be in the public interest. The more ambitious part of the program was a scale model of a typical steel mill complete with straddle trucks, fork lift trucks, and other radio-equipped mobile units. Five operators were directed from a central dispatch point to show material-handling processes tied in with radio. The scale model of the yard, shown in the picture on this page, was supplied by the Timken Roller Bearing Company. Operators and equipment were brought to Washington particularly for the demonstration.

Another part of the program was a presentation of slides showing two-way radio in various industrial uses, prepared by Thompson Products. Inc. Among the guests were all the FCC members and key staff personnel, with the exception of Commissioner Doerfer who was not able to attend.

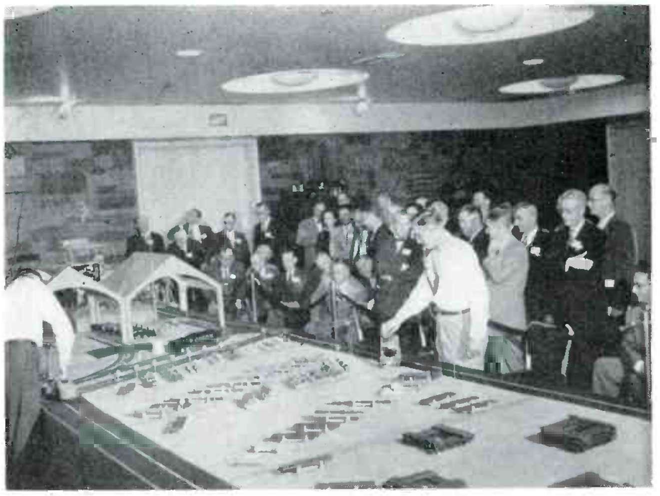
Committee Organization: The CMRU was organized in February, 1953, with five members. These are Herbert E. Markley, chairman, of Timken; Eugene E. Ford and William V. H. Moore, of Thompson Products, Inc.; Victor G. Reis, of Bethlehem Steel; and Richard Thuma, of Allis-Chalmers. The committee was formed "for the purpose of investigating the uses of radio by manufacturing companies and making an organized effort that would insure for them a far larger and more effective use of radio than can be expected under the limitations now imposed by the Special Industrial Radio Service [Rules]." Jeremiah Courtney is counsel for the CMRU, and Jansky & Bailey are consulting engineers.

Committee Actions: One of the most significant provisions of the Special Industrial Radio Service Rules is Section 11.501 (a), of which subparagraph 3 prohibits the use of radio outside the limits of yard areas. This is a severe limitation in some cases, such as that of Timken, which built a plant on the outskirts of Canton 50 years ago. The city has since built up around the plant so that land in the immediate vicinity is expensive; with radio facilities the company has been able to purchase land as much as five miles from its steel mill for material storage, and to call for the materials by radio as they are needed. If the trucks that move the billets from storage area to production line were not controlled by radio it would be extremely difficult to schedule production, since these movements require adherence to a split-second timing pattern.

Unfortunately, the geography of the company's yard area is such that straddle trucks cannot proceed from the storage areas to the steel mill without traversing a short stretch of public highway. The restriction on communication out of yard confines does not benefit any other radio user but impairs the overall efficiency of the Timken operation. There are many instances also in which manufacturing organizations have several plants or buildings within a city, and could show greatly increased efficiency if these buildings could be tied together by means of radio.

Therefore on April 16, 1953, the CMRU presented a suggested Rule revision and comments to the FCC, in which it was asked that 2-way radio operation be permitted with mobile units outside yard areas if such communication did not amount to more than 10% of the total system communications.

Upon further investigation, the Committee concluded that "serious difficulties in the near future" were unavoidable under the present Industrial Service structure, even with the revision proposed; accordingly, a statement of intention was filed with the FCC on May 20, in which notice was given of the CMRU's intention to file the present Petition. Special studies of the Detroit area and of the aircraft industries in the Los Angeles area showed conclusively the inadequacy of present frequency assignments to the Special Industrial Radio Service, the efficacy of two-way radio in manufacturing operations, and the public benefit of such use.



Petition Proposal: Specifically, the CMRU Petition recommends that the basic requirements of present Industrial Rules be retained, but amended so that

1) Any yard-area manufacturer licensed in the Manufacturers Radio Service could operate a mobile radio system without territorial restrictions, and

2) Any corporation operating two or more plants in the same metropolitan area could use a mobile radio system without territorial restrictions if at least one of the plants meets the yard-area qualification, and

3) A conclusive showing of need for additional frequencies would not be required.

The Committee recommended that 40 frequencies in the 460 to 470-mc. Citizens Radio Band be reassigned to the Manufacturers Radio Service on an exclusive basis, and that all frequencies presently assigned to manufacturing licensees and others on a shared basis be retained. It was the Committee's opinion that the 60 frequencies remaining in the Citizens Band would be sufficient for full development of that band but, if this should not prove to be so, then some frequencies could be redeemed for that band by the FCC if it were to reexamine government and FM broadcast allocations.

RAILROAD RADIO

(Continued from page 27)

optimum location of each station. By mounting at the top of a two-section 40-ft. aluminum extension ladder a sliding 20-ft. length of aluminum pipe, to which a base station antenna was attached, it was possible to erect a 63-ft. antenna in about 5 minutes. This antenna system was pivoted to the top of the truck. Mounted also in the truck was a portable transmitter-receiver, on which the voltage at the control grid of the first limiter was calibrated as a function of signal intensity. A small portable gasoline-driven AC alternator furnished power for the equipment. One of our men riding the diesel of a train read mile posts and locations while the train and test truck were in communication. Thus, the men on the truck were able to plot field strength in microvolts as a function of mile-post location, and determine if the test location was ideal or if further tests should be conducted east or west of the location to find a more suitable site.

Each base station is controlled from at least one office which is open at all times. A console unit is installed in the control office with an amplifier and loudspeaker, so that the operator hears all communications within range of his VHF receiver. A handset with push-to-talk button is used. This console is connected to the control unit, transmitter, receiver, and power supply by means of a two-wire audio circuit. Identical equipment is used for both local and remotely-controlled stations. When the push-to-talk button of the handset is pressed, a potential of about 90 volts positive is applied between the console unit and the control unit through a simplex connection on the two control wires, energizing the transmitter. Polyethylene-insulated wires are used for the remote radio control pair to insure reliable operation. In some instances, it is necessary for a way station to control several base radio stations on the same control pair. All base stations are then connected in parallel, and the transmitters are keyed simultaneously.

When it is necessary for the dispatcher to communicate directly with a train, the way station involved connects physically the dispatcher's telephone circuit and the radio control pair. The dispatcher throws his radio switch; then, when he presses the push-to-talk foot switch, about 100 volts positive simplex is applied to his telephone circuit. This voltage is carried to the control unit and energizes the VHF transmitter. One of the locally-controlled stations can be seen in Fig. 3. This is at Falconer, New York.

Our station at Parkers Glen, Pennsylvania is controlled from Port Jervis, New

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RAILROAD RADIO

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York, 15.7 miles east of the transmitter site. In order to obtain adequate coverage through this mountainous territory without installing three base stations, it was found possible to erect a station on top of a mountain. We brought 440-volt power and a control pair from our right-of-way up the mountainside to this station. Remote control is accomplished by a telephone carrier superimposed on the dispatcher's circuit. The band from 9.3 to 11.7 kc. is used to carry the audio to the VHF transmitter and the band from 4.3 to 6.7 kc. to carry the audio from the VHF receiver to the control offices. A 12.4-kc. tone keys the transmitter and a 3.6-kc. tone indicates at Port Jervis that the station is keyed.

The importance of this station, together with the difficulty of access, made it practical to install duplicate equipment.

Conclusion: In September, 1951 the Erie's radio system, consisting of 60 base stations between Chicago and Jersey City, was completed. Mobile radio-equipped vehicles consist of 250 passenger and freight diesels, 67 cabooses, 72 yard switching diesels, and 4 business cars. The yards at Chicago, Hammond, Youngstown, Sharon, Cleveland, Jamestown, and Buffalo are radio-equipped.

MOBILE SALES

(Continued from page 25)

return to home base, the garage offices, is avoided. In peak periods, when the full utilization of the garage truck is important, time isn't lost back-tracking to the garage for the next job assignment. The AAA club dispatcher, in consequence, frequently takes over the radio-equipped wrecker for the entire shift. The result has been to about double the productivity of each garage vehicle, to make radio use really worth-while to the club and the garage, to improve the speed of service to the calling member, and to vest in the

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MOBILE SALES

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club dispatcher such control over the service rendered as was never before attainable.

To return to the point, the AAA clubs were not acquainted with those radio advantages by the engineering salesmen of any manufacturer. That is shown best by the spotty exploitation of this market to date. The numerical order of size of the twenty clubs using two-way radio is 1, 3, 4, 5, 6, 7, 9, 10, 11, 12, 21, 27, 28, 29, 31, 50, 65, 66, 75, and 135. All the values radio now is known to hold for the AAA clubs had to be explored, evaluated, and reduced to realization by the clubs themselves, sparked and coordinated by the Washington Director of the AAA National Automotive Service, Mr. James L. Reardon.

In much the same way other AAA clubs, which have not yet adopted the Washington reorganized method of doing business, have been agreeably surprised to find that radio permits them to cut down the number of garages they are required to subsidize at considerable expense to get night-time or 24-hour service for their members. A single radio-equipped garage, they have found, can easily do the night-time work of several.

The moral, which could be fortified by a hundred case histories, is obvious. Two-way radio is not an electronic gadget to be sold like any other automobile accessory or appliance. It is a way of doing business. It can be sold only if the salesman knows how the customer presently conducts his business, what its problems are, and how radio is going to fit into or change the customer's existing way of doing business. Much has been done in this field of sales endeavor. Much remains to be done and, as the easy-to-sell market disappears, the premiums in the field of radio sales may be expected to fall not to the technical wizards among the engineering sales force, but to the hard-headed business-analyst type of engineering salesman. More power to them!

LOW-COST ASSEMBLIES

(Continued from page 19)

of the curves, although no costs were calculated and the points, therefore, are not plotted.

The first and most obvious conclusion that can be drawn from the curves is that for either frequency, under all conditions, the highest-gain antenna is *always* in the most economical combination! Clearly then, the high-gain antenna is first in providing more signal for less money.

Transmission lines exhibit somewhat different characteristics. From the manner in which the curves cross each other, it must be concluded that the poorest transmission line (RG-17/U) appears economically sound for only extremely short towers, considerably under 100 ft. in height, and even at those heights the difference in costs is negligible. This small difference is probably more than overshadowed by the tendency of solid dielectric cable to fill with water and cold flow if extreme care is not taken during installation.

The ⅞-in. air-dielectric coax would normally be the best choice up to somewhat over 200 ft. at 150 mc., and up to between 150 and 180 ft. at 450 mc. This critical height is increased with a higher power transmitter. Above these heights, the 1 ⅝-in. air-dielectric coax becomes most economical. This is quite plausible, and what might be expected — on longer runs, lower-loss lines should be used.

Tower height seems to be the most expensive way to achieve a satisfactory output signal, and should be resorted to only in extreme cases.

Although comparing transmitter powers is not easy, because of talk-out and talk-back range as mentioned previously, it must be included for completeness. A quick look at Fig. 1 vs. Fig. 2, and Fig. 3 vs. Fig. 4, shows that increasing transmitter power is a good way to increase range without increasing tower height. If an *exact* comparison were to be made between low and high-power transmitters, then in the high-power case the cost of increasing the transmitter power in each mobile unit should be considered. This, of course, may be large or small, depending on the number of mobile units in the system. Such an exact comparison could be made only in specific cases. In general, it would seem that the higher-power transmitter would be desirable but only with the high-gain antenna and better or best transmission line.

The fact that with any transmitter power, the high-gain antenna is always the most economical, is convenient when considering talk-back range. Because noise at the fixed station (which is the main limiting factor on talk-back) is generally coming from the nearby ground level, the beam-shaped pattern of the high-gain antenna discriminates against noise to a certain extent. A 6-db gain antenna furnishes not only 6 db more received signal, but also several db "extra" signal-to-noise ratio, which is equivalent to extra gain and, therefore, extra talk-back range!

In any specific case, there may be circumstances which would change the figures somewhat. For instance, occasionally a tall building, tower, or other structure is already available at little or no

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LOW-COST ASSEMBLIES

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cost to support an antenna. For such a case, all the points would be lowered as to cost, but the general shapes of the curves would remain more or less the same, with about the same conclusions. A very special, and improbable, set of conditions would have to be set up to show a low-gain antenna as being more economical than a high-gain unit.

Conclusions: To summarize: at both frequencies, either transmitter power, any transmission line, any tower height, and any required range, the highest-gain antenna is always the most economical. For transmission lines, solid-dielectric cable should be used on only the shortest runs; 7/8-in. air-dielectric line is better for runs up to medium length, and the lowest-loss line is indicated for the longer runs. High-power transmitters, used with high-gain antennas and the better transmission lines, are good means of eliminating the need for high towers provided that the talk-back problem is solved satisfactorily.

Special conditions may change the curves somewhat, but the conclusions will generally hold true.

LEASED EQUIPMENT

(Continued from page 21)

ment entities operating radio systems under the term "public safety services."

From the beginning APCO has held the concept that police communications must be controlled by the police themselves. APCO makes no claim of originality in this concept, because it is fundamental that a law enforcement agency employ its own detectives, patrolmen, and supervising officers, and not hire them from an outside commercial agency. Our forebears long ago learned the fallacy of such a policy. Police communications are not one whit less important.

The Real Issue is Control: It has been charged that APCO opposes the "interests" because of self-interest. This means, of course, that we dislike the idea of being supplanted in our positions by "outside-interests" personnel.

To a large extent this is true and is, the writer thinks, a natural process, because no man likes the idea of losing any job to which he has devoted his working life and personal interest.

But the charge is basically name-calling. In reality, it cloaks an issue which is much more profound, much more serious, and one which is of tremendous import to the entire radio communications field and its supplying industry.

It concerns control of the public safety portion of the radio frequency spectrum.

It is no secret that many services are ham-strung because of the lack of assignable frequencies. The police, for example, urgently need frequencies in the 15-mc. region for trans-continental work in the National Police Communications Network. Others are also suffering.

AT&T is another company which, with its urban-highway radiotelephone service, is suffering. Its customers, because of the lack of assignable channels, must wait in line, so to speak, for service. Both AT&T and the customers are unhappy about this situation.

The great laboratories are working overtime to find a way around the problem. Daily, research is directed toward devices with which to extend the useful portion of the radio spectrum on the high-frequency end. Terms like channel-splitting suggest that the research engineer might be at the end of the line. Those who do have a reasonable supply of frequencies should be happy. But are they?

Let's imagine now some vast communications combine with financial resources, business acumen, and engineering skill such that it could gradually absorb by outright purchase the radio communications facilities of police, the remaining public safety services and, in fact, all mobile radio communications.

Further, conceive that this combine rents the radio communications facilities back to the original owners, and maintains them with the combine's own personnel. (The problem of displaced people would remain with the original administrator.)

The first loss under this system to a police department, or other service, is that of primary control. The department can, of course, use it at will. But it is like renting handcuffs from a corner hardware store, or its prowl cars from the local u-drive-it establishment!

But the greatest loss would be that of not being identified as the actual controller of the system. Let's examine that point more closely.

In processing license requests, construction permits, and modification permits, it is required by the FCC that a responsible official of the agency involved sign the documents. The technical requirements are complied with beforehand by the radio engineer employed by the agency. This suggests a definite worthiness and trust in the engineer, so affixing the signature becomes a matter of routine.

Under the combine's owner-leaseship plans this process must necessarily continue. However, it would be our imaginary combine's engineers who determine

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and affix on the document the necessary technical information. *Thereby, the combine would become the only liaison between the agency and the FCC.*

This is to say that between two branches of government there would be inserted a third party, a non-government one at that, whose interest is primarily one of financial gain. Is this really a bad situation? Let's try to see what could happen.

There are approximately 7,000 police radio systems in service today. Now, if we assume that the combine is successful in luring 30% of these into their plan, the combine automatically becomes the advisor in technical matters such as frequencies and licensing to some 2,000 police radio systems!

More, the combine suggests that it is interested in radio communications as a whole. The police licensees are but a fragment of the total mobile radio communications picture. An estimate of 75,000 licenses in this category seems reasonable. Apply the 30% factor (it might not stop at 30%), and the combine becomes the technical voice of some 25,000 radio communications systems.

The combine, or a group of combines acting as one, would then be the mightiest communications colossus the world has seen. It would be able to write practically its own ticket regarding the use of the radio spectrum. The people of the United States don't realize this very salient fact. It is devoutly desired that they do. APCO does, and is doing something about it.

There is one more point concerning our imaginary combine which needs a few words, and it concerns Civil Defense.

Civil Defense authorities on the whole are agreed that a successful civil defense program is predicated on dependable communications people and radio systems. With equal surety they point out that the systems which will be depended on are those which are in operation before, during, and after an A-bomb, H-bomb, or a civil disaster of castastrophic proportions.

But who are these communications people and systems? They are, of course, police, fire, conservation and other people and systems directly, totally controlled by a government entity. The people are trained specifically in the work of their systems, and they know what to do when technical things go wrong. They will be on the scene and will not have to be called for maintenance. They use the radio equipment — the very same that the combine proposes to buy and rent back! Does more need be said?

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LEASED EQUIPMENT

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Here some remarks must be made concerning a point that should have been discussed before. These remarks concern those police radio systems which subscribe either to the AT&T, Motorola, or other outside lease and maintenance plans.

With reference to these systems neither APCO nor the writer has any criticism, real or implied. In reality, it is none of our business, but to avoid mention of them at all would be playing ostrich.

It is not known just how many systems of this type are in use today. But there are a few, and now and then another appears. These things just don't happen — somewhere in the process a police administrator has made a decision which he considers to be in the best interests of his department.

If it is his first radio system, he may have been forced to this choice because of the unavailability of a competent radio engineer. It could be also that he has previously owned his radio system and has had an unsavory experience with his personnel.

In circumstances of this type, the writer or any other officer or member of APCO would be the first to recommend an "outside interest" as a remedial measure. We would hope, of course, that at some future time when circumstances permitted he would own again his own system — thus insuring complete control of his communications.

The composers of the Resolution were well aware of the points just considered. These points were, in fact, given a very thorough going-over by the Committee while in the process of evaluating the issue, and the final content of the Resolution was decided only after so doing. The Committee felt, as the Conference later did, that the implications of commercial control of equipment in the police field outweighed any other consideration.

Conclusion: These comments are being concluded with a distinct feeling of relief. The article itself was conceived because so many of our people lacked information on a most vital subject. It was not an easy job.

The criticism of AT&T was justified, but the writer hopes it is clear that its decision was under fire, not the many fine friends APCO has in the AT&T structure. From Dr. Bailey to the newest installation man in a Bell mobile service garage we have the highest respect, and we feel that it is mutual.

With regard to the theme of this article APCO has for many years maintained a silent dignity, at least at the

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LEASED EQUIPMENT

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national level. In the meantime it has pushed with vigor any device made available by AT&T which would improve police communications. Several editions of the APCO Communications Directory bear mute testimony of this fact. If this is not clear, the private-line teletype systems were pushed to the forefront, and not to the rear of these Directories. The same applies to the TWX service.

If further evidence is needed let it be remembered that while the Resolutions Committee was deep in its deliberations concerning Resolution No. 1, another APCO committee was shaping a recommendation advocating the installation of TWX in every State Police Headquarters in the Union. The resulting resolution concerning TWX and the police radiotelegraph service was passed unanimously also at the 1953 Conference. It was recommended to the IACP Conference, and passed unanimously there. The writer is proud indeed to have been one of the chief proponents of this measure. There can be no doubt of APCO objectivity.

With respect to the "outside commercial interests," it is admitted that the treatment accorded the issue is a cursory one. The issue is, in fact, worthy of a volume.

For example, in relation to AT&T, it would have been remarkably simple to establish a distinct parallel between its present ambitions in the mobile field and its activities of yesteryear in absorbing independent telephone systems to build the present wire empire. This premise, regardless of its promise, was rejected by the writer because, as a communications man, he knows that there was a definite public need for such an action.

Neither has the point of organized work stoppages been exploited. This point, with its connotation of picket lines preventing routine maintenance or the actual restoration of a broken-down base station *should never be forgotten!* More comment should not be needed.

On the other hand, police radio communication was developed with no outside assistance. In fact, the writer can think of no branch of the communications art with which AT&T has had so little to do. Its urban-highway service was established long, long after police radio was a vibrant, functioning reality. In its construction, AT&T merely applied principles of communication already developed in the police radio field.

In other words, there was, and is, no public need for its radio services in law enforcement, and other public safety services — at least in radio communications!

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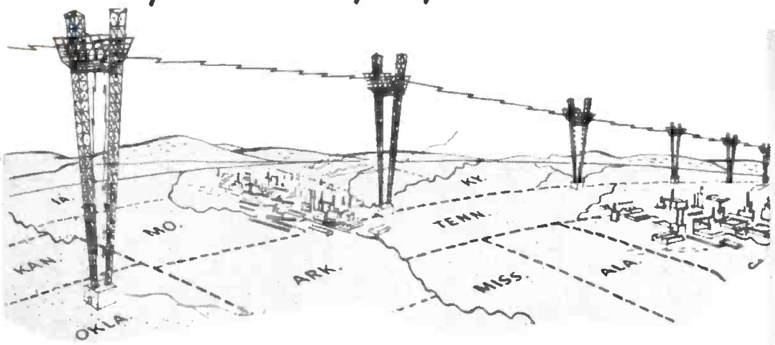

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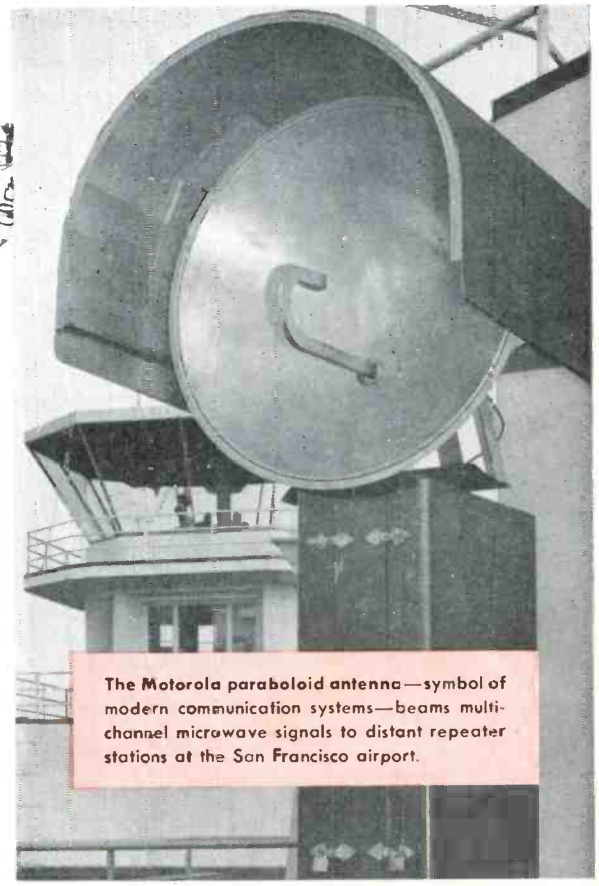

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