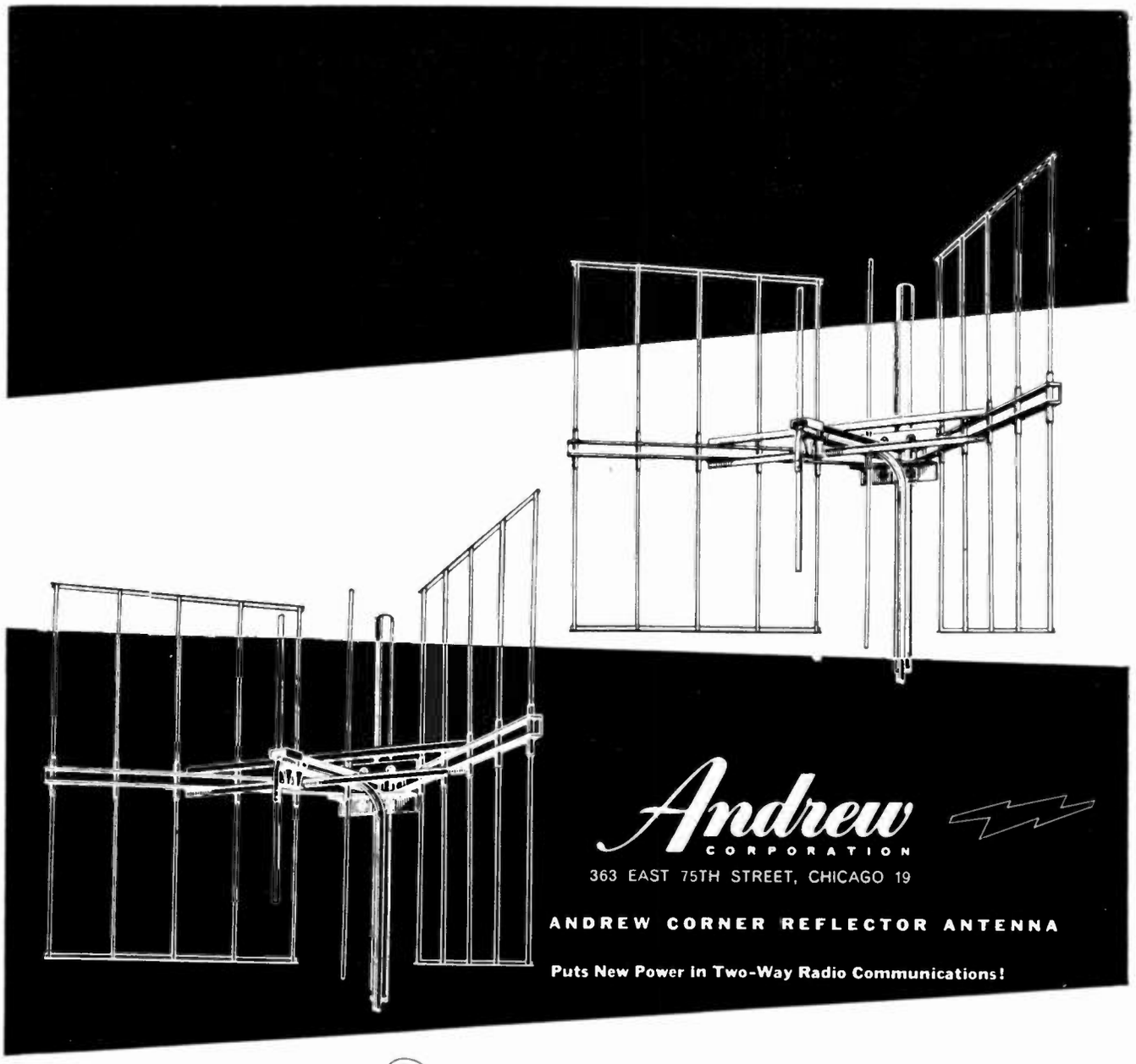
Communication Engineering

Nov.-Dec. 1953 | Published by RADIOCOM, Inc. | Price 65 Cents



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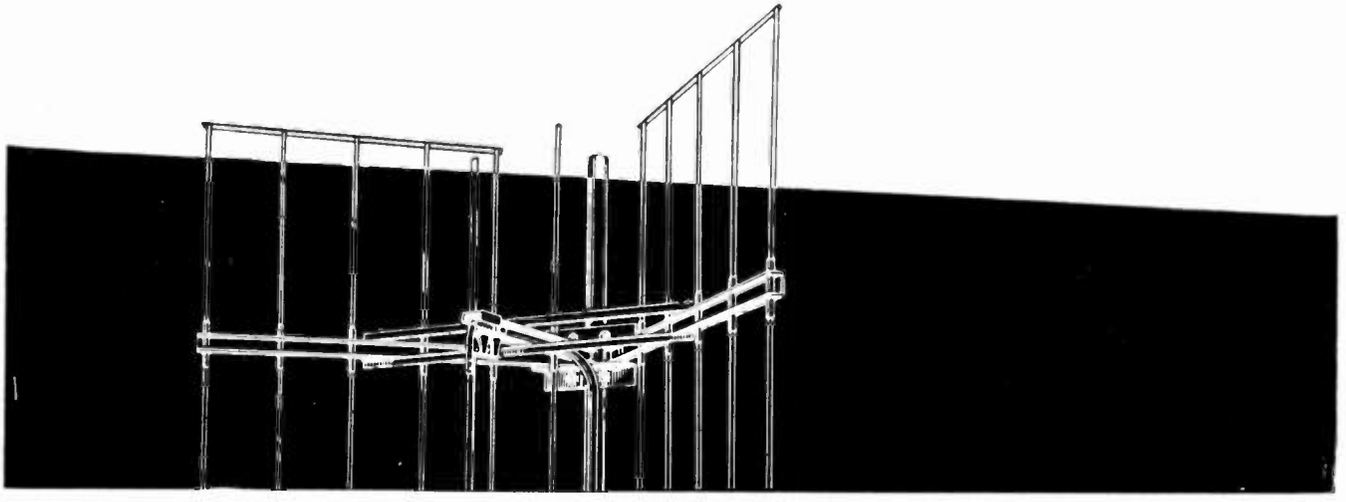
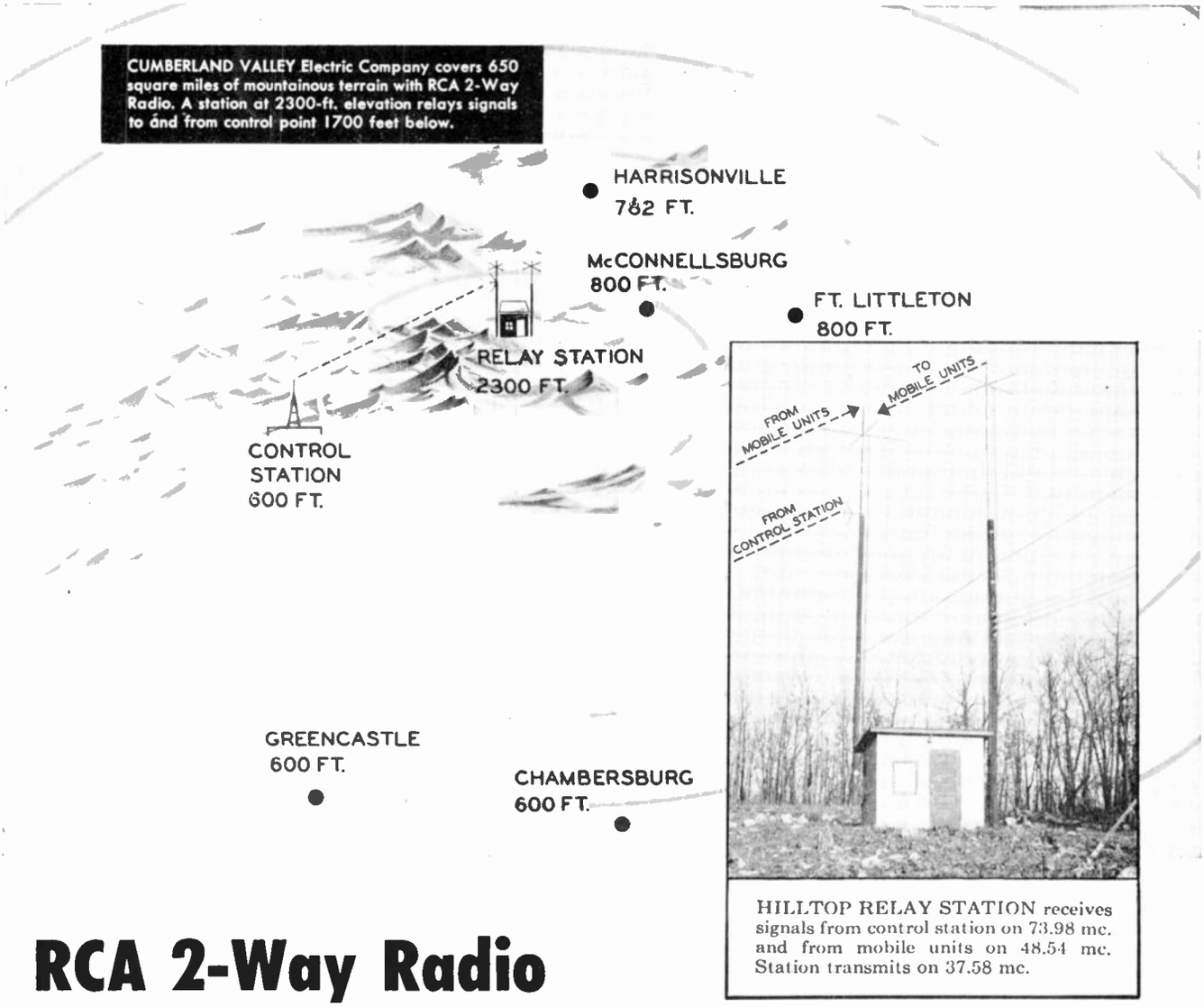
Puts New Power in Two-Way Radio Communications!

Stronger signals at greater distances are BUILT-IN this new narrow-angle antenna. Ideal for serving long stretches of highway, rail or pipe lines, it is equally effective for point-to-point communications, or back-to-back with other services. Gains up to 12 DB can be achieved by stacking. Vertically polarized, uni-directional, Andrew Corner reflector antennas are available in all mobile communications bands. Put them to work for you to INCREASE and IMPROVE your radio coverage. For more information, write us today.





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.

In addition, the installation permits twenty-four-hour communication between mobile units without requiring a twenty-four-hour dispatcher. Superior car-to-car communication, provided by the hilltop relay, keeps crews in direct contact with each other during dispatcher's off-duty hours.

For engineering assistance on difficult communications problems, contact the RCA Communications Specialist at your local RCA Regional Office. For day-in, day-out dependability, specify RCA 2-Way Radio. For Literature... clip coupon below, and mail it today.

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COMMUNICATIONS EQUIPMENT **CAMDEN, N. J.**

Radio Corporation of America
Communications Equipment, Dept. 132W
Building 15-1, Camden, New Jersey

☐ Please send me information on RCA 2-Way Radio.

☐ Please have an RCA Communications Specialist call on me.

Name_____ Title_____

Company_____ Address_____

City_____ Zone_____ State_____

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MICROWAVE PHILCO MICROWAVE PHILCO MICR
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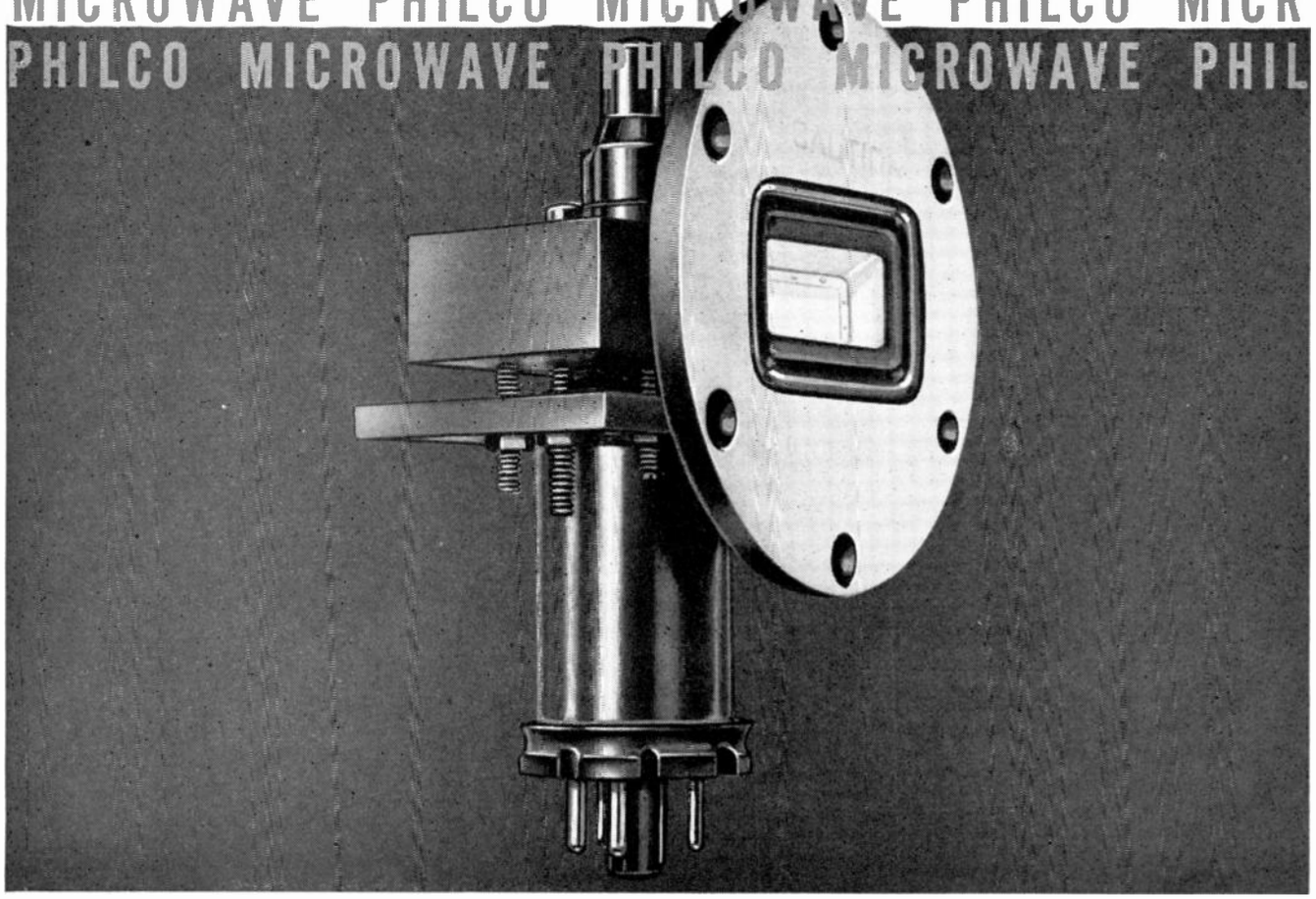

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The heart of Philco Microwave is this "Power House" klystron . . . with it Philco has the highest equipment power output in the 6000-7500 mc band . . . generating a full watt of output power it provides Philco Microwave systems with a reliability safety margin of 30 decibels (1000 to 1) . . . greater assurance of performance under any and all field conditions.

Philco's exclusive feedback design makes possible full use of this powerful klystron . . . requires the use of only two of these klystrons for simultaneous two-way transmission and reception . . . minimizes cumulative distortion and noise with numerous repeater stations. In combination with other Philco features such as custom-sized, high gain, antenna-reflector systems and operation in the preferred and interference free frequency band, the result is reliable, high quality communications.

Look to Philco Microwave for the answer to your communications requirements.

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GOVERNMENT & INDUSTRIAL DIVISION · PHILADELPHIA 44, PA.

Communication Engineering

Formerly FM-TV and Radio Communication

Vol. 13 NOVEMBER - DECEMBER, 1953 No. 6

DEPARTMENTS

ARTICLES

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Publication Office: The Publishing House, Great Barrington, Mass Tel. Great Barrington 1300.

Chicago Office: 5449 W. Augusta Blvd., Tel. Columbus 1-1779.

New York Office: 6 East 39th Street, Room 1209, Tel. Murray Hill 5-6332.

West Coast Office: 1052 West 6th Street, Los Angeles, Tel. Madison 6-1371

Communication Engineering Magazine is mailed on the 20th of January, March, May, July, September, and November.

Subscriptions: Should be sent to Publishing House, Great Barrington, Mass. Single copies 65c. Sub. rates: 3 years—$6.00; 2 years—$5.00; 1 year—$3.00.

Contributions will be neither acknowledged nor returned unless accompanied by adequate postage, packing, and directions, nor will Communication Engineering Magazine be responsible for their safe handling in its office or in transit.

Entered as second-class matter August 22, 1946, at the Post Office, Great Barrington, Mass., under the Act of March 3, 1879. Additional entry at Post Office, Boston, Mass. Printed in the U. S. A.

CPA AUDIT

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

SYSTEMS DATA

THIS issue's reporting period for new communication applications filed with the FCC covers only from September 1 to October 16, because of the advance in COMMUNICATION ENGINEERING's publication date. Even so, the total 30 to 50 and 152 to 174-mc. figures for this period projected on a 2-month basis are down almost to the January-February level, the year's low. The only figures in the table below, which shows 2-way base, mobile, and portable equipments applied for in 30 to 50-mc. and 152 to 174-mc. bands, that did not decrease from those for the July-August period were for police, special industrial, and MCC.

In the low-power industrial service, which accounted for slightly less than half the total portables, the ratio of applications in the 160-mc. band to those in the 40-mc. band has been steadily increasing and is now almost unity.

Base and mobile units in the 450-mc. band were up substantially over the July-August period, although down from previous periods. Actual total for this 6-week period was 10 base and 252 mobile applications, along with several controls and relays.

The complete list of non-tabulated applications is given in the following paragraphs:

POLICE: 46 speedmeters on 2,455 mc.; 7 interzone CW transmitters on 2 to 7 mc.; 2 relays on 75 mc., 1 on 157 mc., and 3 on 450 mc.; 2 control transmitters on 74 mc., 4 on 160 mc., and 1 on 155 mc.

FIRE: 1 relay on 160 mc., 3 on 453 mc., and 1 on 960 mc.; 3 control transmitters on 459 mc. and 1 on 957 mc.

HIGHWAY MAINTENANCE: 12 speedmeters on 2,455 mc.; 80 mobile units and 4 base stations on 457 mc.; 2 relays on 75 mc., 2 on 158 mc., and 2 on 454 mc.; 2 control transmitters on 73 mc. and 2 on 955 mc.

FORESTRY CONSERVATION: 2 relays on 157 mc.

POWER UTILITY: 2 relays on 75 mc., 3 on 450 mc., and 4 on 1,875 mc.; 1 control transmitter on 75 mc. and 4 on 456 mc.; 3 op. fixed transmitters on 950 mc. and 17 on 1,900 mc.

PIPELINE PETROLEUM: 21 fixed and 10 mobile transmitters on 1 to 4 mc.; 2 relays on 455 mc.; 12 op. fixed transmitters on 1,870 mc. and 2 on 6,600 mc.

SPECIAL INDUSTRIAL: 100 mobile units and 3 base stations on 456 mc.; 47 mobile units and 3 base stations on 2 to 4 mc.; 20 mobile units and 3 base stations on 27 mc.; 2 relays on 74 mc. and 2 on 153 mc.; 3 control transmitters on 72 mc.

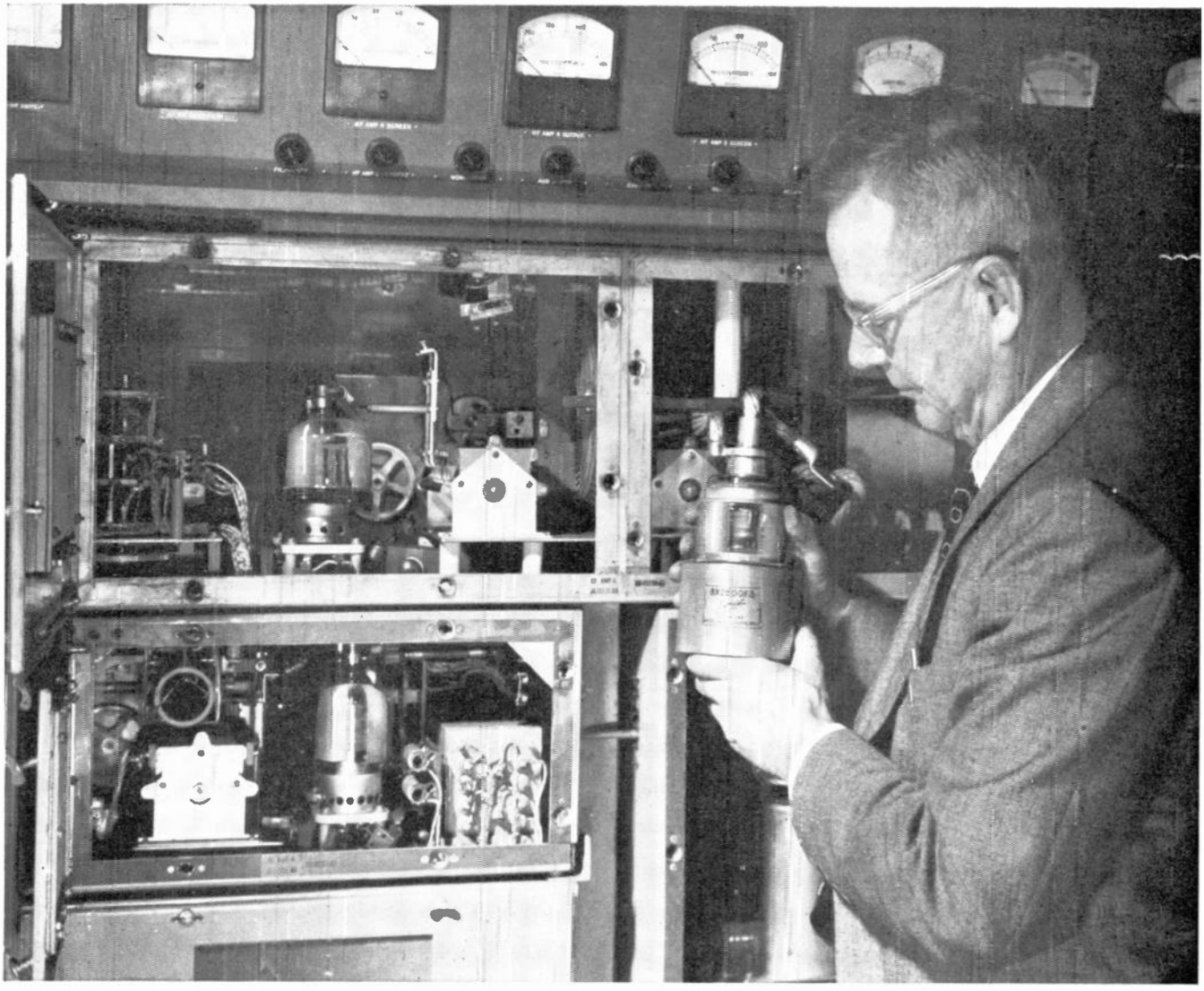
RELAY PRESS: 2 relays and 1 control transmitter on 162 mc.

FOREST PRODUCTS: 100 mobile units and 2 base stations on 29 mc.

TRANSIT UTILITIES: 1 relay and 1 control transmitter.

TABLE OF APPLICATIONS FILED SEPTEMBER 1 TO OCTOBER 16, 1953

	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	1,533	127	36	850	78	16	683	49	20
Fire	597	40	15	377	26	—	220	14	15
Special Emergency	139	51	—	112	44	—	27	7	—
Highway Maintenance	200	13	—	100	11	—	100	2	—
Forestry Conservation	30	29	—	30	16	—	—	13	—
Power Utility	368	42	6	253	35	—	115	7	6
Pipeline Petroleum	318	75	—	300	70	—	18	5	—
Special Industrial	1,716	176	123	1,271	148	53	445	28	70
Low-Power Industrial	—	—	256	—	—	33	—	—	223
Relay Press	—	2	—	—	—	—	—	2	—
Motion Pictures	—	—	—	—	—	—	—	—	—
Forest Products	75	4	—	75	3	—	—	1	—
Taxicabs	1,007	99	—	—	—	—	1,007	99	—
Railroads	735	33	—	—	—	—	735	33	—
Highway Trucks	378	33	—	378	33	—	—	—	—
Intercity Buses	—	—	—	—	—	—	—	—	—
Transit Utilities	—	2	—	—	2	—	—	—	—
Auto Emergency	85	10	—	85	10	—	—	—	—
Radio Paging	—	8	—	—	8	—	—	—	—
Common Carrier	475	2	—	—	—	—	475	2	—
Misc. Common Carrier	620	13	—	—	—	—	620	13	—
TOTALS	8,276	759	436	3,831	484	102	4,445	275	334



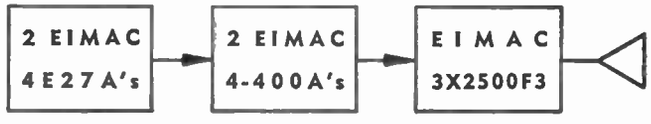
L. G. Young, Bell Telephone Laboratories, Inc., inspects Eimac tubes in LD-T2 transmitter.

Western Electric multi-channel, single side band Transmitters use Eimac tubes in final RF stages

LD-T2 transmitters designed by Bell Telephone Laboratories, for overseas multi-channel communications, are another example of Bell System equipment that meets severe performance requirements. Manufactured by Western Electric, type LD-T2 single sideband suppressed carrier transmitters operating between 4 and 28 mc., handle numerous channels simultaneously with outstanding dependability and performance. Naturally, electron power vacuum tubes in the LD-T2 must meet exacting specifications.

Eimac 4E27A radial-beam power pentodes, 4-400A radial-beam power tetrodes and 3X2500F3 power triodes fill sockets in the final three stages of the RF sections in Western Electric LD-T2 transmitters.

Final Three RF Stages



For information about Eimac electron power tubes write our application engineering department.

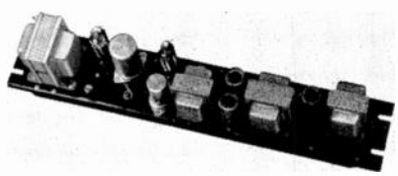
Eimac TUBES

EITEL-McCULLOUGH, INC.
San Bruno, California

PRODUCT INFORMATION

Converter Catalog: Listing the manufacturer's entire line of DC to AC converters, catalog 553 gives complete electrical and mechanical specifications as well as performance charts. The 20 pages are punched to fit standard loose-leaf binders. Copies can be obtained direct from Carter Motor Company, Dept. 26, 2641 N. Maplewood Avenue, Chicago 47, Ill.

Tone Modulator: Long-distance telemetering on audio subcarriers is facilitated by the TMU-1 tone modulator unit. Essentially an absorption-type device, it modulates any

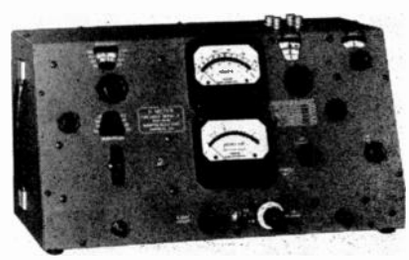


fixed-frequency tone input by AC voltage from a frequency or impulse-type telemeter transmitter. Thus, low-frequency FM telemeter signals are superimposed on an AF carrier. Unit is built on a 3½-inch standard rack panel. Hammarlund Manufacturing Company, Inc., 460 W. 34th Street, New York 1, N. Y.

Photoelectric Control: Emphasizing low cost and dependability, a recent announcement describes the Series 64400 photoelectric control for outdoor lighting. Capacity is 575 watts, and appropriate accessories can be obtained for mounting on any type of support. Should be useful for antenna structure obstruction light control. The Fisher-Pierce Company, Inc., 170 Pearl Street, South Braintree, Boston 85, Mass.

Communication Equipment: Ten new bulletins are available on recent two-way radio equipments, describing six base-station and four mobile combinations. Base stations are 60-watt units for operation in the 25 to 50-mc. band, and 50-watt units for the 152 to 174-mc. band. Three types for floor, desk, and pole-mounting are provided for each frequency range. Mobile combinations include two 10-watt, 30-watt, and 50-watt units. One of the 10-watt equipments is designed for front-mounting. All 152 to 174-mc. band station and mobile units can be converted to split-channel operation; 20 or 40-kc. channel widths are available in 25 to 50-mc. station units. Inquiry Section, GE Electronics Division, Electronics Park, Syracuse, N. Y.

Redesigned *Q*-Meter: Type 260-A *Q*-meter, replacing type 160-A, covers 50 kc. to 50 mc.

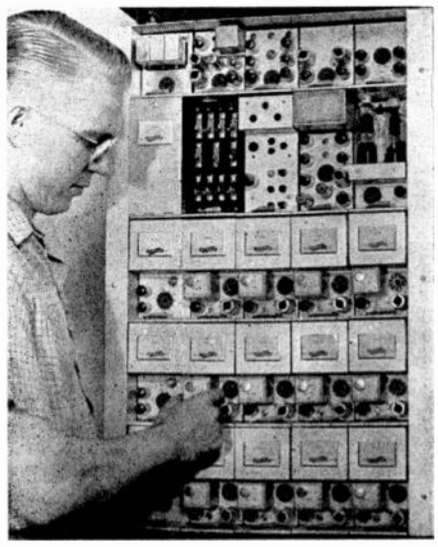


and permits readings as low as 10. A delta-*Q* scale is furnished to indicate changes in *Q* resulting from variations in test-circuit parameters. Accuracy is better than ± 1%. Range switch actuates a mask which exposes correct dial calibration. Voltage injection system is completely new, and the monitor thermocouple has been ruggedized. Boonton Radio Corp., Boonton, N. J.

Heavy-Duty Feed-Thru: Designated type 112, a new series of high-current feed-thru capacitors for suppressing RF interference is rated at 50 amperes. Entire shell is threaded except for two straddle-milled flats to prevent loosening or rotation under vibration. Glass-to-metal solder seals; 250 ACVW. Engineering Bulletin No. 216, giving full details, is available on letterhead request to Sprague Electric Company, 243 Marshall Street, North Adams, Mass.

Miniature Microphones: The MC series of magnetic microphones is said to be small, rugged, and immune to heat and humidity extremes. Measuring only 1 in. in diameter and ⅜ in. thick, these controlled-reluctance microphones are available with or without mu-metal shield. Detailed technical information can be obtained from Sales Division, Shure Brothers, Inc., 225 W. Huron Street, Chicago 10, Ill.

12-Channel Carrier System: Deliveries of 45A carrier telephone systems, which provide up to 12 carrier-derived voice channels on an open-wire line, are now being made. They



can be installed on lines already equipped with systems using frequencies up to 35 kc., and coordinate with systems such as Western Electric type J and Lenkurt type 42C. Equipment is miniatured and utilizes interchangeable plug-in units; complete system occupies 31½ ins. of standard rack space. Transmission characteristics are suitable for application to long-haul circuits, although system is economical on circuits as short as 10 miles. Lenkurt Electric Company, Inc., San Carlos, Calif.

Continued on page 7

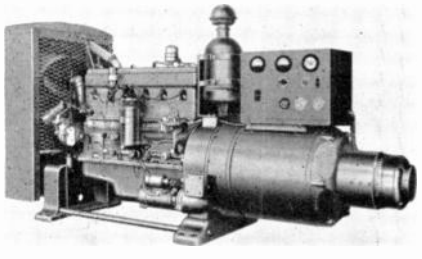
NEW PRODUCTS

(Continued from page 6)

Equipment Knobs: A new line of hand-machined and engraved dural knobs for electrical equipment provides grounded controls which harmonize with any well-designed equipment. Backs are recessed, sides are fluted, faces are machine-finished; screw-type mounting is employed for standard round or half-round ¼-in. shafts. Diameters from 1 to 2½ ins. Pacific Transducer Corp., 11921 W. Pico Boulevard, Los Angeles 64, Calif.

Control Catalog: Models 1 and 2 variable resistors are dscribed in catalog 42-164, just released. Model 1 controls are subminiature units rated at 1/10 watt, available with or without SPST line switch in low and high-torque ratings, from 500 ohms to 10 megohms in 7 standard tapers. Model 2 is a standard ½-watt control, available from 250 ohms to 10 megohms in 14 standard tapers, with or without switch, and in single, twin, and dual concentric shaft styles. Catalog is obtainable from Centralab, 900 E. Keefe Avenue, Dept. J-39, Milwaukee 1, Wis.

Power Plant Book: A new pocket-size booklet describes the three general groups of engine-driven electric plants: AC, DC, and bat-



tery-charging. Plant operation for each is discussed. Gasoline, diesel, and gas engine drivers are also compared in first cost, installation, and maintenance expenses, and the advantages of each for specific types of installation are given. Copies of the Blue Book are available from D. W. Onan & Sons, Inc., Minneapolis, Minn.

New Type of Screened Room: Bulletin 5 describes a series of screen-room panels that are fully interchangeable and easy to assemble. Only 2 panel sizes are needed; they can be assembled to make a room of any desired size which can be changed later to meet the need for expansion or relocation. Attenuation from 200 kc. to 413 mc. averages 114 db; meets MIL-S-4957 specification. Ace Engineering & Machine Company, 3644 Lawrence Street, Philadelphia 40, Pa.

Steatite-Cased Capacitors: The Budroc line of paper tubular capacitors has steatite ceramic casing and Polykane end seals, was developed specifically for high-temperature and/or high-humidity applications. Capacity range is .0005 to 1 mfd. at 200 to 1600 VDCW. Those rated up to 400 VDCW are also rated for −40° to +90° C.; above this working voltage temperature rating is −55° to+100° C. All are guaranteed to withstand 250 hours operation at 95% RH and +40° C. Further information is given in bulletin NB154, available from Industrial Division, Cornell-Dubilier Electric Corp., 333 Hamilton Boulevard, South Plainfield, N. J.

Base-Station Accessories: Three new uni-directional base-station microphones, employ-

Continued on page 10

THIS MONTH'S COVER

This microwave station on the American Bank Building in New Orleans is one of 8 in the communication system of the Freeport Sulphur Company. The 6,700-mc. system connects mine fields on the Louisana Gulf coast with Port Sulphur, where sulphur is stored and loaded for shipment, and with the New Orleans headquarters. Unique in the problems which had to be overcome, this was the first microwave point-to-point system authorized in the special industrial service. A complete description will appear in a forthcoming issue.

COMPANIES & PEOPLE

Robert E. Lee: Coming as a surprise to most observers, the appointment of Commissioner Lee to the FCC for a seven-year term was made October 6. This appointment brings the FCC up to full strength, comprised of four Republicans and two Democrats, and one Independent. Only 41, Lee was born in Chicago and earned a degree in accounting from De Paul University. He received training in law at Chicago College of Commerce & Law, and worked at auditing until 1938 when he joined the FBI. Rising rapidly in that agency, he went from financial investigator to chief clerk in charge of fiscal matters. In 1947, he resigned to head up survey and investigation for the House Appropriations Committee. Commissioner Lee is married and has three children.

Arthur C. Rustad: Promoted to general manager of Crosby Laboratories, Inc., of Long Island. He was formerly with Press Wireless, Inc., and Press Wireless Mfg. Company, coming to Crosby originally as production manager.

Virgil M. Graham: Elected vice president and member of the Executive Committee of the U.S. National Committee on the International Electrotechnical Commission. The IEC, of which the ASA is the American parent body, is an international standardizing organization in the electrical and electronic fields. Mr. Graham is director of technical relations for Sylvania Electric Products, Inc., and has been active in standardization work for 30 years.

Edward J. Nally: Died September 22 at his home in Bronxville, N. Y., at the age of 94. Mr. Nally was the first president of RCA, serving in that capacity from 1919 until 1923. He continued on the RCA board until 1950. Beginning his communications career with the Western Union Telegraph Company in 1875, he was appointed assistant general superintendent of the Western Division, Postal-Telegraph Cable Company, in 1890. He became first vice president and general manager in 1906. In 1913 Mr. Nally joined Marconi Wireless Telegraph Company in the same capacity, and served until the company was acquired by RCA in 1919. Few have seen such sweeping changes in an industry, and fewer still have had so much to do with them.

Wire Firm Expansion: The new 25,000-ft. wing of the Chester Cable Corp., Chester, N. Y., is scheduled for full production Nov. 1. Wire and cable for industrial and military applications will be produced there.

New Department: The Commercial Equipment Dept. has been established in General Electric's Electronics Division to concentrate the Company's efforts in TV station equipment, 2-way radio and microwave communication, and germanium products. William J. Morlock was appointed general manager; Lacy W. Goostree, Jr., manager of marketing; Charles M. Heiden, manager of engineer-

Continued on page 9

MEETINGS and EVENTS

NOVEMBER 12 - 13,
IRE PROF. GRP. ON VEHICULAR COMM.
Hotel Somerset, Boston, Mass.

DECEMBER 14 - 16,
SCEL WIRE & CABLE SYMPOSIUM
Berkeley Carteret Hotel, Asbury Park, N. J.

JANUARY 18 - 22, 1954,
AIEE WINTER GENERAL MEETING
Statler Hotel, New York City

APRIL 24,
CINCINNATI SECTION IRE CONFERENCE
Cincinnati, Ohio

COMPANIES & PEOPLE

(Continued from page 8)

ing; and Clair C. Lasher, manager of manufacturing.

Telephone Equipment Firm: Telecom, Inc. of Kansas City, Mo., has been set up to manufacture telephone switchboards and other electrical apparatus for the communication field. Marketing will be through established distributing channels. John Van Horn was elected president of the new company.

Henry C. Roemer: Formerly president of Federal Telephone and Radio Company, Mr. Roemer has been designated vice president in charge of administration of the domestic divisions of the IT&T. These divisions are Federal Telephone and Radio, Federal Telecommunication Laboratories, Kellogg Switchboard and Supply, Coolerator, and Capehart-Farnsworth. Raymond S. Perry has assumed the presidency of Federal.

Southern Electric Sold: All assets of Southern Electric & Transmission Company of Dallas, Texas, have been acquired by Stromberg-Carlson Company. Southern Electric has dissolved as a partnership and has become a division of the larger company. Since Stromberg has been distributing wire carrier equipment made by Southern, the move is expected to increase both manufacturing and sales potential.

Dr. George M. Anderson: Appointed head of the engineering development group at Edison Laboratory, Thomas A. Edison, Inc. He did undergraduate and graduate work at Carnegie Tech and was assistant professor of electrical engineering there for three years. Before joining Edison, Dr. Anderson was with Westinghouse for two years working on atomic reactors.

New Camden Plant: The $1.5 million, 90,000-ft. manufacturing plant of Radio Condenser Company began operation on October 7. Located at Camden, N. J., the new plant is part of an expansion program that will permit the Company to double its production of variable capacitors, auto radio tuners, and UHF tuners.

Dr. Adair Morrison: Named head of the research section, Sprague Electric Company Research and Engineering Dept. He received degrees from Canada's University of Saskatchewan and McGill University, and worked with the National Research Council of Canada and Arthur D. Little, Inc. In his new

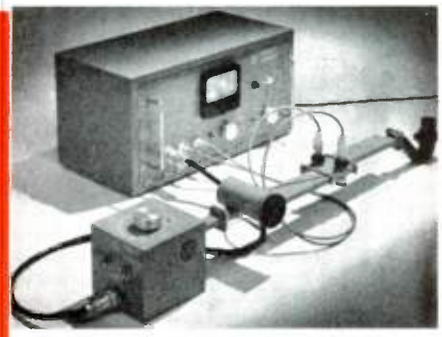
Continued on page 14

NEW PRODUCTS

(Continued from page 7)

ing smaller and more sensitive cartridges than previous models, have spring-suspended moving-coil units to eliminate shock noises. Two models, the TU151 and TU152, are desk-stand mounted and are identical except for microphone connectors. The TU140 is mounted in a movable floating arm by means of which the mike can be positioned anywhere within a 3-ft. range of its base. Screwdriver adjustment provides selection of low, medium, or high output impedance. Communications and Electronics Division, Motorola, Inc., 4545 West Augusta Blvd., Chicago 51, Ill.

Continuous VSWR Meter: Model 110A X-band VSWR indicator provides for continuous



measurement throughout the range from 8,500 to 9,600 mc. on waveguide components, with scales from 1.06 to 2.5. Equipment includes oscillator, wavemeter, forward and reversed directional coupler with bolometer take-offs for source and reflected power, and a direct-reading ratiometer. Overall accuracy is within 2%; simplicity of measurement makes the unit useful for production go-no go tests. Color Television, Inc., 1003 E. San Carlos Avenue, San Carlos, Calif.

Subminiature Resistor: Type 1101 resistor is ¼ in. in diameter and 13/32 in. long, can be wound in values up to 175,000 ohms. Resistance tolerances to ± .1% are available with power ratings of .1 watt. Impregnation for temperature and humidity resistance. Dept. SR, The Daven Company, 191 Central Avenue, Newark 4, N. J.

Miniature Ball Bearings: A very handsome 20-page booklet offers the latest design and application data on miniature ball bearings. Technical data, supplemented by drawings, graphs, tables, and photographs are given for ball bearings ranging from .1 to .375 in. OD, as well as radial, angular contact, pivot, and thrust bearings. Copies can be obtained from Miniature Precision Bearings, Inc., Keene, N. H.

Audio Mixer Controls: A new line of variable attenuators includes ladder, T, H, L, and potentiometer configurations up to 32 steps. Resistive elements are non-inductive, wire-wound and hermetically sealed. Temperature range is claimed to be —40 to + 100° C., and humidity tolerance up to 95%. Bulletin A-2 available on request to Hycor Sales Company of Calif., 11423 Vanowen Street, North Hollywood, Calif.

Wire-Wrapping Gadgets: Suitable for stranded or solid wire, a new line of wire-wrapping tools expedites making neat, fast turns of one or more wires around terminals

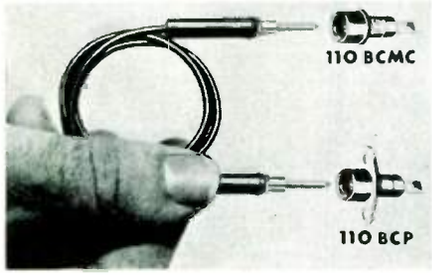
Continued on page 11

NEW PRODUCTS

(Continued from page 10)

in preparation for soldering. Models for small, medium, and large terminals are obtainable. Contact, Inc., 238 Main Street, Cambridge, Mass.

Check-Point Jacks: New Mini-Test jacks take up very little space, mount on front



panel of any equipment so that critical voltages can be monitored quickly and as often as desired. Two models are available, as shown: one simply pushes into .347 hole and locking tabs spring into position. Other has mounting plate that can be fastened with spot welds, eyelets, or rivets. Alden Products Company, 117 North Main Street, Brockton 64, Mass.

Small Indicator Lights: Series L6000 subminiature indicator or warning lights are suitable for standard or edge-lit panels, have amber, blue, green, red, or white lens. Require only ½ in. behind panel; lens is 27/64 in. long for maximum side visibility. Weight is about ½ oz. Unit employs standard AN-3140 lamp. Hetherington, Inc., Sharon Hill, Pa.

Hermetically-Sealed Relays: Union type M 6PDT relays are said to be the smallest and lightest available. Weight is 3½ ozs., and volume is 1½ cu. ins. Designed to meet MIL-R-5757 A and B specifications, it has a minimum life expectancy of 1 million operations. Standard contact ratings are 2 amperes at 26.5 VDC for 100,000 operations; these and other ratings can be varied on special order. Various mountings are available. Union Switch & Signal Division, Westinghouse Air Brake Company, Dept. 67, 1789-1807 Braddock Avenue, Pittsburgh 18, Pennsylvania.

New Banana Plugs: Type FNT banana plugs, shown here, are styled for easy gripping and versatility. Units are molded of mica-filled bakelite; contacts and screws are nickel-plated brass. Leads can be brought in directly at base or through hole at bottom. Specif-

ications and prices are obtainable from Components Division, National Company, Inc., 61 Sherman Street, Malden, Mass.

Continued on page 12

NEW PRODUCTS

(Continued from page 11)

High-K Ceramics: K-Lok ceramic disc capacitors combine high capacitance with substantial stability under environmental extremes. Capacity is constant, relative to 25° C. value, within ± 5% from —55 to + 105° C. and +5, —10% from —55 to + 125° C. Available in 4 styles with range of 220 to 4,500 mmf. Rated at 1,000 VDCW at 85° C., and 500 VDCW at 125° C.; 10,000 megohms minimum insulation resistance. Samples available on request to Erie Resistor Corp., Erie, Pa.

Wide-Range AC VTVM: Model 1040 VTVM has a useful frequency range of 7 to 250,000 cycles. Sensitivity is high, and input capacity is low; thus, the instrument is suitable for low-frequency vibration studies, frequency and gain measurements on amplifiers, transmission loss and other measurements on filters and carrier systems, and standard maintenance work. Weight is 12 lbs., dimensions 4⅞ by 5⅝ by 9⅞ ins. Further details on specifications and prices available on request to Freed Transformer Company, 1718 Weirfield Street, Brooklyn (Ridgewood) 27, N. Y.

Waveguide Attenuator: A new type of waveguide attenuator, Motel X382A, furnishes direct readings from zero to 50 db with accu-

racy of ± 2%. No interpolation or charts are required. Frequency range is X-band, from 8,200 to 12,400 mc.; VSWR less than 1.15 throughout range. Power can be fed to either end of attenuator. Hewlett-Packard Company, 395 Page Mill Road, Palo Alto, Calif.

Taper Connectors: A brochure now available gives facts and descriptions on two types of self-locking taper connectors for individual wires. Round and flat taper pins, tabs, and receptacles are specified, and high-speed automatic wire terminators are described. Aircraft-Marine Products, Inc., 2100 Paxton Street, Harrisburg, Pa.

Miniature Magnetic Amplifier: An input signal of .2 microampere is sufficient to produce a usable DC output from model M-21 high-gain magnetic amplifier. Gain is linear with current, at a value of 200. Cost is said to be very low, about 1/3 that of equivalent types, and size is only 2¼ by 2¼ by 3 ins. For low-level applications only, with inputs ranging from .2 to 30 microamperes. Rubissow Electronic Research Laboratories, 119 W. 63rd Street, New York 23, N. Y.

Telemetering Booklet: Bulletin B226 describes a new line of indicating or recording controllers for temperature, pressure, flow, liquid level, and time program. Information is given on FM method of intelligence transmission used, application data, and engineering specifications. Available from The Bristol Company, Waterbury 20, Conn.

Super-Sensitive Relays: The SS series of

Continued on page 13

NEW PRODUCTS

(Continued from page 12)

relays operates on 10 milliwatts or less, resists a 10-G vibration, and is available in open or hermetically-sealed style. Contacts are silver, SPDT, and rated at 2 amperes, 28 VDC or 115 VAC. Maximum sensitivity, one to two milliwatts. Potter and Brumfield, Princeton, Ind.

Side-Indicating Meters: Miniature side-indicating panel meters, Model 1120, furnish

maximum scale length with minimum panel area. Ammeters, voltmeters, VU, db, and other meter types can be obtained in zero-center, left, and right-hand models. Complete information can be obtained from International Instruments, Inc., P. O. Box 2954, New Haven 15, Conn.

UHF Variable Capacitor: Teflon variable capacitors for 500 mc. and up are claimed to have very low dielectric loss, good heat and humidity resistance, constancy of setting, and price comparable to other VHF types. A wide range of values is available. Information can be obtained from the Tri-Point Mfg. & Development Company, 401 Grand Street, Brooklyn, N. Y.

Low-Cost Adaptor: Type 76 single-sideband adaptor incorporates Burnell toroidal-coil filters rather than the crystal filters used in previous models, which results in substantially reduced cost, smaller size, greater ruggedness, and simplified alignment procedure. More information can be obtained from Crosby Lab-

oratories, Inc., Box 253, Hicksville, Long Island, N. Y.

Vacuum-Impregnation Book: A recently-issued revised edition of a 24-page brochure, catalog 760, describes in detail a wide range of typical applications and equipment for vacuum-impregnation. Free on request to F. J. Stokes Machine Company, 5500 Tabor Road, Philadelphia 20, Pa.

Concluded on page 37

COMPANIES & PEOPLE

(Continued from page 9)

position, Dr. Morrison will be in charge of investigations in fundamental sciences related to electrical component technology.

Service Office Appointments: Communications Engineering Company has opened a service office in New Orleans, managed by Charles M. Scroggins, and one in Oklahoma City managed by Edward S. Rosier.

Transistor Book: Said to be the first book-length treatment of transistors, *Principles of Transistor Circuits* (John Wiley & Sons) is the work of nine engineers at General Electric's Syracuse electronics laboratory. Basic theory and application information is given in 535 pages. The book is arranged to cover three main categories: low-frequency, high-frequency, and large-signal nonlinear operation. A significant contribution to transistor literature.

J. J. Dowling: Elected vice president of Tensolite Insulated Wire Company, Inc., of Tarrytown, N. Y. Tensolite manufactures miniature wire and cable. Mr. Dowling will continue as general manager.

Engineering Products Expansion: Two new divisions have been formed in RCA's Engineering Products Dept. R. B. Lanskail has been appointed manager of the Government Contracts Administration Division, and B. J. Sibbold manager of the Commercial Sales Division.

John E. Martin: Appointed Director of Research for the Gabriel Company. Graduated from London University in 1941, he worked during the war on naval radar research for the British Admiralty, and later did antenna design for the BBC. Mr. Martin came to this Country in 1952 and joined Gabriel then. His headquarters will be at the Needham, Mass. Laboratories.

Gastonia Plant: A new plant at Gastonia, North Carolina, enclosing 160,000 sq. ft. is being fitted with machinery and equipment by the Pyramid Electric Company of North Bergen, N. J. Paper, ceramic, and motor-starting capacitors will be manufactured in the new plant beginning around January 1. Ultimately, 1,000 persons will be employed there.

$2.5 Million Order: The Electronics Division of Westinghouse Electric Corp. has received a supplementary order in that amount from the Air Force for type

Concluded on page 15

COMPANIES & PEOPLE

(Continued from page 14)

MW high-frequency transmitters. Previous order ($3 million) for the equipment, operating on 2 to 30 mc., was delivered last year.

Changes: Harry Coleman Hagerty, financial vice president and director of the Metropolitan Life Insurance Company, has been elected a director of RCA, to fill the vacancy left by the resignation of Lewis L. Straus who was appointed Chairman of the Atomic Energy Commission. NBC directorship also vacated by Mr. Straus has been filled by William E. Robinson, publisher and executive vice president of the Herald Tribune, and a director of RCA.

Transportation Registry: Now in preparation, the 1953 edition will be off the press in the latter part of November. Priced at $2.00, this Registry will list all communication systems operated by taxicab, railroad, highway truck, intercity bus, transit utility, and auto emergency companies. Each system is listed alphabetically by state and city, giving name and mailing address, base station location, number of mobile units and base stations, call letters, frequencies, equipment make, and special notes. Information requests and orders should be addressed to Registry Editor, Radiocom, Inc., The Publishing House, Great Barrington, Mass.

Jack Colvin: Appointed director of engineering for Gates Radio Company. Mr. Colvin, formerly with Commercial Radio Company of New York, the American Broadcasting Company, and RCA, replaces Fred O. Grimwood who died in April, 1952.

John A. Rankin: Director of engineering at Magnavox has been elected a director of the company. Prior to joining Magnavox in 1951, he was with Belmont Radio and RCA.

Bradford, Pennsylvania: Bradford Components, Inc., has opened a plant at 27 Bishop Street to manufacture precision wire-wound resistors, coils, and subassemblies. F. Gordon Schermerhorn, formerly manager of Speer's resistor division, is president. Other executives are John G. Cumming, Jr., vice president and treasurer; Alfred E. Dougherty, secretary; Lawrence Lopez, engineering director; Lennon W. Gould, plant engineer; and Karl E. Bretz, sales director.

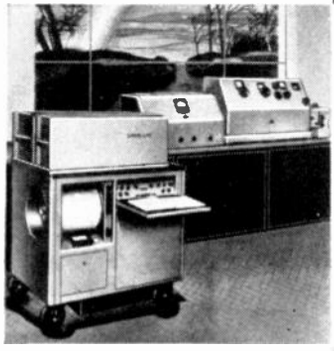
Robert J. Stahl: Former chief engineer of Color Television, Inc., has joined Dalmo Victory Company at San Carlos, Calif., as consulting engineer.

Products of Scientific Research

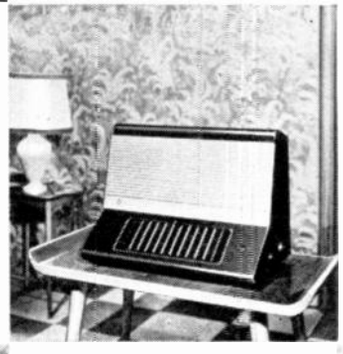
Products of Pye scientific research cover ever-widening fields of application. Information gained through experiment on each project is constantly used to develop and improve all allied manufactures. Through advances thus achieved Pye lead the world in quality and design of radio, television and telecommunications equipment.

TELEVISION CAMERAS

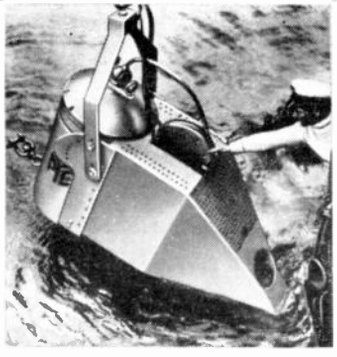
"REPORTER" MOBILE V.H.F. RADIO-TELEPHONE



INFRARED SPECTROMETER



MULTI-WAVEBAND RADIO RECEIVER



UNDERWATER TELEVISION CAMERA

pH METER AND MILLIVOLTMETER

PYE LIMITED CAMBRIDGE · ENGLAND

Gain Antennas for 450 Mc.

HOW SUPPORT PIPES AND FEED CABLES SITUATED NEAR GAIN ANTENNAS AFFECT HORIZONTAL AND VERTICAL RADIATION — *By* EDWARD F. HARRIS*

THE use of gain antennas at base stations, while recognized as an advantage at the lower communication frequencies, has been accepted as a necessary requirement in the 450 to 470-mc. region. Past experience with base-station installations indicates that there are many cases in which a knowledge of the effects of reflecting objects on the pattern of the gain antenna would be extremely helpful. Since it is not always possible to mount an antenna at the top of its support and in the clear, pattern shaping often occurs. Of course, there are installations for which pattern shaping is desired.

A typical problem is the operation of several base-station arrays from the same support, perhaps a wood telephone pole. The pole itself does not represent a serious shadowing member but the coaxial feed cable to the top units, which pass in proximity to the lower antenna, must be considered. Data given here was taken in an effort to provide the systems engineer with guidance by establishing a trend of pattern behavior for omnidirectional gain antennas.

Horizontal Directivity: The antenna employed in these tests was a Mark Products model C-3455, a 3-element colinear array employing extended spacing between elements and delivering 4 db gain over a half-wave dipole, when mounted in the clear[1]. The measurements hold, in general, for the higher-gain base-station array such as the Mark C-7455, a 7-element unit; the Workshop 6-HW; and the Andrew 4000. Fig. 1A shows the measured vertical radiation pattern of the C-3455 at 460 mc. The total beam width is 28° when mounted in the clear. Fig. 1B is the measured horizontal pattern and, in effect, provides a calibration for the measurement setup. Since the array has good symmetry, the total variation in the horizontal pattern is less than .5 db; this pattern can be employed as a basis of comparison.

In order to study the effects of the reflecting support pipe, the antenna was mounted on a fixture which facilitated various fixed spacings from a 10-ft. section of pipe running parallel to the antenna and extending equally above and below the radiating aperture. Two sizes of pipe were used. A ½-in. tube was used to simulate a cable running by the antenna and to provide data on reflecting members of relatively small diameter; a 2⅜-in. pipe was used to simulate actual support members.

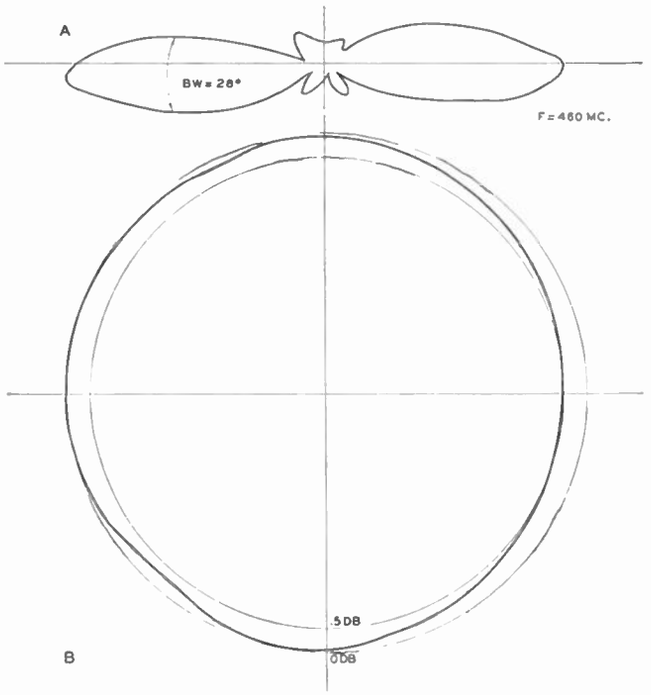
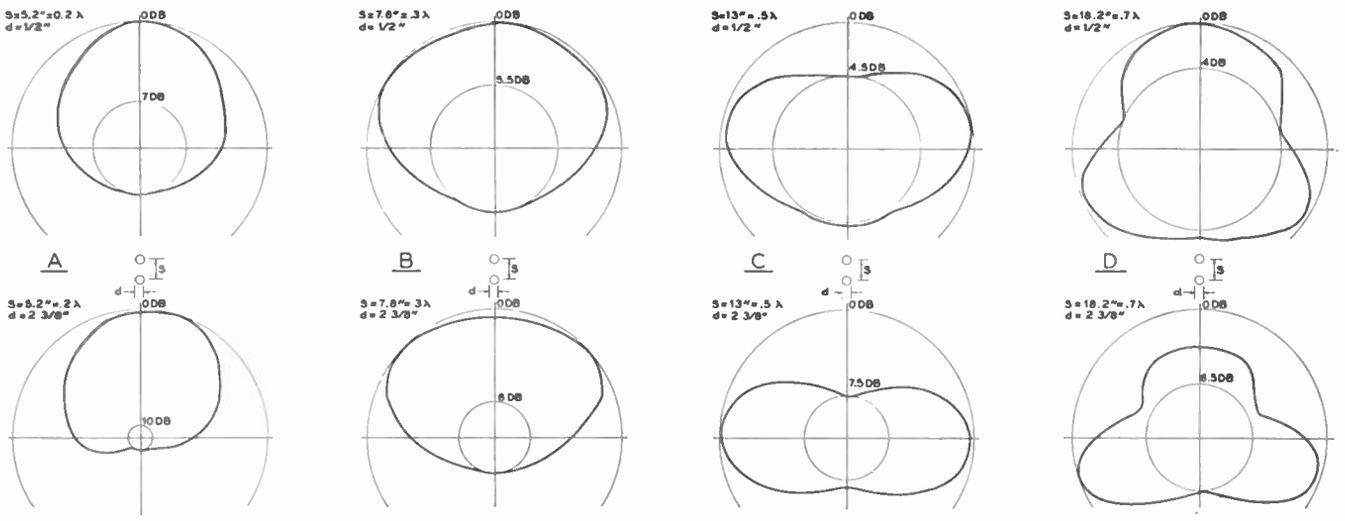


FIG. 1. RADIATION PATTERN OF GAIN ANTENNA MOUNTED IN THE CLEAR

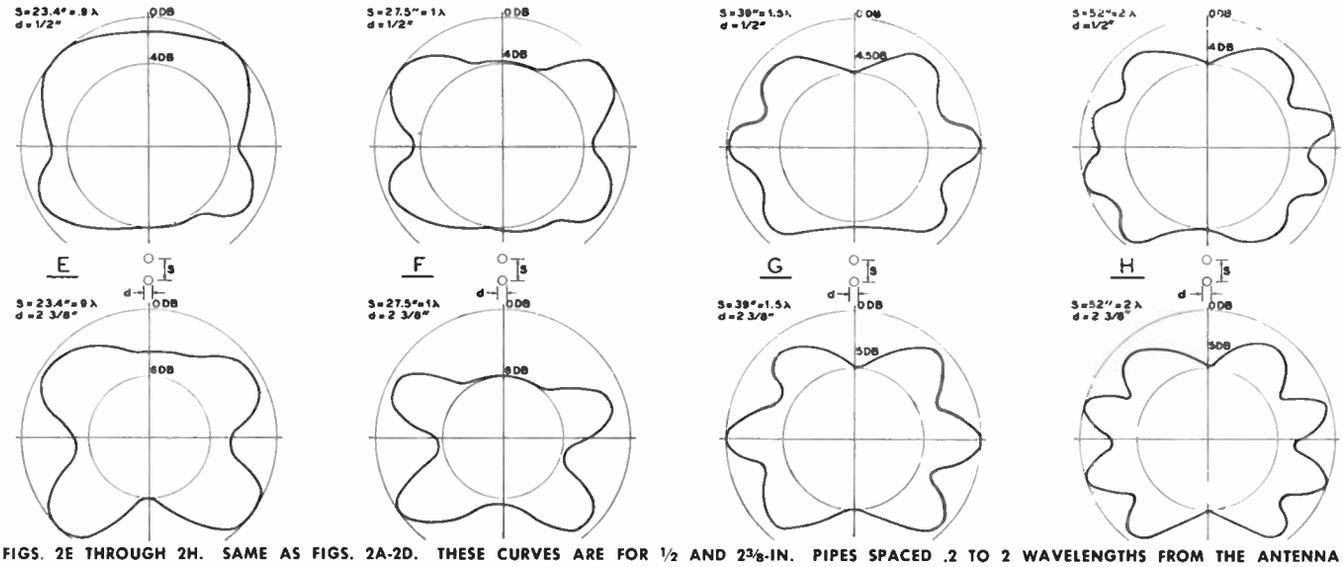
Fig. 2A through 2H is the complete set of measurements reproduced directly from the original patterns as run on an automatic polar recorder. The spacing both for the ½-in. reflector and the 2⅜-in. reflector is varied from about .2 wavelength through 2.0 wavelength. At .2 wavelength the pattern is decidedly unidirectional; the front-to-back variation is 7 db with the smaller tube, and about 10 db with the larger. As

FIGS. 2A THROUGH 2D. HORIZONTAL RADIATION PATTERNS OF NORMALLY OMNIDIRECTIONAL ANTENNA WITH PIPES OF TWO SIZES MOUNTED NEARBY



*Chief Engineer, Mark Products Company, 3547-49 Montrose Avenue, Chicago 18, Ill.

[1]E. F. Harris, "UHF Mobile Antenna," *Electronics*, May, 1953.



FIGS. 2E THROUGH 2H. SAME AS FIGS. 2A-2D. THESE CURVES ARE FOR ½ AND 2⅜-IN. PIPES SPACED .2 TO 2 WAVELENGTHS FROM THE ANTENNA

the spacing is increased the pattern tends first to elongate in the side directions and then, as S goes beyond about .7 wavelengths, multi-lobing effects occur. In all cases, for the smaller and larger members the pattern shapes are very similar, the main difference being in the depth of the minima. In every case the total variation is greater with the larger diameter reflecting member.

In the spacing range of .7 wavelength, the patterns indicate that the possibilities for general-coverage applications are quite good. Although the pattern is a distinct 3-lobed figure, the total variation using the ½-in. reflector is only 4 db; with the 2⅜-in. reflector, this increases to 6.5 db.

With a 39-in. spacing (1.5 wavelength) and the 2⅜-in. pipe, Fig. 2G, the total variation is 5 db. This amounts to ± 2.5 db around the median circle. If the median level is assumed to be that of the antenna gain in the clear, and it is assigned a value of 4 db above a dipole (for the C-3455), the antenna gain even in the dips of the pattern is still some 1.5 db above a dipole in the clear. With a higher-gain base-station antenna, such as the C-7455 which has a free-space gain of some 7 db, the level in the minima of the pattern with the antenna mounted 39 ins. from a 2⅜-in. pipe is 4.5 db above that of a free-space dipole. Also, this increases to 9.5 db over a dipole in maximum directions. However, it is evident that the important considerations are the median level and the total db variation from this value. The 39-in. spacing is readily obtainable in most field installations, and seems to be optimum for the conditions shown. This holds, of course, only at 450 mc.

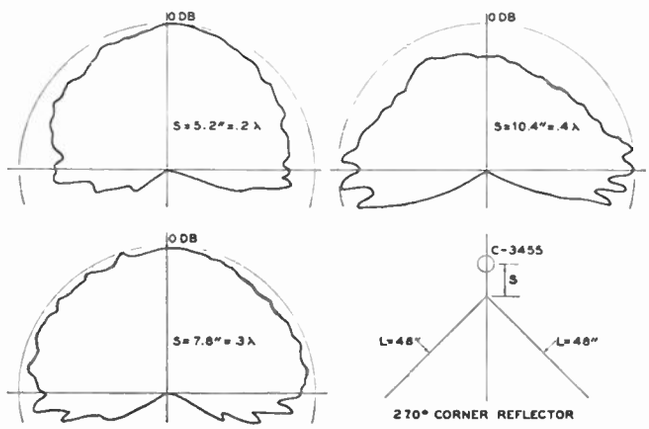


FIG. 5. EFFECTS OF 270° REFLECTOR MOUNTED AT VARIOUS DISTANCES

Vertical Effects: In addition to the horizontal pattern which gives azimuthal coverage data, the effects of the reflecting

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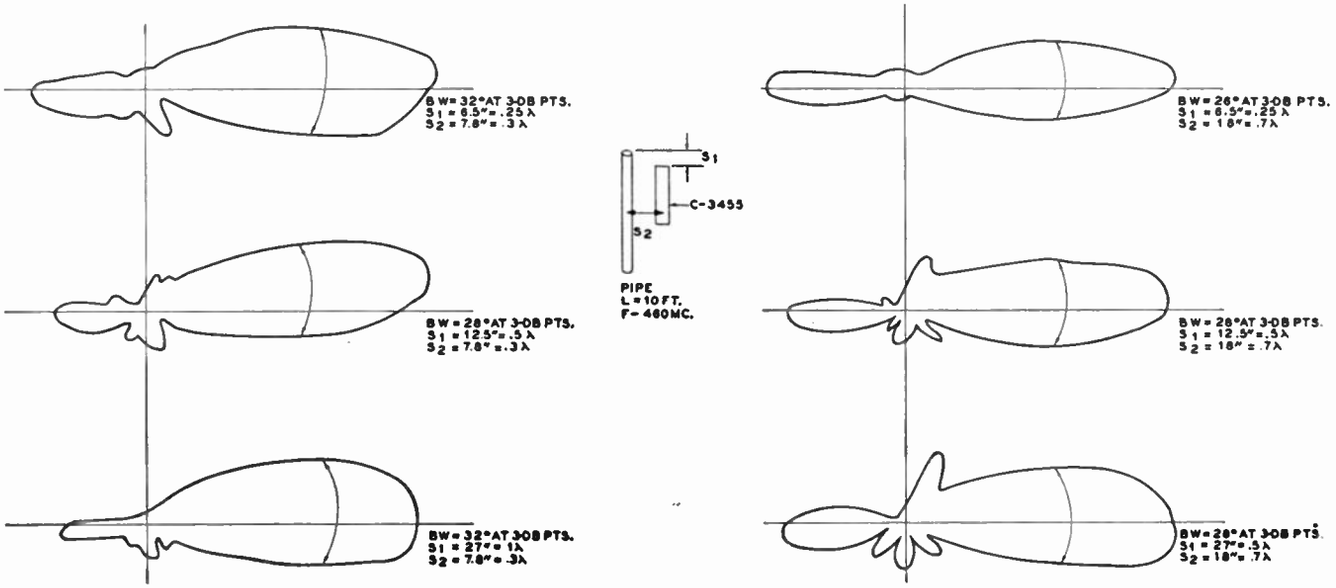
FIGS. 3 AND 4. HOW DISTANCE FROM TOP OF SUPPORT PIPE AFFECTS THE VERTICAL RADIATION PATTERN, FOR TWO LATERAL SPACINGS FROM PIPE



Advantages of FCC Form 400

WHY FORM 400 WAS ADOPTED, AND HOW IT INCREASES FLEXIBILITY AS WELL AS APPLICATION PROCESSING EFFICIENCY — *By* MERLE E. FLOEGEL*

JANUARY 5, 1953 is perhaps one of the most important dates in the history of the Safety and Special Radio Services Bureau of the Federal Communications Commission. On that date FCC form 400, and the associated rule changes necessary for its implementation, became effective. This action on the part of the Commission is very significant. There was more involved than the adoption of a new application form for the Public Safety, Industrial, and Land Transportation Radio Services.

Actually, an entirely new concept of licensing procedures had been introduced. Many of the deep-rooted practices which had grown up with the art of radio communication had been discarded, and in their place strange and unfamiliar instructions had been issued. What was the reason for this radical departure from tried and true methods of many years standing?

The Commission is, of course, ever on the alert for more efficient methods of carrying on its regular business. It is a well-known fact that during the past several years the number of applications received by the Commission's Safety and Special Radio Services Bureau has increased continuously, whereas the number of persons available for application processing has steadily decreased. It became imperative, therefore, if the Commission was to fulfill its obligation to the public, that some means be found to process these applications with the minimum expenditure of man-hours. It appeared that this objective might be achieved in two ways:

1. Reduce the time required to process each application, and
2. If possible, reduce the number of applications required for modifications of existing authority.

Several months before the adoption of the new form, a survey was conducted for the purpose of analyzing the applications on file at that time and awaiting action. It was found that many of these applications were requests for authority to replace one type of authorized equipment with another type of equally acceptable equipment. In some instances the new equipment was similar in type but produced by a different manufacturer, and had a slightly different power rating. In other cases it was found that the applicant was requesting a change in power in order to meet unforeseen requirements.

It was then decided to explore the possibility of publishing a list of equipment which the Commission might determine as acceptable for licensing purposes, and to issue an authorization which, in effect, would encompass all equipment on the list. Then, if each licensee were permitted to interchange equipment, without seeking modification of his authorization, the need for submitting such requests would be eliminated. Further study of the problem indicated that such a procedure was entirely feasible, and it was therefore adopted.

Insofar as the Public Safety, Industrial, and Land Transportation Radio services are concerned, this action has reduced considerably the number of applications in which authority to replace equipment is requested, and time formerly spent in processing such applications can now be devoted to applications for new facilities. Licensees should be very careful, though, when changing equipment to be sure that the new equipment is in fact on the list.[1] Special authority is required to operate unlisted equipment. Such authority is listed on the authorization under "Special Conditions."

In order to allow for maximum flexibility in interchanging the equipment, it was necessary for the Commission to authorize the maximum power permitted by the Rules. It should be noted, however, that the Rule requiring the use of the minimum power necessary for adequate communications must still be observed. This is stated in sections 10.106, 11.106 and 16.106, and reads as follows:

"The power *which may be used* by a station in these services shall be no more than the minimum required for satisfactory technical operation commensurate with the size of the area to be served and local conditions which affect radio transmission and reception." (Underscoring supplied.)

Applications which are submitted in proper form can be processed quickly. Defective applications require additional time to process and, in many cases, must be returned to the applicant for correction. Many of the defects apparently are caused by unfamiliarity with the new form and the new procedures. One of the most common errors is the entering of such words as "On File," "No Change," or "See Exhibit No.—", in the authorization portion of the form. Items 1 through 7 *must* be answered completely *each time* the application is submitted, because these items constitute the body of the authorization. Applications for modification of existing authority should be prepared in exactly the same manner as an application for a new station, except that any supplementary material which is on file with the Commission, and correct at the time the application is submitted, need not be refiled.

For example, suppose a base station transmitter is located at 1234 Main Street, and it is desired to move it to 5678 Spring Street. The *new location* — 5678 Spring Street. — and the new geographical coordinates should be shown in Item 3; the *new* antenna height should be shown in Item 7; the box opposite the word "Modification" in Item 16 (a) should be checked; and the nature of the desired modification, which in this case would be "change location of base station transmitter," should be stated in Item 16 (b).

Many applicants fail to show in Item 4 (a) the name of the radio service in which they desire to operate. "Public Safety," "Industrial," or "Land Transportation" should *not* be written in, as these titles are not names of specific radio services. "Police," "Fire," "Power," "Special Industrial," "Railroad." "Taxicab," or another appropriate name should be shown instead. A complete listing of the names of all the services for which the Form 400 may be used is included in Parts 10, 11, and 16 of the Rules, and also in the Instructions for completion of FCC form 400.

Many radio communication systems consist of a base station and a group of mobile units. In such cases the base station and the mobile units may be combined on one authorization and the area of operation of the mobile units shown in Item 5. The area of operation of the mobile units should not be shown on the base station authorization if the mobile units are covered on a separate authorization. Anyone authorized a base station and a group of mobile units on one license, when applying for a second base station, should submit *three* complete applications; one for the existing base station only, one for the new base station, and one for the group of mobile units showing the area of operation of these units. (Two or more

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*Safety and Special Radio Services Bureau, Federal Communications Commission, Washington 25, D. C.

[1]EDITOR'S NOTE: The complete list of approved types, with additions and revisions as of May 1, 1953, is contained in the Appendix to the Registry of Public Safety Systems, published by COMMUNICATION ENGINEERING. The list of approved transmitters is not distributed by the FCC.

Tower Rules

SIMPLIFIED PRESENTATION OF FCC RULES ABOUT ANTENNA STRUCTURES

ON June 30, 1953, a recapitulation of FCC Rules Part 17, concerning construction, marking, and lighting of antenna structures, was published in the Federal Register. This incorporated all revisions up to and including that of June 3, 1953. Since it supersedes all previous material in Part 17, this information is presented here in rearranged and simplified form for quick reference.

Applications: FCC Form 301, section V-G must be filed with all broadcast applications for radio facilities. Form 401-A (revised) must be filed with any non-broadcast application for radio facilities in the following cases:

1) When the overall height of the proposed antenna structures will exceed 170 ft. above ground level, unless the antenna is to be mounted on an existing man-made structure and does not increase overall height by more than 20 ft., or

2) When the overall height of the antenna structures will exceed one ft. above an established airport landing area[1] elevation for each 200 ft. from the nearest boundary of the landing area, unless the overall height is less than 20 ft. or the antenna is mounted on an existing man-made structure or natural formation and does not increase the overall height of the structure or formation by more than 20 ft.

Processing Policy: All applications which, according to the criteria in the next section, require aeronautical study are referred by the FCC to the Airspace Subcommittee of the Air Coordinating Committee for its recommendation. If this subcommittee recommends approval of the application, the FCC will assume that the proposed structure would not constitute a hazard to air navigation and will process the application accordingly. If the subcommittee recommends denial of the application or if its members disagree as to whether the application should or should not be denied, the applicant will be notified and the FCC will take whatever further action seems appropriate under the circumstances.

All applications which do not require aeronautical study according to the criteria in the next section will be assumed by the FCC not to constitute a hazard to air navigation, and will be processed without reference to the Airspace Subcommittee.

Aeronautical Study Criteria: In no case is an aeronautical study required for an antenna which is to be mounted on an existing natural or man-made structure, if the overall height of the structure will be increased 20 ft. or less. All other antenna structures over 500 ft. in overall height require aeronautical study, regardless of location.

Antenna structures over 170 ft. up to and including 500 ft. in overall height require aeronautical study if *a*) they are to be located in areas of established coastal corridors[2], or if *b*) antenna structures less than 500 ft. high would necessitate raising the minimum flight altitude within civil airways[3] and designated air traffic control areas,[4] or *c*) if the antenna structure would project above the landing area, or the limiting heights or surfaces specified in the remainder of this section, of any airport now in existence or which is provided for in approved plans.

Antenna structures 170 ft. or less in overall height do not require aeronautical study unless they are in the vicinity of airports and approach areas and would project above the heights or surfaces set forth in the remainder of this section.

Antenna structures in the vicinity of airports and approach areas will require special aeronautical study if they project above the following heights or surfaces:

a) In instrument approach areas,[5] more than 100 ft. above the ground or 100 ft. above the elevation of the approach end of the runway, whichever is higher, within 3 miles of the runway ends and increasing in height above ground at the rate of 25 ft. higher for each additional mile of distance from the runway ends, but not to exceed 250 ft. within ten miles of the runway ends.

b) More than 170 ft. above the ground or the established airport elevation, whichever is higher, within three miles of the reference point[6] of a feeder (or larger class) airport, and

[1]A landing area is any locality on land or water which is used or approved for use for the landing and takeoff of aircraft, regardless of other facilities.

[2]These are certain established corridors of low-level flight paths from Dept. of Defense or Coast Guard air stations located within 20 miles of the Atlantic, Pacific, or Gulf Coast. Corridors are 10 miles in width from the air stations to the nearby coasts. Information on these corridors will be available from aeronautical charts, CAA publications, and regional CAA offices.

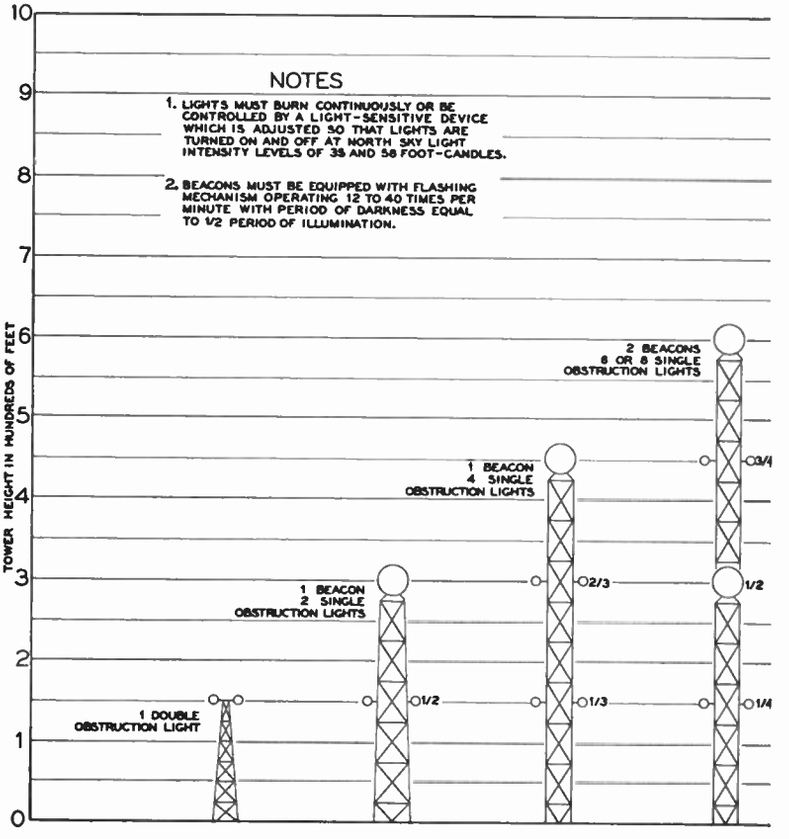
[3,4]Aerial routes and traffic control areas designated by the Administrator of Civil Aeronautics. Information can be obtained from CAA publications and regional offices.

[5]An *approach surface* is an imaginary inclined plane through the air space located directly above the *approach area*. An *instrument approach area* is an approach area wherein instrument approaches are authorized. Dimensions of approach areas are measured horizontally. The approach surface extends upward and outward from the beginning of the approach area at the elevation of the runway, at both ends.

The approach area has a length of 10,000 ft. beginning at 200 ft. (1,000 ft. for Dept. of Defense air bases) from the end of each runway on an extended center line through the runway. Approach areas of all runways which may be used for instrument operation extend outward an additional 40,000 ft. The approach area is located symmetrically with respect to the extended runway center line; has a total width of 1,000 ft. (1,500 ft. for Dept. of Defense air bases) at the end of instrument runways; and flares uniformly to a total width of 4,000 ft. at the end of the 10,000-ft. section and to a total width of 16,000 ft. at the end of the additional 40,000-ft. section. For non-instrument runways, the approach area has total widths at the runway and approach ends, respectively, as follows: express air carrier service and larger airports, 500 and 2,500 ft.; trunk line air carrier service airports, 400 and 2,400 ft.; feeder air carrier service airports, 300 and 2,300 ft.; secondary airports, 250 and 2,250 ft.

For instrument runways the slope of the approach surface along the extended runway center line is 50 to 1 for the inner 10,000-ft. section, and 40 to 1 for the outer 40,000-ft. section. For all other runways as long or longer than that required for feeder air carrier service, the slope of the approach surface is 40 to 1. On airports with runways of shorter lengths, the slope of the approach surface is 20 to 1 for all runways.

[6]The *reference point* is a point selected and marked at the approximate geometric center of the airport landing area.



increasing in height above ground at the rate of 100 ft. for each additional mile of distance from the airport (but not to exceeed 500 ft. above ground).

c) Any elevation which would increase the final approach minimum flight altitude.[7]

d) The approach surface, horizontal surface,[8] conical surface,[9] or transitional surface.[10]

In any aeronautical study, the circumstances that the antenna structure would be shielded by natural formations or existing man-made structures will be taken into account. No structures presently existing or authorized are affected by these criteria.

Painting and Lighting: Antenna structures must be painted and lighted when they require aeronautical study or when they exceed 170 ft. above the ground. Where aeronautical study is not required, painting and lighting specifications given here will be assigned; these same specifications will usually apply if aeronautical study is required, although the FCC may

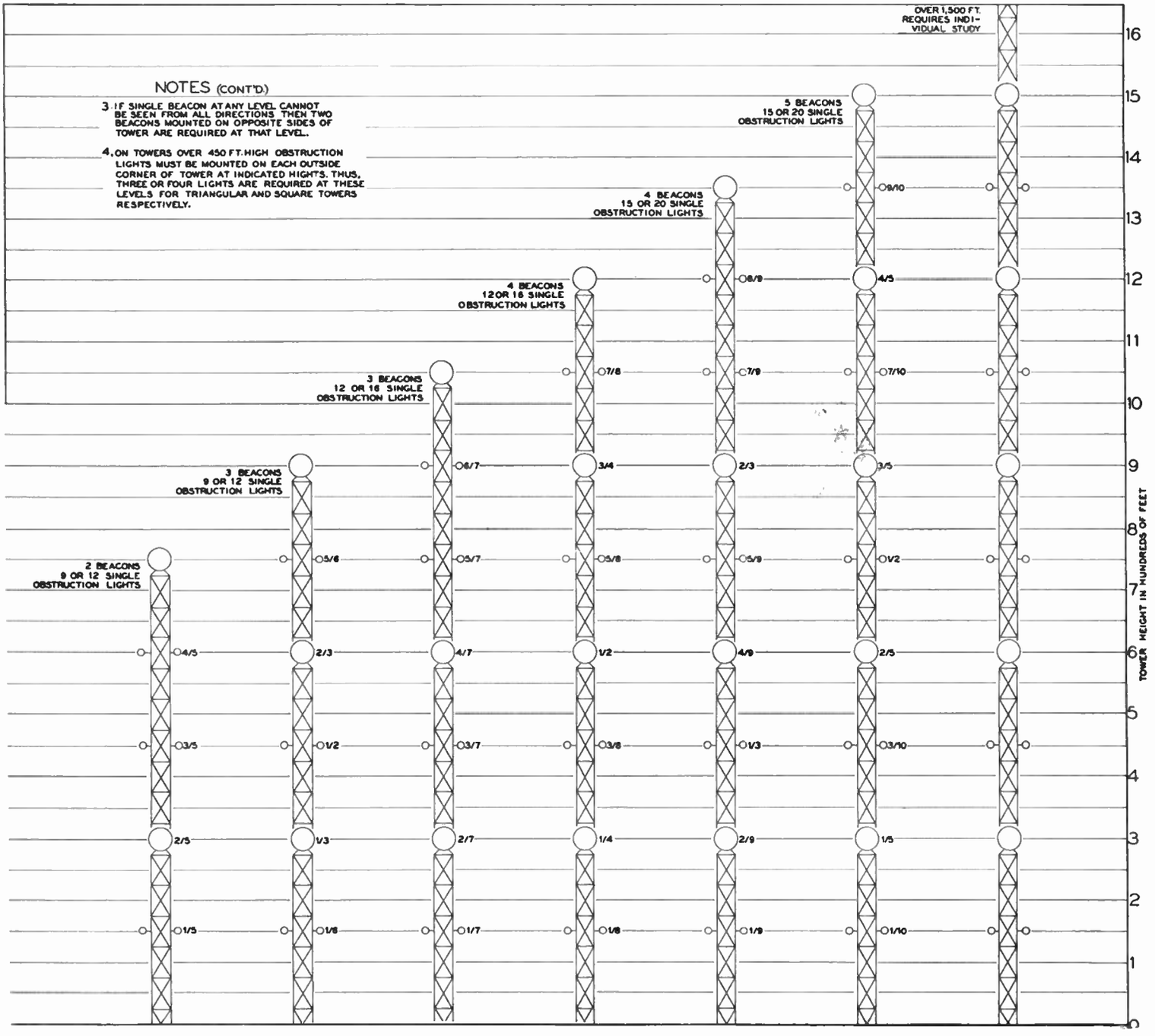
Continued on page 43

[7]The *final approach minimum flight altitude* is that normally established by the highest point within 5 miles of the center line of the final approach course of the radio facility used for final let-down, extending for a distance of 10 miles along this course outward from the radio facility. These altitudes are published in Instrument Approach and Landing Charts and the Flight Information Manual.

[8]The *horizontal surface* is an imaginary plane, circular in shape, 150 ft. above the established airport elevation and having a radius from the airport reference point according to the following table: intercontinental express airports and Dept. of Defense air bases, 13,000 ft.; intercontinental airports, 11,500 ft.; continental airports, 10,000 ft.; express airports, 8,500 ft.; trunk line airports, 7,000 ft.; feeder airports, 6,000 ft.; smaller airports, 5,000 ft.

[9]The *conical surface* is an imaginary surface extending upward and outward from the periphery of the horizontal surface, having a slope of 20 to 1 measured in a vertical plane passing through the reference point. Measuring radially outward from the periphery of the horizontal surface, the conical surface extends for a horizontal distance of 7,000 ft. for intercontinental and intercontinental express airports and Dept. of Defense air bases; 5,000 ft. for continental, express, trunk line, and feeder airports; and 3,000 ft. for all smaller airports.

[10]*Transitional surfaces* are imaginary inclined planes at right angles to the runway, with a slope of 7 to 1, extending upward and outward from lines parallel to and level with the runway. These lines are at horizontal distances from the runway equal to half the minimum width of the approach area. Transitional surfaces extend from the edges of all approach surfaces to the intersection with the horizontal surface or conical surface. Approach surfaces for instrument runways projecting through and beyond the limits of the conical surface have transitional surfaces extending to 5,000 ft. measured horizontally and at right angles to the edges of the approach surfaces.



Project Tinkertoy

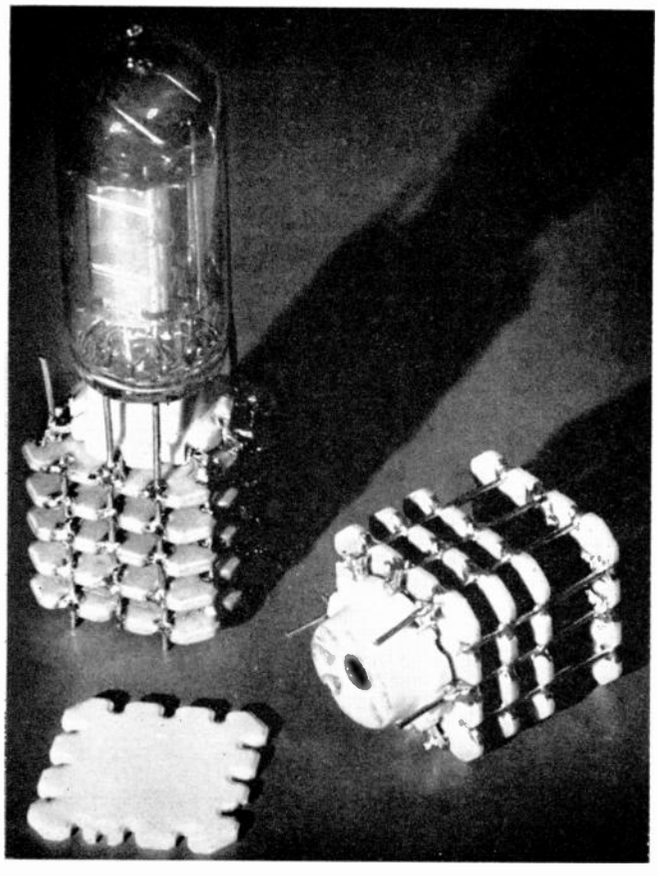
DESCRIBING A NEW CONCEPT OF MECHANIZED PRODUCTION, AND THE TECHNIQUES WHICH HAVE MADE IT POSSIBLE OF REALIZATION IN PILOT RUNS

This technical report from the National Bureau of Standards describes a development that will, certainly, rank among the most significant of the year. The particular operation described was developed specifically to produce military electronic gear, but there is no insurmountable reason why the basic system or a modification cannot be adapted to any type of communication equipment to be produced in reasonable quantities. Further information can be obtained from the sources given in the bibliography at the end of the article.—EDITOR.

AN automatic production line for the manufacture of electronic products, and a novel system of electronics design which makes this possible, have been developed by the National Bureau of Standards. The program which resulted in these developments was code-named Project Tinkertoy.*

Starting from raw or semi-processed materials, machines manufacture automatically ceramic materials and adhesive carbon resistors, print conducting circuits, and mount resistors, capacitors, and other miniaturized component parts on standard, uniform steatite wafers. The wafers are stacked much like building blocks to form a module capable of performing all the functions of one or more electronic stages. Automatic inspection machines check physical and electrical characteristics of the wafers and the parts thereon at numerous stations along the production line. The completed module is a standardized, interchangeable subassembly combining all of the requirements of an electronic circuit with ruggedness, reliability, and extreme compactness.

*Sponsored by the Navy Bureau of Aeronautics.



Project Tinkertoy was begun in May, 1950, and has reached the point at which electronic subassemblies can be produced successfully by mechanical means. The pilot plant, Fig. 1, is operated by a commercial contractor as part of a large-scale production evaluation program under the Bureau's technical direction. The basic objective of the Bureau of Aeronautics in establishing the program was the development of facilities or systems suitable for rapid mobilization in emergency periods. The facilities are also dual-purposed in nature, and are expected to reduce lead time in production.

Basic Philosophy: The key to the automatic, mechanized production of electronic equipment is the design system developed by NBS. Called MDE, for Modular Design of Electronics, the system depends on a series of mechanically standardized and uniform modules (building blocks), producible with a wide range of electrical characteristics.

Each module, as shown in Fig. 2, consists of some 4 to 6 thin ceramic wafers bearing various circuits associated with a specific stage. A number of individual modules are combined to form a major subassembly. The composition of modules into major subassemblies is possible because there is great similarity between circuits and parts of circuits in modern equipment.

Electronic assemblies consist largely of electronic tubes and arrays of simple parts, such as resistors and capacitors, which account for the mass of the individual parts and are also responsible for the bulk of the manual work in conventional production. These assemblies have been the chief target for redesign in the MDE system. In Fig. 3 are shown a typical assembly produced by conventional hand methods and an equivalent MDE-designed unit.

The production of modules and assemblies, designed in accordance with the MDE system, is achieved mechanically; the process is termed MPE for Mechanized Production of Electronics. Non-critical raw materials are used for the most part. Ceramic wafers, 7/8 ins. square by 1/16 in. thick, are produced directly in quantity from the raw ingredients. Ceramic capacitors are produced in a similar fashion. Another part of the line produces adhesive tape resistors.

FIG. 1, BELOW: EXPERIMENTAL PRODUCTION PLANT FOR MPE ASSEMBLIES

FIG. 2, LEFT: CERAMIC WAFER ON WHICH IS MOUNTED THE INDIVIDUAL CIRCUIT COMPONENTS, AND COMPLETED MODULE CIRCUIT SUBASSEMBLY

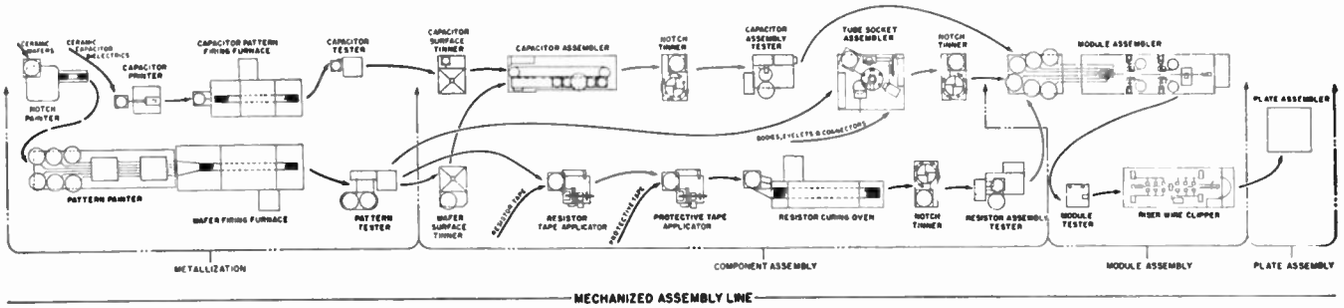


FIG. 4. DIAGRAM OF THE NBS-DEVELOPED COMPLETELY AUTOMATIC PRODUCTION LINE FOR MANUFACTURING AND TESTING CIRCUIT SUBASSEMBLIES

These and other basic parts are fed into the production line, shown schematically in Fig. 4. The appropriate circuits are printed by automatic machines. Circuit configuration is achieved through photographic processing; quality control is established by automatic inspection, directed by information prepared in punched card form. Special components, not suitable for printing techniques, can be incorporated into the modules. Automatic physical and electrical inspection is provided for in the production line.

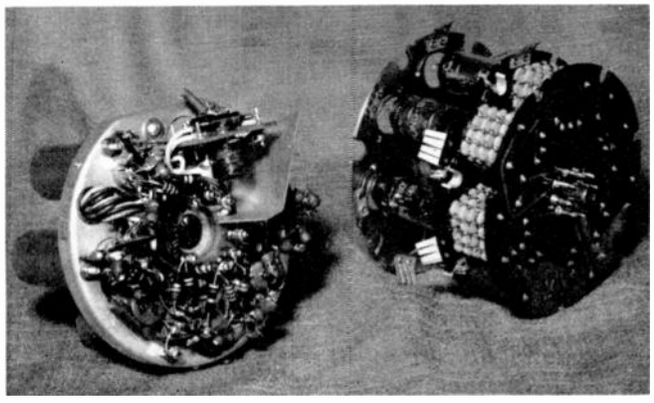
The system is based almost entirely on the use of bulk or semiprocessed materials, since the MPE line produces all the large-quantity parts except for the tubes. Joining modules together to form subassemblies can also be accomplished by machines. The pilot plant is designed for a production goal of 1,000 modules per hour.

Modular Design: In a system such as that described, flexibility of product and the general characteristics of conventional assembly methods are compatibly combined. At the same time, product standardization and uniformity — the prerequisites for economical processing by automatic machinery — are inherent in the system. Interconnection is relatively simple between any number of modular units. By combining modular assemblies containing different component parts, circuits can be developed to amplify signals, generate and shape waves, scale count, and perform conventional electronic functions.

In the MDE design system the conventional circuit diagram of the tested electronic model is dispensed with. All necessary production programming information is given on a work sheet. Each work sheet contains the front and back outlines of six wafers with appropriate numbering to identify each notch in the wafers, each riser wire, and the component (s) to be mounted on each wafer. The engineer translates his conventional wiring diagram to an MDE diagram. He indicates the position of the piece and its proper value and tolerances. Lines are drawn to indicate how the circuits between wafers are to be connected.

FIG. 3. BELOW: CONVENTIONAL HAND-ASSEMBLED UNIT, MPE COUNTERPART

FIG. 5, RIGHT: CERAMIC WAFER MOLDING MACHINE WHICH CAN OPERATE AT THE RATE OF 2,800 PIECES PER HOUR. WAFERS MUST THEN BE CURED

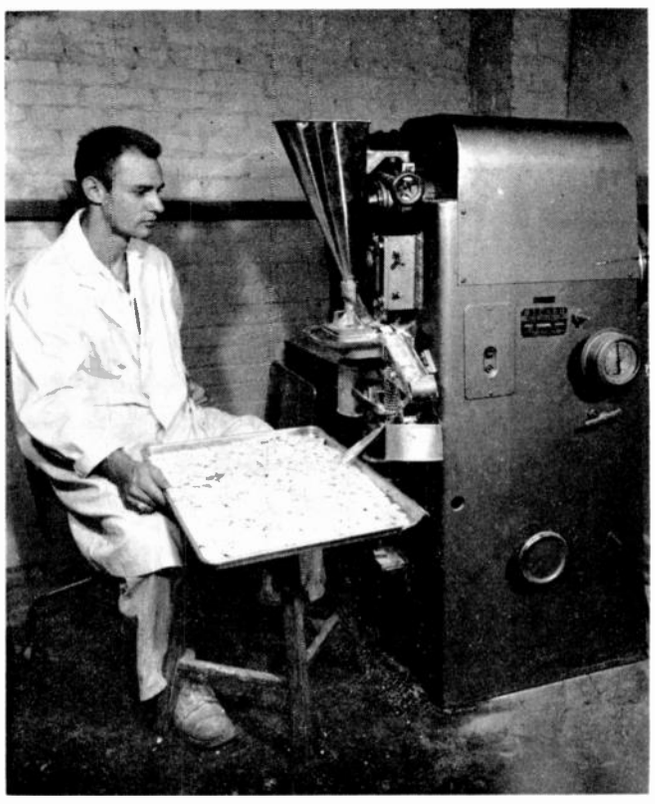


The engineer's work sheet becomes the basic document from which a draftsman makes an ink drawing that can be reproduced in large numbers. The draftsman prepares also a larger version of the work sheet that is photographed and subsequently used to make stencils for the circuit-printing machines. The numbers of wafers and the tube sockets listed on the work sheets give an indication of the quantity of raw ceramic materials that must be mixed. The number and value of resistors marked on the work sheets determine the required production of tape resistors.

The work sheet is used also to establish the inspection procedure. Current paths on each wafer are marked on punch cards. These cards accompany the wafers through all the manufacturing processes. Finally, the sheet is used in the construction of the standard modules or counterparts that are employed in final testing and inspection.

Mechanized Production: The MPE process consists of the mechanized production of ceramic wafers, titanate capacitors, and tape resistors, as well as their automatic assembly and inspection. In some military equipment a single chassis may have as many as 100 resistors and 100 capacitors. Facilities of the pilot plant provide for the manufacture of nearly all these pieces from raw materials.

Steatite wafers and tube sockets are processed from talc, kaolin, and barium titanate. After thorough mixing, milling,



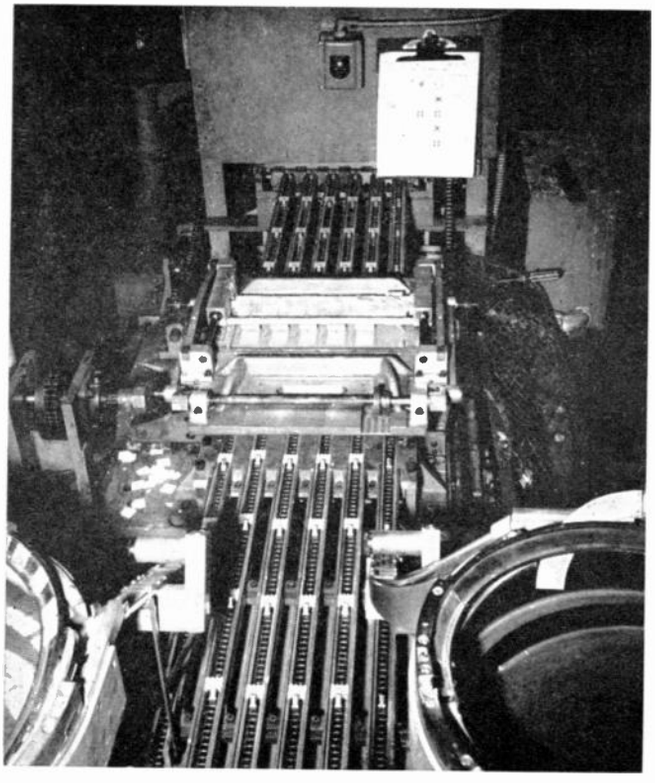
and drying, the pieces are stamped out at about 2,800 per hour by the machine shown in Fig. 5. They are cured at 2,300° F. in a tunnel kiln. Then, the pieces are mechanically gaged; all that do not conform to close tolerances are rejected.

The standard wafer is pressed with 12 peripheral notches (three on a side) and a keying notch on one side. In the final module assembly, riser wires are soldered automatically into the twelve notches, and serve as physical supports for the module as well as electrical connectors between wafer-mounted circuits. The keying notch is a medium by which individual wafers are machine-oriented for the application of component parts.

Titanate capacitor bodies are manufactured in much the same manner as the ceramic wafers. The capacitor is a nonporous ceramic composed usually of magnesium, barium, calcium, and strontium titanates of high purity, with organic binders and water. After firing, it is about ½ in. square and 1/50 in. thick. Capacity values can be varied from 7 mmf. to .01 mfd. by changing the relative proportions of the constituent minerals. Raw material batches weighing about five pounds will produce about 100,000 capacitors.

Materials required for the manufacture of tape resistors are a heat-resistant asbestos paper tape known as Quinterra, polyethylene tape, carbon black or graphite, resin, and a solvent. The resistor formulation — a mixture of the carbon, resin, and solvent — is ground to a fine adhesive powder. The compound is then sprayed on a loop of Quinterra tape, and a protective coating of polyethylene tape is applied. The tape is slit into five or six narrow strips and stored on rolls in a refrigerator. A 75-ft. roll of tape makes over 10,000 resistors. The tape resistors produced have a range from 10 ohms to 10 megohms, will hold rated resistance within ± 10% up to temperatures near 200° F., and are capable of ¼-watt power dissipation at the operating temperature.

Metallizing is the name given to a series of operations in which appropriate sections of the wafer or capacitor body are silver-painted. During these operations circuits are printed on the wafers, notches are coated, conducting surfaces and leads are applied to capacitors, components are furnace-cured, and circuits are inspected. Finally, all silvered surfaces receive a thin coating of solder. All the operations are mechanized.



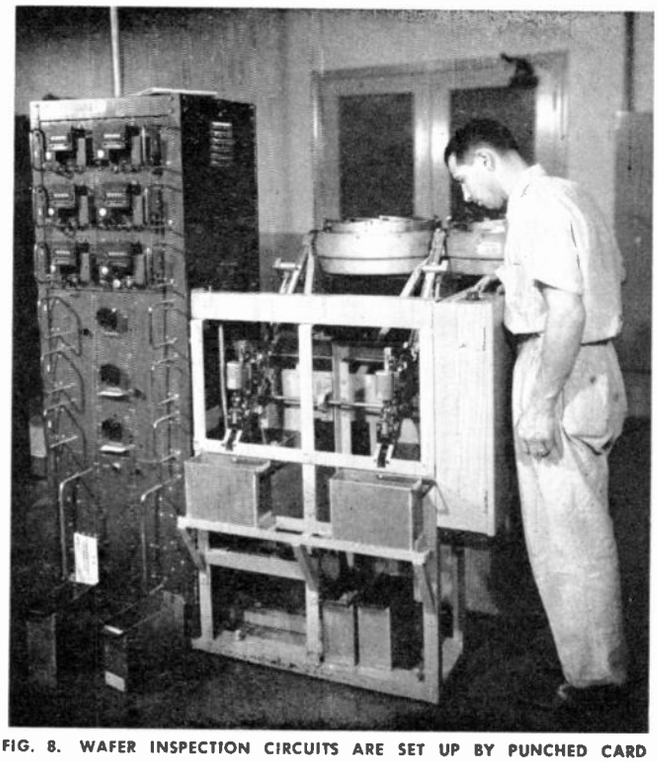


FIG. 8. WAFER INSPECTION CIRCUITS ARE SET UP BY PUNCHED CARD

Fig. 6 is a view of a wafer pattern printer. As the wafers are issued from a vibratory feeder in the foreground, they pass under a stencil screen bearing circuit patterns for up to six wafers. Patterns are printed simultaneously with the appropriate silver conducting circuit. The paint is dried partially in the oven visible in the background and the wafers are inverted. The unprinted surfaces are then exposed under another stencil screen bearing appropriate circuit patterns. Patterns are then physically and chemically bonded to the wafer surfaces in a curing furnace.

The keying notch pressed into each wafer is used initially during the metallizing operation. Wafers are loaded into vibratory bowl feeders, Fig. 7, which have spiral escape channels. A series of four exit ports followed by steps are set into the channels. A small screw is inserted into each exit port that permits only those wafers to pass on which the key is aligned with

FIG. 6, LEFT: WAFERS ARE PRINTED ON BOTH SIDES IN THIS MACHINE
FIG. 7, BELOW: A VIBRATORY BOWL FEEDER WHICH ORIENTS THE WAFERS

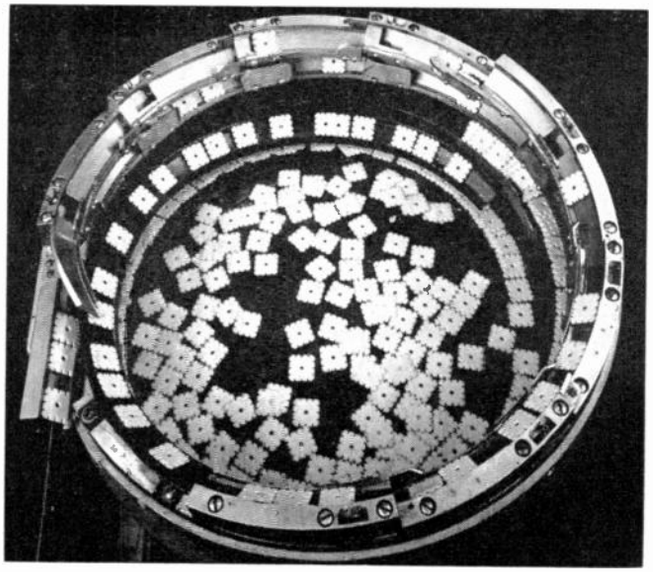


FIG. 10. ONE OF THE AUTOMATIC FACTORY'S SURFACE TINNING MACHINES

the screw. If the wafer is incorrectly oriented, it is turned 90° as it falls down the channel step following the exit port. A grooved channel inverts the wafer if it fails to pass through the other four ports, and the keying procedure is repeated. Consequently, all wafers passing from the feeders are oriented in the same direction and have the same surface turned upward.

Another feature of the vibratory bowl feeders is the mechanism that controls the quantity of wafers being issued. The issuing channel is provided with a photoelectric cell that functions only if the light path is completed. If the channel is not filled with wafers, the completed photocell light path energizes the circuit, causing the bowl to vibrate. When the channel is full, the bowl stops vibrating and, therefore, stops issuing wafers.

Inspection of pattern-printed wafers can be seen in Fig. 8. The appropriate inspection circuit is programmed by a punched card, which accompanies the particular batch of wafers from its initial printing up to its final assembly into a module. Wafers are loaded into a vibratory feeder which issues them to an inspecting device that checks and accepts those wafers bearing the proper conducting circuits.

Tape resistors, titanate capacitors, tube sockets, and other miniature parts are mounted on the wafers between the appropriate silvered conducting patterns. Rolls of resistor tape are fed to a machine that cuts the tape into ½-in. lengths, presses the resistors between the printed electrodes on the surface of the wafer, applies pressure, and ejects the completed resistor-mounted wafer. As many as two resistor tapes can be applied to each wafer surface.

A single machine is used to mount up to two capacitors on each surface of a wafer. Each capacitor is oriented and the silvered circuit on each surface is tested electrically before mounting. For example, if four capacitors are to be mounted on a wafer, the first two are dropped into a conveyor-driven jig. They are followed by a slave that centers the capacitors, and the properly-oriented wafer is added. The remaining two capacitors are dropped on top of the wafer. The jig is conveyed through a pair of induction heaters that cause the tinned surfaces on the parts to bond. Fig. 9 gives one view of the capacitor-wafer assembling machine.

In the tube socket assembler, silvered tube pins are set mechanically into the proper holes in the steatite tube socket, a wafer is placed on top of the socket, and a rivet binds the two pieces together.

After the various parts have been mounted on the wafers, the notches on the wafers are tinned with solder. The machine for this purpose grips each component-mounted wafer and dips one side into flux and solder. The tinning operation is repeated on the other three sides after successive 90° turns of the wafer. This operation is shown in Fig. 10.

Uniform component parts, including wafer-mounted coils, toroids, potentiometers, and crystals, can then be assembled. The complete assembly of the module is accomplished in a single machine, Fig. 11. Six vibratory feeders issue the wafers to a loading device that holds the wafers in an upright position between sets of jaws. A chain drive carries the jig to a soldering position at which six riser wires are guided into appropriate

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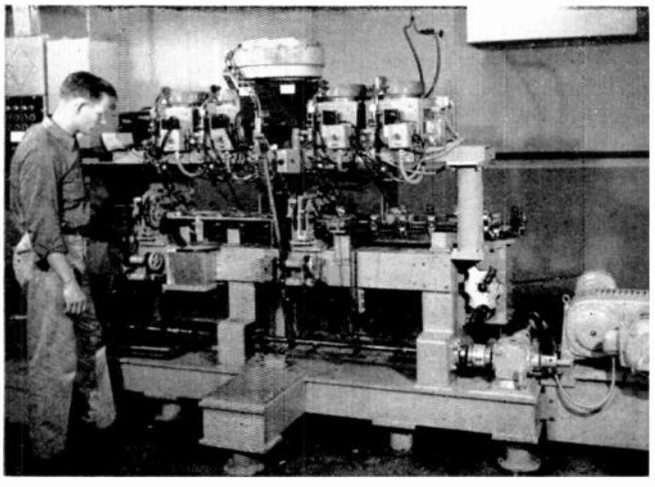
FIG. 9, BELOW: THIS MACHINE BONDS UP TO 4 CAPACITORS ON A WAFER
FIG. 11, RIGHT: PART OF THE MODULE ASSEMBLY SECTION OF MPE PLANT



COMMUNICATION REVIEW

THE Associated Police Communication Officers adopted a resolution at the recent annual meeting in Detroit concerning AT&T's statement of policy with regard to interconnection of Telephone Company facilities with private or municipal communication systems. It will be recalled that the offer was made to purchase such systems, where practicable, and to lease them to the original owners. Apco's resolution called on the International Association of Chiefs of Police to "take cognizance of this nation-wide and concerted . . . effort by . . . 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 best of their ability and in the best interests of police administration."

Thus, as expected, reaction to AT&T's proposal has been swift, universal, and (for the most part) condemnatory. Reasons for this attitude are not hard to unearth, and the major ones are not selfish in nature.[1] The danger is that it will appear to be an attractive offer to some supervisors of vital systems having maintenance difficulties. Indignation is running high because a well-known southeastern municipal system has already been turned over to Southern Bell.

ON October 13, Major Armstrong, assisted by John Bose, delivered a highly significant paper on multiplex FM transmission before a joint meeting of the Radio Club of America and the Audio Engineering Society at Columbia University. This was accompanied by a striking demonstration of reception from station KE2XCC at Alpine, N. J., and tape recordings made under test conditions.

While the paper was concerned mainly with FM broadcasting of two different programs, or two channels for binaural reception, this development furnishes the means to provide new communication services.

Stated simply, it is now possible for an FM broadcast station to handle one or two voice communication channels without interfering with its regular 15,000-cycle broadcast program. Since FM transmitters are of substantially higher power than those used for communication, and have high-gain antennas of substantial height, most of them can provide solid coverage over a radius of 50 miles or more over rough terrain, and upwards of 75 miles in flat country.

This added facility is too new for the FCC to have given it any formal consideration yet. However, since it opens up the possibility of adding two communication channels at each of some 650 FM transmitters without the slightest interference with broadcast service, it is certain that the Commission will welcome this development as a means of relieving congestion in the safety and special services. Moreover, it opens up possibilities for new types of systems or services because of the enormous coverage obtainable. Such a station as WMIT, for example, can deliver solid coverage over an area of nearly 100,000 square miles.

Consider how advantageously two long-range channels could serve a manufacturing company that had plants and offices in outlying sections of a city where there is an FM station. One channel could be used for communication with company cars and trucks, while the other could be free to serve for special messages and paging.

Probably Major Armstrong used two broadcast programs for demonstration purposes because they provided the most severe test of his method of multiplexing. It is a relatively simple matter to substitute two narrow-band voice channels for the second 8,000-cycle program channel.

Under 15,000-cycle modulation on the first channel, and 8,000 cycles on the second, the signal-to-noise ratio was better than 70 db with 1 millivolt at the input of the receiver. Cross modulation in the second channel from the first was better than 60 db below the program on the second channel. The effect of the second on the first was insignificant.

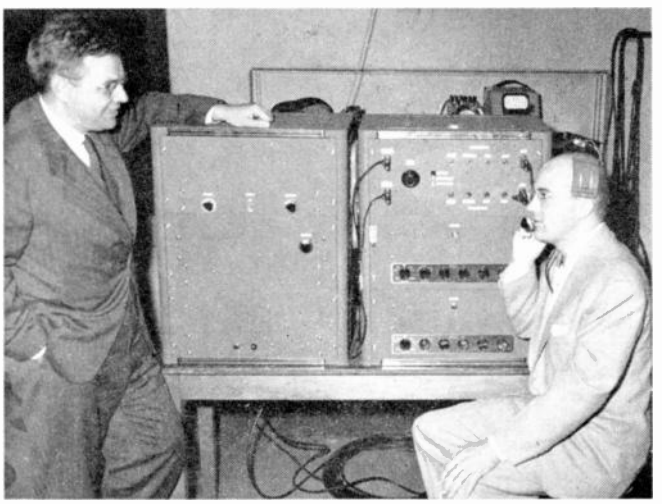
FM broadcasters will surely welcome proposals to add such communication services, as a means of obtaining additional revenue. It is reasonable to expect, therefore, that Major Armstrong's latest contribution to the radio art will soon materialize in various commercial, profit-making forms.

APROPOS FM broadcasting and the FCC, Commissioner Edward M. Webster said in September, "If the broadcast industry does not take some steps to increase the utilization of the FM frequencies, I have no hesitancy in stating that I would have difficulty in finding it in the public interest to retain all of the 88 to 108-megacycle band for FM broadcasting in the event the Commission is petitioned to reallocate a portion of the band to accommodate new services or to relieve the congestion in existing services.

"The figures, I believe, clearly indicate that efficient usage of the 88 to 108-megacycle FM band is not being made by the broadcasting industry. Therefore, any radio service which is not making efficent use of its available frequencies is, in my opinion, in a somewhat untenable position with respect to justifying its right to retain all the frequencies allocated to it.

"In view of the figures previously mentioned, I fear that the FM broadcast service may find itself in such a position in the face of the constant demand for additional frequencies by the non-broadcast services already authorized, as well as demands for the establishment of new services which would also require additional frequency allocations. Many of the established services are operating under extreme conditions of frequency congestion, and additional spectrum space for those services could provide for more efficient operation and per-

[1] See the extensive discussion of this matter in *Communication Review*, last issue of COMMUNICATION ENGINEERING.



EQUIPMENT FOR 2-CHANNEL TRANSMISSION ON BROADCAST FM CARRIER

haps a broader scope of permissible communications." Certainly, food for thought. Current general opinion is that part of the FM band would be ideal for reallocation of present 72 to 76-mc. assignments.

ACCORDING to a report by the FCC Safety and Special Radio Services Bureau, applications will be processed on an immediate basis by the Bureau by January. But when applications require special handling, there will still be some delay. These include appulications for facilities not in accordance with the Rules, those which must be designated for hearing, those which conflict with government assignments, those which must have an aerial survey, those for experimental frequencies, those for STA's, and those specifying equipment not on the approved list. Currently, 450-mc. applications involve some delay because they are checked by the engineering staff.

IN a paper given at the Fall General Meeting of the AIEE W. M. Runt, Jr. described the petroleum industry's radio communication problem in eye-opening terms. Difficulties stem primarily from the fact that 47% of the industry's transmitters are concentrated in four States — Texas, Louisiana, Arkansas, and Mississippi — and most of these are in an area 75 miles wide along the Louisiana Gulf Coast.

In the NPRFCA alone there were over 550 radio user-members, with 21,400 transmitters, as of June 30. A typical system consists of a base station and 100 mobile units. Statistics show that the daily 8-hour message traffic is between 800 and 900, with a call every 30 seconds during peak loads. According to Mr. Rust, continual expansion must entail channel-splitting and time-sharing; even so, only the fullest cooperation between users can prevent severe service degradation.

Most technical conventions and meetings are so preoccupied with TV and computer papers that communication problems get short shrift. Thereby, the annual meeting of the IRE Professional Group on Vehicular Communication assumes additional importance. Theme of the meeting on November 12 and 13 at the Somerset Hotel, Boston, is "Design, Planning, and Operation of Mobile Communications Systems." Chairman of this year's meeting is P. R. Kendall. The program follows:

FIRST SESSION — Moderator, Beverly Dudley, Chairman Boston Section, IRE.

1) "Address of Welcome," by the Moderator.

2) "Integrating Microwave and Mobile Radio Systems," by J. R. Neubauer, RCA.

3) "A Commissioner's Reflections on the Mobile Radio Service," by E. M. Webster, Commissioner, FCC.

LUNCHEON — Keynote address by The Honorable Donald S. Leonard, Commissioner of Police, Detroit, Mich.

SECOND SESSION — Moderator, Waldo A. Shipman, Chairman National PGVC.

4) "Duplex and Multi-Channel Mobile Equipment," by W. Ornstein, Canadian Marconi.

5) "Mobile Radio System Performance in the United States Forest Service," by W. S. Claypool, U. S. Dept. of Agriculture.

6) "Electronics in Action," film by Raytheon.

7) "The Knee of the Nose," by R. P. Gifford, General Electric Company.

8) "Maintenance of Mobile Equipment," by M. G. Steele, New England Telephone Company.

THIRD SESSION — Moderator, Frederick T. Budelman, Past Chairman, National PGVC.

9) "Portable Equipment in Communications Systems," by W. J. Weisz, Motorola.

10) "Mobile and Fixed Radio Relay Operation in the Power Radio Service," by G. E. Dodrill, Rural Electrification Association.

11) "Problems in Maintenance and Operation of Long-Haul and Distribution Radio Networks," by D. E. York, United Fuel Gas Company.

12) "Planning and Operation of the Erie Railroad Main Line Radio Communications System," by W. J. Young, Erie Railroad.

FOURTH SESSION — Moderator, Robert W. Lewis, Chairman Boston Chapter, PGVC.

13) Discussion and question period.

Copies of the proceedings will be available from the PGVC.

A gentle warning to the entire industry came from Edwin L. White, Chief of the Safety and Special Services Bureau, speaking before the IMSA in Columbus, Ohio. Colonel White said that frequency coordinating committee recommendations may have to be reexamined; that some committees "are taking the easy way out and are approving all requested assignments without study;" that one committee had approved a request "apparently without investigation, to use a busy frequency, even though there was an idle frequncy available in the area."

CHESTER GOULD, CARTOONIST-CREATOR OF DICK TRACY AND HIS 2-WAY WRIST RADIO, IS SHOWN MOTOROLA HANDIE-TALKIE BY DANIEL E. NOBLE

The damage such practices can do to orderly, efficient utilization of the precious spectrum cannot be overstated. Rectification lies best in the hands of the presently responsible parties — the organized radio user associations.

REPRESENTATIVES of the petroleum, railroad and utilities industries and the RETMA Microwave Section will meet December 2 and 3 at San Antonio to prepare a final draft of recommended rules on microwaves for submission to the FCC. It is probable that the recommendations, which may be submitted by January 1, will be general and will include the suggestion that licenses be issued for systems rather than individual stations.

Microwave Multiplex Techniques

HISTORY OF MULTIPLEXING — BASIC MULTIPLEX METHODS — DETAILS OF FREQUENCY DIVISION TECHNIQUES — SIGNALING — *By* E. J. RUDISUHLE*

THE era when a radio communication circuit consisted of a single-channel point-to-point system came to an end some time ago. The luxury of a single channel over each transmission path can now be afforded only in certain special cases, such as on mobile radiotelephone and ship-to-shore systems. In commercial applications, whether used by telephone and telegraph utilities or in private industry, almost every point-to-point communications system must be capable of carrying many channels.

Modern communication systems yield high-quality circuits for telephony, telegraphy, and telemetering. The demand for these circuits is constantly increasing, and the communication engineer must continually find better and more economical means to provide them.

Typical examples of the extent to which transmission paths can now be multiplied in usefulness can be seen in the telephone industry, wherein one pair of wires is made to provide as many as 16 telephone channels, two cable pairs are made to carry up to 24 channels, and a microwave radio system can be made to furnish as many as 1,800 channels. Maximum use is achieved also in the armed forces, where logistic considerations require a great number of communication circuits with a minimum of equipment.

Economic factors frequently dictate the use of multiple circuits on another type of transmission medium, such as those employed in the electric power field. High-voltage power lines are often used to provide several voice communication circuits. These channels can be further subdivided to supply telegraph channels or a number of telemetering circuits for controlling and metering in the system. Because communication engineers, radio supervisors, and maintenance technicians are becoming more concerned with multi-channel point-to-point systems, particularly microwave circuits, this article deals with the basic methods and techniques of multiplexing as applied to such carriers.

History of Multiplexing: Multiplexing of communication circuits is accomplished primarily with two basic types of

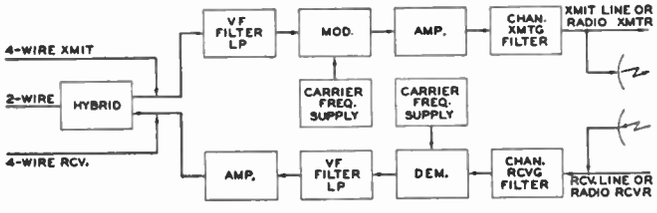


FIG. 1. DIAGRAM OF TYPICAL FREQUENCY DIVISION MULTIPLEX SYSTEM

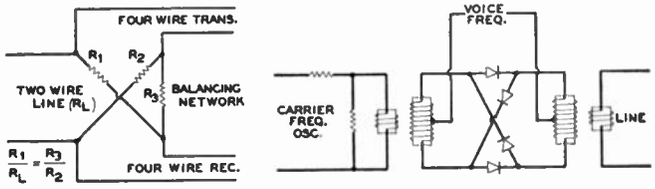
equipment. The best-known and oldest method is frequency division, wherein each voice-frequency band is superimposed on a selected carrier frequency above the audible range. By using a number of different frequencies and a system of filters, many voice channels are thereby obtained in the available frequency spectrum. The other common method is time-division, by which short-duration samples of each signal are transmitted at a rapid rate.

Frequency division multiplexing has been in use since the 1880's, when a number of pioneers — notably Elisha Gray, Pupin, Leblanc, John Stone Stone, and Hutin — were experimenting with vibrating-reed types of equipment in an effort to supply more than one telegraph circuit on a single pair of wires.

These early primitive circuits used tuning forks to supply carrier frequencies for both modulation and demodulation. Later, magnetic-core receivers were employed; in one of the early experiments, an electrolytic demodulator was employed.

Invention of the wireless diverted much of the best engineering and creative talent to radio. However, in 1910 and 1911 Major (later Major General) G. O. Squier of the U. S. Army Signal Corps demonstrated a successful telephone carrier system operated over a short cable circuit.

Since Squier's research, the history of frequency division multiplexing has been closely associated with that of the commercial telephone industry. The Bell Telephone System and later its Laboratories were responsible for the major develop-



FIGS. 2 AND 3. HYBRID NETWORK AND A BALANCED MODULATOR CIRCUIT

ments in the field. The use of vacuum tubes in amplifier, modulator, and demodulator circuits, development of modern filter theory, solution of a number of critical line transmission problems, and the design of the first commercial frequency division multiplexing or carrier system were all Bell developments.

The first commercially-practical carrier circuit, a laboratory model, was tested in 1914 and proved itself in a South Bend, Indiana to Toledo, Ohio test circuit. This was followed rapidly by development of standard commercial equipment for use throughout the American Telephone & Telegraph Company's long distance systems. In 1921 this commercial equipment was being installed on open-wire pairs to provide an additional three channels of telephone communications. By 1928, several transcontinental carrier circuits were in operation along with many shorter circuits between such points as Chicago and Pittsburgh and between San Francisco and Los Angeles.

By 1933, development had proceeded far enough to permit design of 12-channel transcontinental cable carrier systems. Economic factors in the early 1930's delayed their use, but by 1938 the first such systems were in commercial operation.

Two trends in the design of modern carrier systems are significant. First is the use of compandors (dynamic range compressors and expandors) to improve signal-to-noise ratios and to permit certain relaxations in design requirements. Second is the miniaturization of systems demanded by the increasing need for additional toll circuits and the associated problem of housing the equipment.

Characteristics: Frequency division systems have a number of advantages, especially for telephone circuits and other installations where the channelizing equipment must fit into an already-existing communication network.

One of the most important advantages of frequency division is the comparatively narrow transmission bandwidth re-

*Engineering Representative, Lenkurt Electric Company, San Carlos 1, Calif.

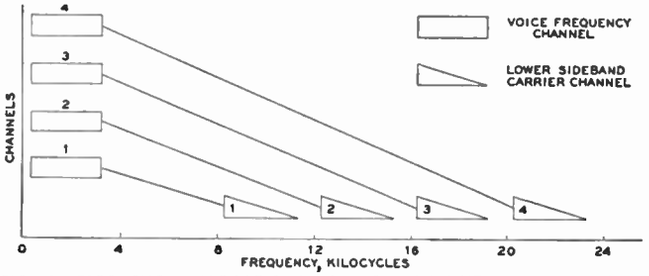


FIG. 4. FREQUENCY ALLOCATIONS FOR FOUR-CHANNEL CARRIER SYSTEM

quired. Single-sideband frequency division systems can supply a voice channel 3,400 cycles wide in 4,000 cycles of bandwidth. This narrow bandwidth permits extensions of frequency division systems on cables and open-wire lines without bringing each channel down to voice frequencies.

The narrow bandwidth is advantageous also in microwave channels for which the bandwidth is limited. Some radio allocations are already severely limited in bandwidth by the FCC, and it can be expected that other allocations will be similarly limited as their use continues to grow.

A second important advantage of frequency division systems is the greater number of channels possible. The maximum number of frequency division channels is limited only by the available transmission spectrum. In addition, frequency division systems are generally easy to operate and maintain, particularly by personnel already trained in voice-frequency equipment.

Frequency division systems differ in the types of signals they produce. Some types transmit the carrier and both sidebands. In other systems, one sideband is suppressed and the carrier is transmitted for signaling and synchronization. In the most common systems, however, the carrier and one sideband are suppressed; only one sideband is transmitted.

The last type has a number of advantages. One factor is the amount of power required to transmit the intelligence. In amplitude modulation systems, the carrier represents two-thirds the total power and the sidebands, which include all the intelligence, one-third the power. Thus, by eliminating the carrier and one sideband, the intelligence can be transmitted with only one-sixth the power. This results in more efficient loading of the radio system or other transmission medium. It also permits transmission of the sidebands at a higher level, which results in greater discrimination to noise.

The most significant advantage of single-sideband systems, however, lies in the economy of frequency spectrum they provide. Twice as many channels can be accommodated in a given bandwidth with single-sideband as are possible with double-sideband systems. The following discussion, accordingly, will be based on the single-sideband frequency division system.

General Design: Primary component of a frequency division multiplexing system is the channel unit. Design of this, as well as that of the entire carrier system, is based on the principle of dividing the spectrum into frequency bands by means of filters.

Studies have shown that a frequency bandwidth of approximately 2,500 to 3,000 cycles is adequate for transmission of normal spoken intelligence. Channel filters, therefore, are designed to pass only this frequency band. In the illustrations following, a voice frequency band from 200 to 3,200 cycles is assumed.

Each of the voice channels modulates a different carrier which translates it to a channel above the 3,200-cycle range. In multiplexing systems, the subcarrier frequencies usually range from just above the highest frequency in the voice band to the practical upper limit of the transmission medium

FIG. 5. FREQUENCY-ATTENUATION CHARACTERISTICS OF MULTIPLEXING CHANNEL FILTERS USED IN TYPE 45A FOUR-CHANNEL CARRIER EQUIPMENT

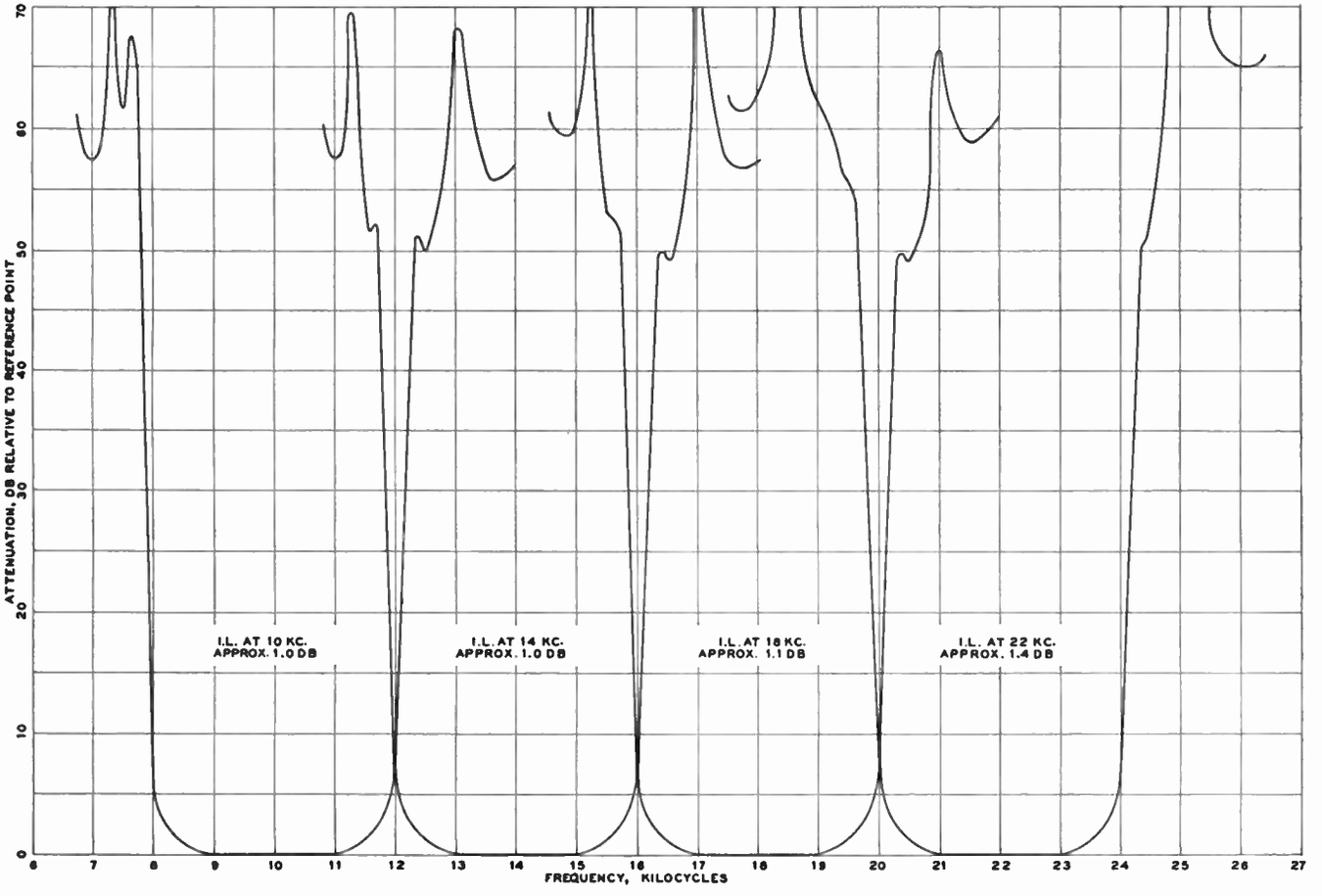
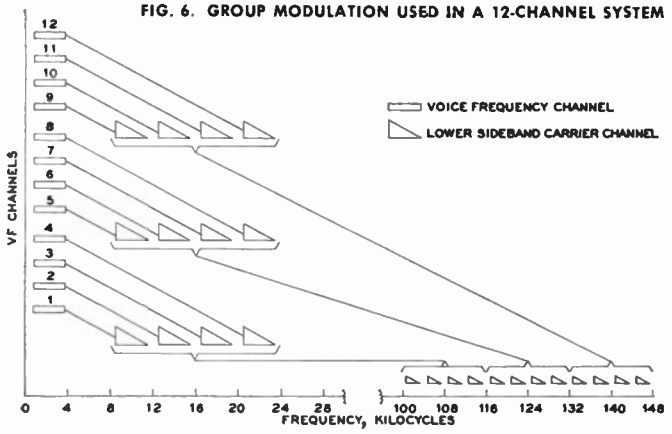


FIG. 6. GROUP MODULATION USED IN A 12-CHANNEL SYSTEM



(the highest permissible modulation frequency in microwave systems.)

A block diagram of a basic carrier channel is given in Fig. 1. As shown, the carrier channel can be connected to either a two-wire or a four-wire physical line. In telephone industry terminology, a two-wire line indicates that the same pair of wires is used for both transmitting and receiving. "Four-wire" indicates that one pair is used for transmitting and a second pair is used for receiving. Radio circuits, in telephone terminology, are considered four-wire circuits since separate equipment is used for transmitting and receiving. In telephone work cable circuits are generally four-wire systems, while open-wire lines are two-wire.

For two-wire operation different frequencies are assigned opposing directions of transmission. Frequency division systems for radio applications are generally four-wire types with the same frequency band allotted both directions of transmission. Separation of the transmission directions then takes place in the radio carrier frequency allocation.

Intelligence entering the carrier system shown in Fig. 1 goes first through the hybrid if the incoming line is two-wire. A schematic of a typical resistance hybrid for conversion of a two-wire circuit to four-wire is shown in Fig. 2.

From the hybrid, the incoming signal is sent through a low-pass filter designed to limit the intelligence to the chosen range, in this case 200 to 3,200 cycles. The 200 to 3,200-cycle signal is then applied to a modulator. A number of different types of modulation and modulators are used in various carrier systems. In this case, amplitude modulation employing a balanced ring modulator is used. This is the most common type of modulation now being used in carrier systems.

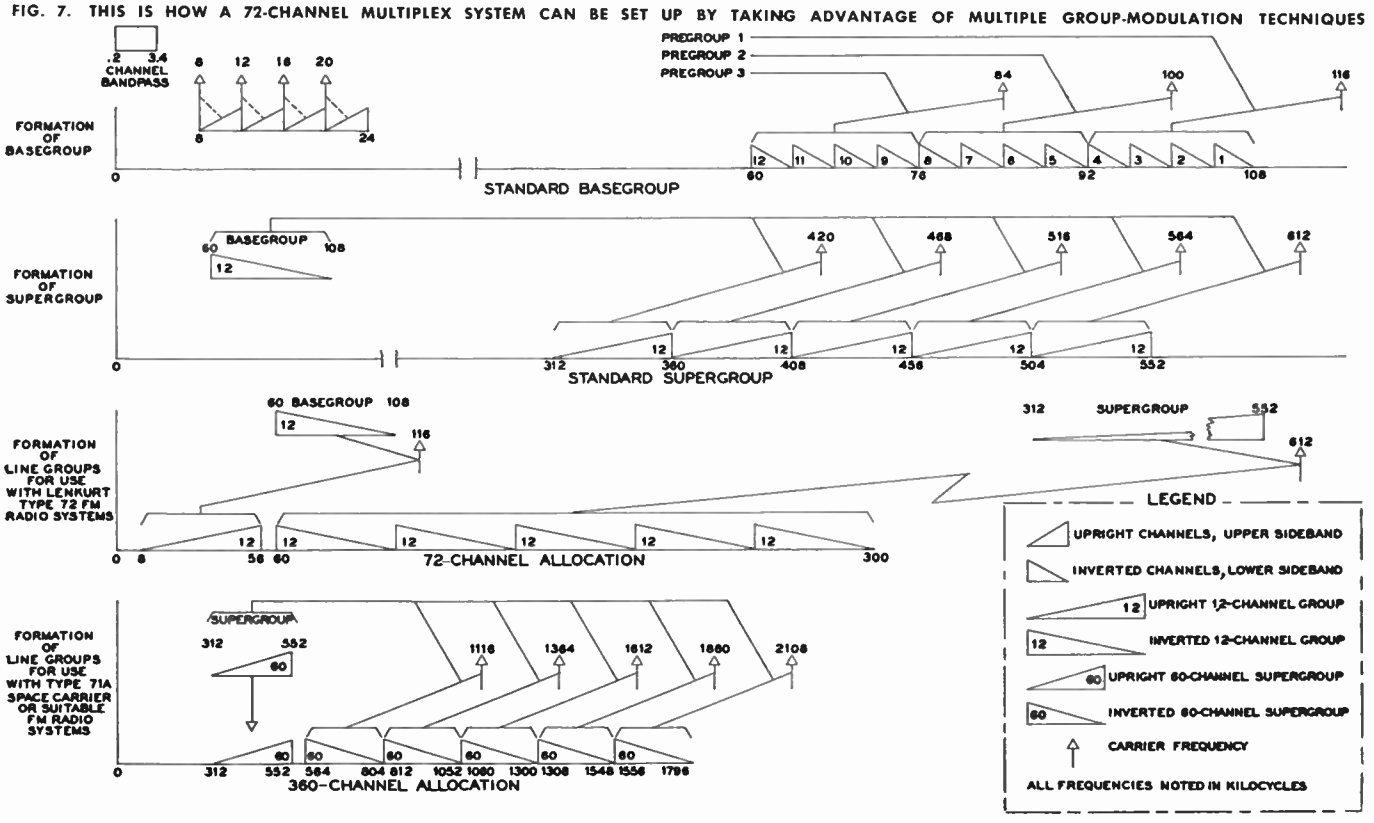
A typical balanced modulator used for a suppressed-carrier system is diagrammed in Fig. 3. Theoretically, the output of this modulator is only the upper and lower sidebands, the voice frequencies and the carrier frequency being balanced out. Practically, there is some carrier leak, but it is usually attenuated sufficiently that it does not affect the system.

Each voice-frequency channel modulates a different carrier, the frequency of which is selected in accordance with a standard allocation. A diagram showing the allocation for a simple four-channel carrier system is given in Fig. 4.

The output of the modulator, nominally only the upper and lower sidebands, is amplified and sent through a band-pass filter before transmission on the line or the radio system. The channel filter removes one of the sidebands, either of which may be transmitted. Typical attenuation characteristics of channel filters for the Lenkurt type 45A single-sideband, suppressed-carrier system for open-wire lines can be seen in Fig. 5. While the voice bandwidth is limited to 3,000 cycles, each channel carrier is separated by 4 kc. in this illustration. The difference between the voice frequency bandwidth and the channel carrier separation provides a guard band to reduce the possibility of interference between channels and to permit the introduction of signaling and pilot regulation tones.

In the frequency allocation diagram, Fig. 4, it will be noted that the lowest frequency containing voice intelligence is 8 kc. The frequencies between 200 and 8,000 cycles have two functions in radio multiplex systems. An order wire or service channel usually is assigned from 200 to 3,200 cycles. Signaling can be assigned to the 4 to 8-kc. band with all the

FIG. 7. THIS IS HOW A 72-CHANNEL MULTIPLEX SYSTEM CAN BE SET UP BY TAKING ADVANTAGE OF MULTIPLE GROUP-MODULATION TECHNIQUES



signaling tones for a 12-channel system accommodated therein. The modern trend in carrier system applications, however, is toward signaling associated with each voice band. When the 4 to 8-kc. band is not used for signaling, it may be assigned to telegraph tones or to control, alarm, and supervisory tones for the radio and carrier equipment.

advantages, chiefly in reducing the number of different units and in reducing the number of high-frequency components.

Lenkurt types 45 and 33C carrier systems are typical of those system which utilize group modulation to obtain many channels. Type 45D equipment, which in one frequency allocation provides as many as 72 channels for radio

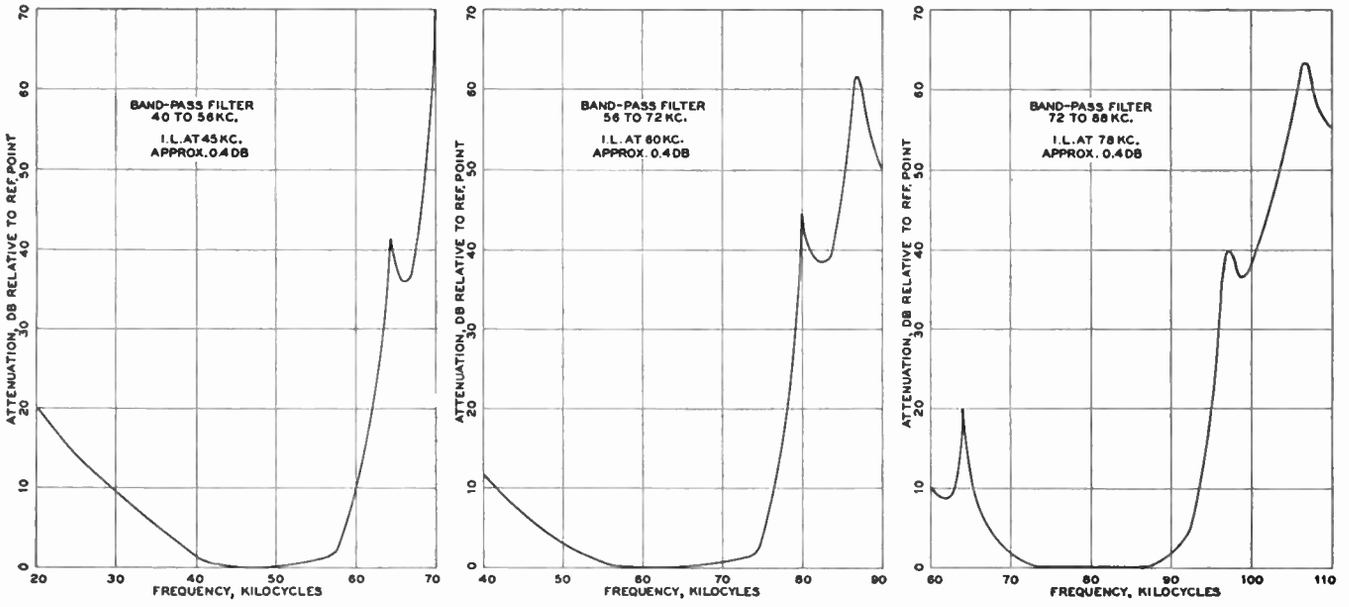


FIG. 8. BANDPASS FILTER CHARACTERISTICS FOR TYPE 45A PREGROUPS. SHAPE OF THE CURVE VARIES IN THE DIFFERENT FREQUENCY RANGES

The original 200 to 3,200-cycle voice-frequency intelligence, translated by the carrier to a higher frequency and amplified for transmission, forms one half of a communication circuit. In telephone terminology, this is a one-way circuit and may be referred to either as an east-west or west-east channel, depending on the direction of transmission. The other half of the circuit can be formed in exactly the same way, with equipment at the far terminal exactly duplicating that at the near terminal.

The receiving circuit for these channels is indicated on the diagram in Fig. 1. Incoming signals pass through a filter which rejects all frequencies except those associated with the given channel.

The frequencies from each channel filter are then applied to a demodulator, an exact replica of the modulator, and the voice-frequency intelligence which results is sent through a voice-frequency filter to eliminate the undesired sideband. The intelligence is then amplified and fed to the hybrid for transmission on the connecting voice-frequency circuit.

Since signals are modulated by one carrier and demodulated by another, it is important that carrier supplies be stable. Absolute synchronization of carrier frequencies, however, is not necessary. Modern carrier-frequency supplies, such as that used in type 45 equipment, are accurate to one part in a million. End-to-end frequency shift in the 45 system, therefore, is less than one cycle.

Group Modulation: The method of adding carrier channels in which each new channel requires new channel filter designs and a separate, new carrier supply is used when the number of channels does not exceed about 12. Beyond that point, a number of factors necessitate the use of a group-modulation process.

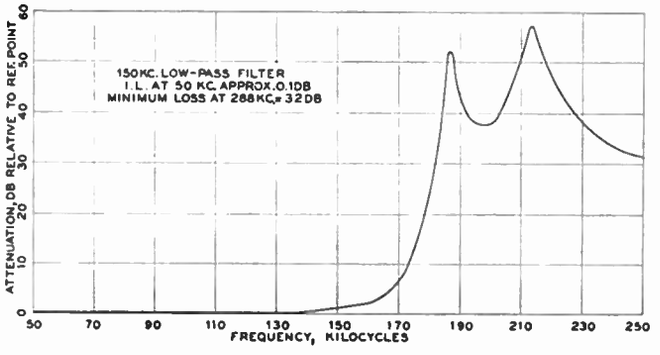
In group modulation a wide band of frequencies including the intelligence of a number of voice channels, formed by regular carrier methods, is used to modulate a new carrier. Any number of channels can be included in a group. The frequency allocation chart of Fig. 6 shows how group modulation can be used. Group modulation has a number of applications, repeats the group modulation process twice in forming the 72-channel band which modulates the radio carrier. Each voice channel is modulated to translate it to one of four pregroup positions between 8 and 24 kc. The pregroup containing these four channels is then group-modulated to place it in a standard basegroup containing twelve channels between 60 and 108 kc.

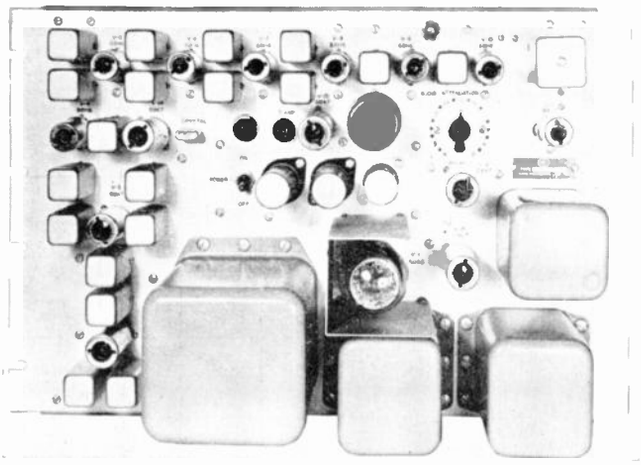
Each 12-channel basegroup is modulated with one of five carriers to create a supergroup with a total of 60 channels between 312 and 552 kc. In the last stage of the 72-channel allocation, the supergroup is translated to the band from 60 to 300 kc. and one basegroup is translated to the band from 8 to 56 kc., thus forming 72 channels between 8 and 300 kc. This sequence of translation is in accordance with international agreements. A diagram illustrating the process is given in Fig. 7. Attenuation-frequency characteristics of type 45A pregroup and basegroup filters are plotted in Figs. 8 and 9, respectively.

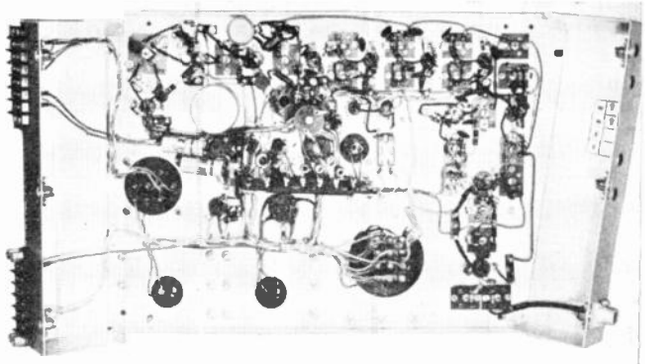
Lenkurt type 45D systems are designed especially for radio and operate on a true four-wire basis with identical frequencies used for both directions of transmission. Therefore, formation of the channels for the opposite path accompanying the 72 channels described above is identical.

Continued on page 40

FIG. 9. ATTENUATION CURVE FOR A 45A LOW-PASS BASEGROUP FILTER







FIGS. 1 AND 2. FRONT AND REAR VIEWS OF RACK-MOUNTED RECEIVER, WHICH INCORPORATES ITS OWN POWER SUPPLY ON THE SAME CHASSIS

150-Mc. Point-to-Point & Relay Units

WIDE-BAND FM EQUIPMENT OPERATING AT 150 MC. HAS BEEN DEVELOPED FOR VARIOUS MULTI-CHANNEL POINT-TO-POINT AND RELAY APPLICATIONS

IT is well known that point-to-point systems operating in the 150-mc. frequency range have certain distinct advantages with respect to those which utilize the higher frequencies. Depending on the specific application and the location of the system, these advantages often outweigh the limitations imposed on bandwidth by government regulations or by equipment factors. The equipment described here[1] was developed specifically for multi-channel point-to-point or relay applications in the 150-mc. band.

General Description: Type 755C equipment consists of an FM transmitter, a transmitter power supply, and a receiver which can be used as terminal or repeater units in multiplex point-to-point communication systems. Up to five voice channels or their equivalent can be handled by frequency-division multiplexing; voice, telegraph, telemeter, remote-control, and facsimile signals can be accommodated. Channelizing units are not supplied. Standard corner-reflector antennas are available, or the antennas can be custom-engineered for the specific application.

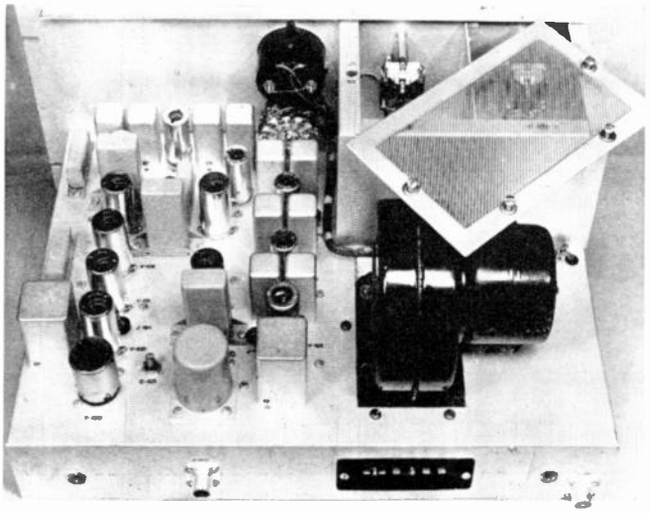
Operating frequency range of the equipment is 152 to 174 mc. System deviation is ± 50 kc. for 100% modulation; this is adjustable on special order. Modulation frequency response is ± 1 db from .2 to 20 kc., and amplitude distortion is 1% from .2 to 10 kc. Intermodulation is —46 dbm for A-B test tones between .2 and 20 kc.; modulator noise is —60 dbm per 3-kc. interval from .2 to 20 kc., with receiver input more than 65db below 1 watt. Modulation input is —20 dbm, and modulation output is 0 dbm test tone level. Thus, the system is suitable for telephone company use, where such operation is authorized.

Allowable space loss between transmitter and receiver terminals is 115 db for a 50-db signal-to-noise ratio per 3 kc. channel. This can be increased by using a type 747 RF amplifier, which has an output of 100 watts.

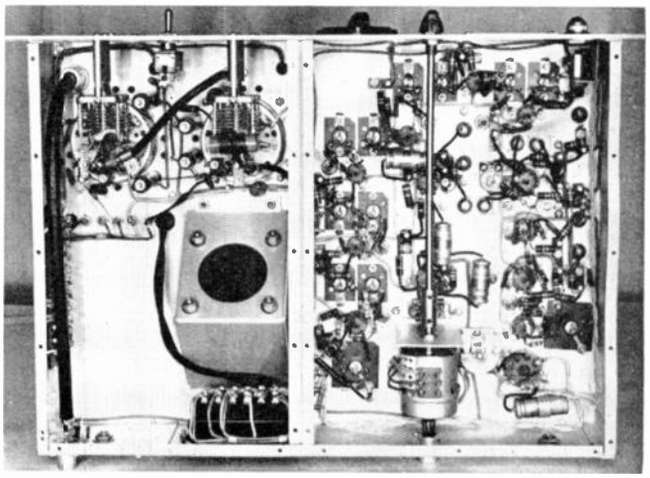
Primary power input is 115 volts, 50 to 60 cycles, single-phase AC at 415 watts. If the 747 amplifier is used the total power requirement is increased to 765 watts.

All units are built on standard 19-in. rack panels. The transmitter modulator and power output panel is 8¾ ins. high; the transmitter power supply panel is 15¾ ins. high, and the receiver panel is 12¼ ins. high. These units fit in an open-front cabinet with a rear door. Overall dimensions of the cabinet are 42¾ ins. high by 23¼ ins. wide by 19 ins. deep.

[1]Manufacturer: Radio Engineering Laboratories, Inc., 36-40 37th Street, Long Island City, 1, N. Y.



FIGS. 4 AND 5. TOP AND BOTTOM OF THE 755C TRANSMITTER CHASSIS



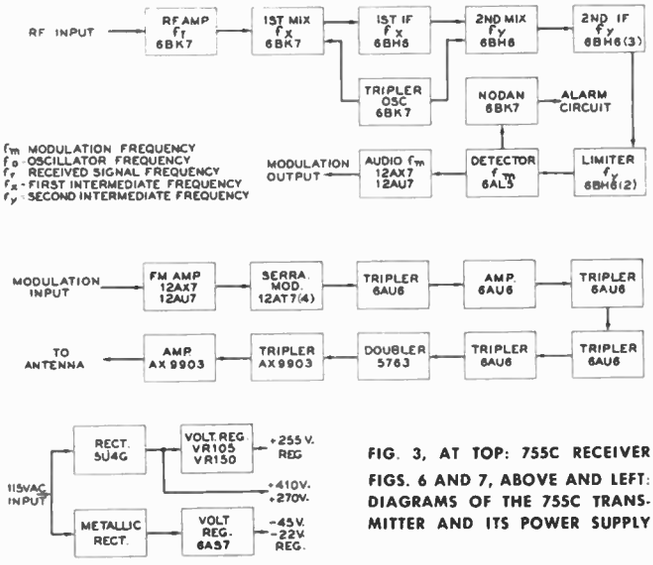


FIG. 3, AT TOP: 755C RECEIVER FIGS. 6 AND 7, ABOVE AND LEFT: DIAGRAMS OF THE 755C TRANSMITTER AND ITS POWER SUPPLY

Receiver: Front and rear views of the receiver chassis are given in Figs. 1 and 2. The circuit is a double-IF single-frequency crystal-controlled superheterodyne, as the diagram in Fig. 3 shows. Threshold signal is 135 db below 1 watt, or about 1.6 microvolts. A 6BK7 used in a NODAN (Noise Operated Device Anti-Noise) circuit furnishes an alarm signal when the input signal drops below a given value.

Input impedance is 50 ohms; output is 600 or 150 ohms.

Transmitter: Four 12AT7's are employed in a Serrasoid phase-shift modulator. Oscillator multiplication is 486, so that the original oscillator frequency is about 330 kc. Because such a low frequency is used, the peak deviation capability of the transmitter is 120 kc., and when it is limited to 50 kc. or less the distortion is negligible.

Top and bottom views of the transmitter proper appear in Figs. 4 and 5. A blower is used to cool the AX9903 tubes used in the tripler-driver and final amplifier stages; the transmitter and transmitter power supply circuits are shown in Figs. 6 and 7. Power output is 25 watts nominal. The modulator input impedance is 600 or 150 ohms.

Front, top, and bottom views of the 747 power amplifier are given in Figs. 8, 9, and 10 respectively. This is basically a 100-watt push-pull output stage employing a pair of 4X-150A's. The power supply is on a separate chassis.

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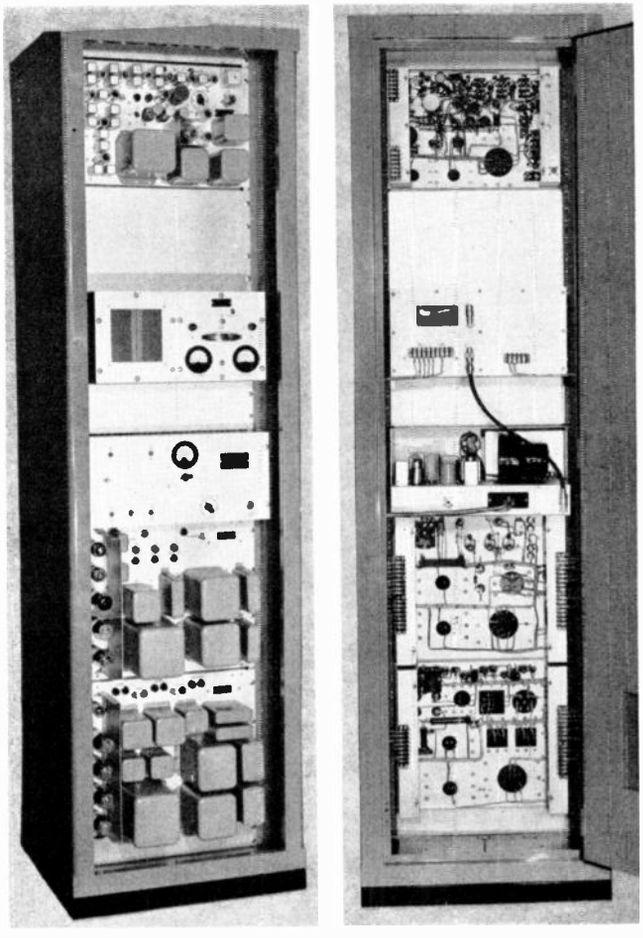
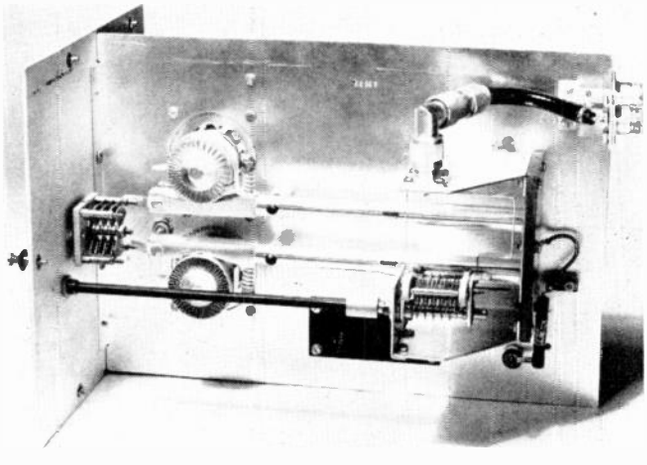
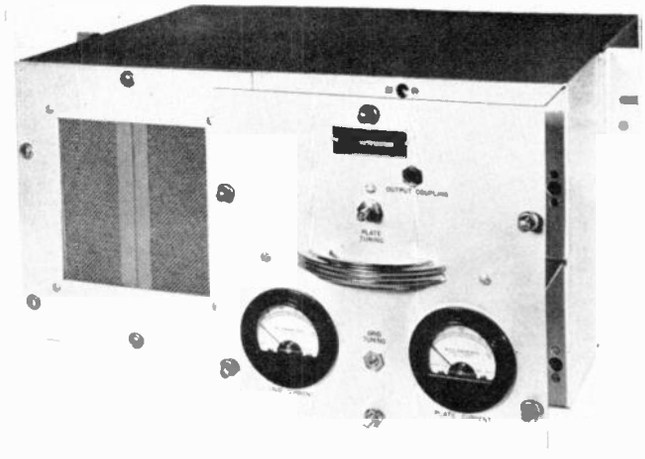
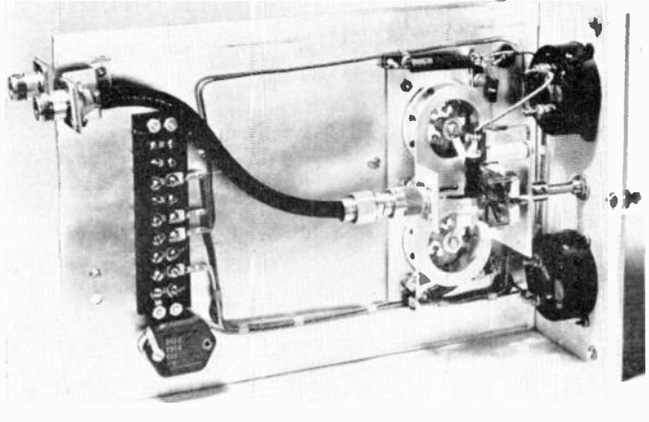




FIGS. 11 AND 12, TOP RIGHT: THE COMPLETE 150-MC. TERMINAL RACK FIG. 9, RIGHT: TOP OF A 747 100-WATT AMPLIFIER, SHOWING AX9903'S FIGS. 8 AND 10, BOTTOM ROW: FRONT AND BOTTOM VIEWS OF THE 747





LCFX Nomograph

THIS INGENIOUS DOUBLE NOMOGRAPH COMBINES HIGH ACCURACY AND WIDE RANGE IN ALL PARAMETERS FOR TUNED CIRCUITS — *By* H. M. SCHLICKE*

THIS nomograph represents the often-used simultaneous equations

$f = \frac{1}{2}\pi(LC)^{\frac{1}{2}}$ and
$X = 2\pi fL = \frac{1}{2}\pi fC$

for simple tuned circuits over a wide range of decades pertaining to all parameters involved. The limits of the nomograph are:

$1 \text{ cycle} < f < 10^{11} \text{ cycles}$
$10^{-6}\ \mu\text{Hy} < L < 10^{11}\ \mu\text{Hy}$
$10^{-6} \text{ ohms} < X < 10^{7} \text{ ohms}$
$1\mu\mu F < C < 10^{11}\mu\mu F$

In addition, compared to conventional graphs of the same size and covering the same range of magnitudes, this nomograph has at least ten-fold increased accuracy.

This is achieved by providing a coarse system (a) to determine the orders of magnitude and a fine system (b) that permits of reading the exact numerical values.

The dot system (a) aligns in a straight line commensurable exponents of powers of 10, by which the corresponding fine scales (b) must be multiplied.

For the purpose of illustration, an example is shown on the nomograph. Given is:

$f = 4.5$ mc. and
$C = 70\mu\mu F$

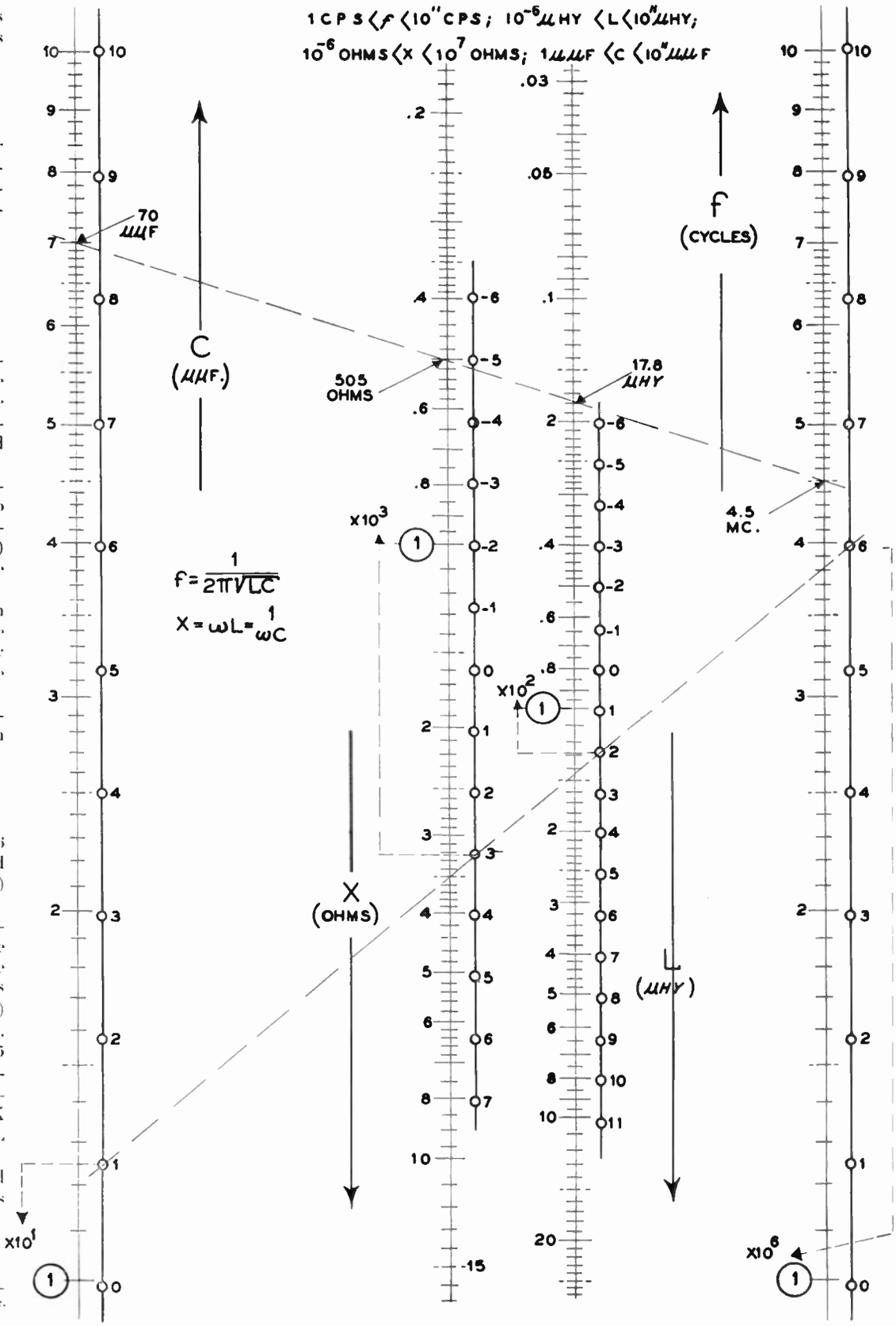
This requires a line through 6 (10^6 cycles = mc.) for f and through 1(10^1 $\mu\mu$F. = 10$\mu\mu$F) in the dot system (a).

The line in system (a) determines 10^2 (2) on the coarse L scale and 10^3 (3) on the coarse X scale as multipliers for the respective fine (b) scales to be used subsequently.

Now, on the (b) scale, 4.5 for f and 7.0 for C are connected by a straight-edge, resulting in 0.505 ohms for X and 0.178 microhenry for L on the (b) scales.

Since X must be multiplied by 10^3 and L by 10^2, the results are

$X = 505$ ohms
$L = 17.8\ \mu$Hy



*Allen-Bradley Company, Milwaukee, Wis.

How SUNRAY OIL boosts pipe line capacity 25%

Three years ago production skyrocketed at the Sunray Oil Corporation refineries in Duncan and Allen, Okla. Expansion throughout the system overloaded the 6-inch pipe line between the two cities. Bigger pipe was not available.

Sunray engineers hit on a cost-cutting solution—installed three electrically powered booster stations between regular pumping stations. They know that electric motors cost less to install . . . require little maintenance . . . are easily adapted to remote control circuits.

Then engineers selected an RCA 960-mc Microwave radio-relay system to effect complete remote control of the *"boosters"* from regular pumping stations. Microwave stations spaced miles apart proved cheaper to install and maintain than direct wire. And Microwave systems are virtually weatherproof.

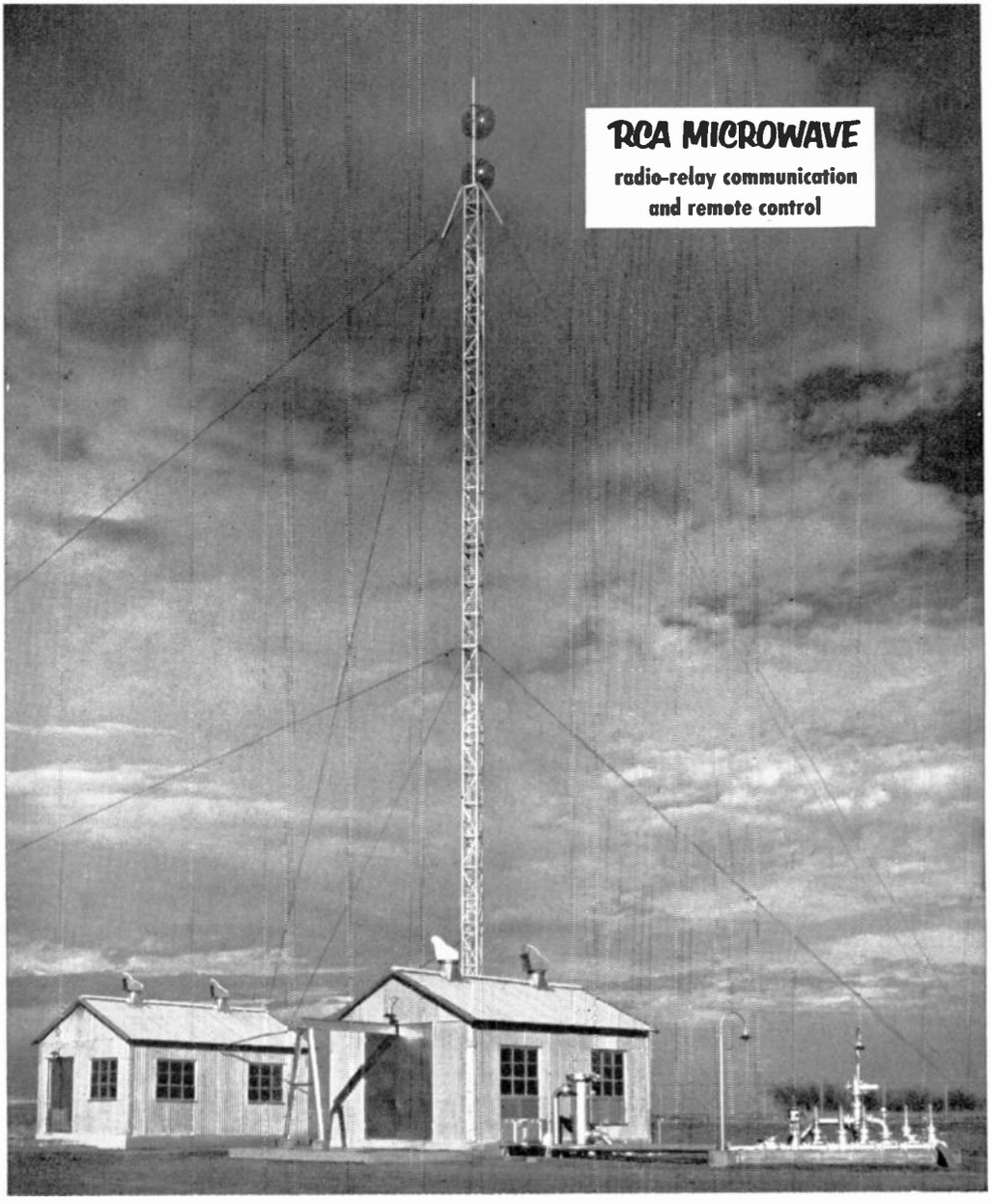
When the Sunray microwave-operated "*boosters*" were put in operation on January 31, 1952, *the pipe line's capacity immediately increased 25 per cent!*

RCA Microwave "beams" highly directional radio signals from station to station by "dish" antennas. Since 1946 RCA has installed many fully reliable Microwave systems, some over 1,000 miles long. *All have proved themselves in performance*—for utilities, government agencies, telegraph companies, turnpikes, as well as pipe lines.

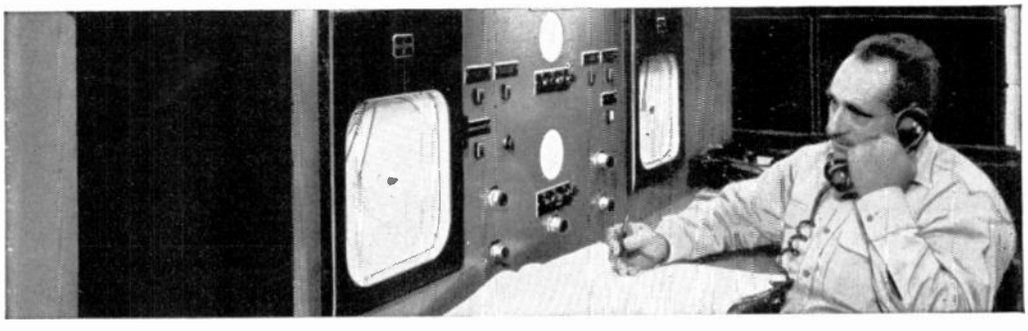
In addition to remote control and supervisory functions, RCA Microwave provides as many voice and teletype channels as you need—and does it with a minimum of frequency space. It employs readily available tubes and familiar circuits which are easy to service. It interconnects with your telephone lines and switchboards.

If you desire, RCA supervises survey, construction and installation—offers a complete single-source, single-responsibility service. And only RCA can provide the nationwide service facilities of the RCA Service Company.

For more information, mail the coupon ▶



Unattended booster station at Pernell, Okla. Radio-beam signals via RCA Microwave operate the booster by full remote control. Maintenance man inspects each station once every 24 hours.



Telemeter charts give continuous record of power and pressures at boosters. Operator remote-controls valves and pumps of booster stations. Signal lights indicate equipment failure and emergency generator operation. 2-way voice channel contacts maintenance personnel.

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☐ Have an RCA representative get in touch with me.

NEW DIAL PROCESS

A new economical method for manufacturing precision instrument dials, scales, and other calibrating devices has been developed by the Precision Photomechanical Corporation of Englewood, New Jersey. The scale or pattern is generated optically in this process.

Precision instruments can be only as accurate as the indicating dials used with them. Scientific advances in instrumentation have made possible almost exact reproducibility of performance, provided the calibrating dials do not impose limitations because of their inaccuracy. Generally, there are three primary sources of error in divided circles or dials. In order to produce dials of the required precision, the errors from each source must be reduced to an absolute minimum. The three sources are non-uniformity in spacing, non-uniformity in line width, and eccentricity between that of generation and the center of rotation.

PPM engineers have evolved a process for producing precise markings by means of an optico-mechanical recording instrument. There is no possibility of error in uniformity of spacing or character, because a single-line master pattern is employed for all units.

Dial graduations can be made any width from three microns, for microscopic dials, up to any size desired. Errors produced by tool wear and backlash, unavoidable in mechanically-produced dials, are eliminated; the optical generation process does not affect the single-line master pattern and, therefore, all graduations are absolutely uniform in width.

The master dial is generated on a glass plate that is ground optically flat before it is made light-sensitive. Its dimensional stability is, accordingly, that of the glass.

Even when the first two sources of error have been eliminated, any deviation from coincidence of the centers of generation and rotation will introduce errors. Any center of rotation is on a diameter of the divided circle. The greatest angular errors are at 90° from the ends of this diameter. It is simple to calculate the error in angular spacing caused by an error in concentricity or line width; typical values are given below:

Angle Tolerance, Minutes	Dial Diameter, Inches 3	4	5	6
1	.00045	.00060	.00075	.00090
5	.00025	.0030	.00375	.0045
10	.0045	.0060	.0075	.0090

By generating masters on bored centers and printing dials on reamed center-holes, the eccentricity can easily be kept to less than .001 in. This means that a precision of 1′ can be produced on dials as small as 3 ins. in diameter. With verniers of equal precision, the dials can be read to 1′ and with dials of larger diameter the precision obtainable improves in a linear manner.

The center hole around which the graduations are generated is held to a tolerance of —.0000, +.0002 in. Photographically-produced replicas are made by contact-printing under vacuum. Dial blanks are printed from the master using a center hole of the same tolerance as that of the master. By this means, the requisite dimensional stability and accuracy is obtained. Using the center hole as a reference in machining operations insures concentricity of the graduations with both inner and outer diameters.

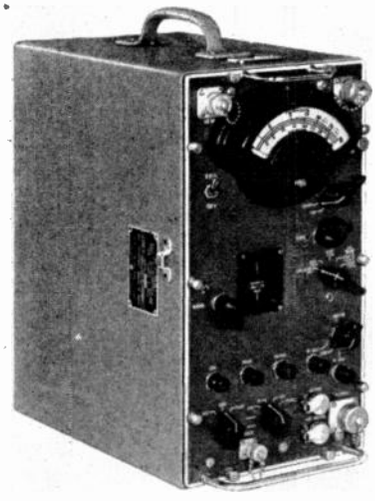
Any style or type of legend can be incorporated permanently as part of the dial. The dials can be made of any metal or plastic material. Dials produced on plastics such as Lamicoid, Vinylite, Plexiglass, or Lucite may be opaque, transparent, translucent, or reflective. Graduations may be white in reflected light and any desired color in transmitted light. Colors are applied not by laminating the necessary colored plastic to a base material which may have a different expansion coefficient, but by coating the

plastic with a thin film of pigmented finish. The finish provides a permenent support for the photographic emulsion and also forms the background color.

NEW PRODUCTS

(Continued from page 13)

BFO Kit Addition: A BFO kit has been released which is intended for addition to the NM-20A radio interference and field intensity meter. The BFO permits detection and copying of unmodulated signals throughout the frequency range of 150 kc. to 25 mc. Kit comes complete with all parts, wire, and



hardware. Stoddart Aircraft Radio Company, Inc., 6644 Santa Monica Blvd., Hollywood 38, Calif.

Tubes: Literature is available on the following new tube types:

General Electric Tube Department, Electronics Park, Syracuse, N. Y. —Type GL-6299, co-planar triode, UHF low-level class A RF amplifier operative up to 2,000 mc.; at 1,200 mc., noise figure is 8.5 db and gain is 16 db.

RCA, Tube Department, Harrison, N. J. – RCA-12X4, full-wave vacuum rectifier, 7-pin miniature, for use in 12-volt vibrator power supplies; RCA-6101, Premium-type medium-mu twin triode, 7-pin miniature, class A amplifier and control tube for mobile and aircraft equipment, prototype 6J6; RCA-6293, beam-power amplifier for pulse modulator service in fixed and mobile equipment.

Sylvania Electric Products, Inc., Sales Dept., 1740 Broadway, New York, N. Y. — 6BQ7A, twin triode for VHF cascode amplifier service with higher gain than 6BQ7, can replace prototype with slight realignment of tuned circuits.

FCC FORM 400

(Continued from page 19)

base station transmitters operated from a common control point are not considered as separate base stations.)

Many businesses are now using radio communication systems in connection with their daily operations. It often happens that when the business is sold, the radio equipment is included in the purchase price. If the new owner wishes to continue the operation of the radio system he must obtain his own authorization. If the station is licensed under Parts 10, 11, or 16 of the Commission's Rules, the new owner should submit an application to the Commission on FCC Form 400. Each item must be completed in the same manner as if he were applying for a new station except "Assignment of License" in Item 16 (a) must be checked. The name of the new owner, and the names of all the partners, if any, and/or the trade name of the company is to be shown in Item 2. A notarized letter from the present owner must be submitted with the application. The letter must contain a statement that he desires to assign to the new owner all rights, title, and interest in and to such authorization and, upon approval of the application by the Commission, he will submit his current license to the Commission for cancellation. The letter should also give the call sign and the location of the station, and the file number and expiration date of the authorization which is being assigned.

It has been reported that some frequency-coordinating committees have experienced difficulty in making recommendations to new applicants since the authorizations on Form 400 do not show the actual power in use at the existing stations in their region, and therefore the service area and interference range of these stations cannot be estimated easily.

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FCC FORM 400

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It is unfortunate that this information cannot be shown. To do so would considerably reduce one of the most important advantages of the new system, namely, freedom to interchange equipment. The height of the antenna is shown on the authorization, however, and it is believed that this information will prove to be just as useful — if not more so — than the operating power. The service area of a given station is determined not only by the power of the transmitter but also by the height and the gain of the antenna. Thus, although one type of information has been deleted from the authorization, another type has been added. In designing the Form 400 an effort was made to request only such information as is needed to determine whether or not the applicant has fulfilled the requirements of the rules and is entitled to an authorization. Requests for any additional information would be burdensome for the applicant and the Commission.

Unlike the Form 401 which was used when applying for a new or modified construction permit, or the Form 403 which was used when applying for a new or modified license, the Form 400 is an application for an authorization. The type of authorization which is issued by the Commission depends upon the circumstances in each individual case. It may be a construction permit, a license, or a combined construction permit and license.

For example, upon approval of an application for a microwave relay station, a construction permit only is issued because the installation and testing of the equipment sometimes takes several months. A separate application for license to cover the construction permit is required when the station is ready for regular use.

The Communications Act of 1934, as amended, provides that persons installing radio transmitting equipment aboard railroad rolling stock may obtain a license for such equipment without first obtaining a construction permit; therefore, licenses are issued immediately in those cases. Applicants for new stations in the mobile services are no longer faced with a long on-the-job construction period. Transmitters can now be purchased and installed as a unit and made ready for use soon after power lines and antenna have been connected. In such instances a combined construction permit and license is issued. The Field Offices maintain records of the dates on which stations in their districts are put in operation.

In order to reduce the processing time

to a minimum the FCC Form has been designed in such a way that the applicant prepares the authorization and the necessary copies as a part of the application. Since the authorization is returned to him in a window envelope, even addressing is eliminated.

Although FCC Form 400 has been in effect for several months, it still is too early to predict the actual saving in processing time which will be gained through its use. It is interesting to note, however, that in terms of *new stations added* during the last fiscal year (July 1, 1952 through June 30, 1953) the Public Safety, Industrial, and Land Transportation Radio Services have expanded at a normal or greater-than-normal rate. The number of applications pending has already shown a decline. Thus, the FCC Form 400 seems to be serving its intended purpose, as the Commission is continuing to license new stations while at the same time reducing the total number and the processing time of the applications.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACTS OF CONGRESS OF AUGUST 24, 1912, AND MARCH 3, 1933

Of COMMUNICATION ENGINEERING, published monthly at Great Barrington, Massachusetts, for October 1, 1953

State of Massachusetts
County of Berkshire, ss.

Before me, a Notary Public in and for the State and county aforesaid, personally appeared Roy F. Allison, who having been duly sworn according to law, deposes and says that he is the editor of the COMMUNICATION ENGINEERING Magazine and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business manager are: Publisher, Radiocom, Inc., Great Barrington, Massachusetts; Editor, Roy F. Allison, West Egremont, Massachusetts; Managing Editor, none; Business Manager, none.

2. That the owner is: Radiocom, Inc., Great Barrington, Massachusetts. The names and addresses of the stockholders owning 1 per cent or more of total amount of stock are Milton B. Sleeper, Monterey, Massachusetts, Charles Fowler, South Egremont, Massachusetts, Ethel V. Sleeper, Monterey, Massachusetts.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: None.

4. That the two paragraphs next above giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company, but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

(Signed) ROY F. ALLISON, *Editor*

Sworn to and subscribed before me this First day of October, 1952.

[SEAL] LILLIAN BENDROSS, *Notary Public*
Commission expires July 1, 1954.

MULTIPLEXING

(Continued from page 31)

Signaling: Signaling is an important part of any communication system. In the course of telephone progress many methods for signaling over carrier channels were developed which are now in use. Generally speaking, signals from a sending switchboard or telephone instrument operate relays in the transmitting branch of a carrier terminal which control the transmission of internally-generated signaling frequencies. These are transmitted to the distant terminal where they cause operation of additional relays which, in turn, provide for application of the proper type of signal to the receiving switchboard or telephone instrument. The principal differences in signaling methods are the frequencies of the internally-generated signals and the manner in which these signals are applied to the lines for transmission to the distant terminals.

Two or more methods of signaling can be used with most carrier systems; most popular are ringdown signaling and dial signaling. Ringdown signaling makes use of a steady transmitted current of uncritical duration. Operation of a ringing key at one point transmits a signal which actuates an audible or visible signal at a distant point. The term "ringdown" is a holdover from early telephone days, when a ringing signal caused a magnetic indicator to drop at the distant terminal. AC ringdown denotes a type of signaling in which the operator's key controls transmission of an AC signal from the sending source, and in which equipment at the receiving end operates from alternating current. DC ringdown operates similarly except that DC signals substitute for AC.

In dial signaling, pulses of critical duration are transmitted between two points. The dial pulses operate automatic line-selection equipment at the receiving terminal. Sequence of the pulses is determined by the operator, but the duration of the pulses is predetermined by adjustment of the dial equipment. Standard dial-type telephones, such as are used by telephone companies, can be employed.

Crosstalk and Equalization: An important consideration in multiplexing systems is inter-channel and inter-system crosstalk. A properly-designed and adjusted carrier terminal does not contribute appreciable crosstalk to a system. The transmission medium, whether wire line or radio, has a much greater potential for crosstalk contribution.

Crosstalk must be held to certain prescribed minimums in order to avoid degradation of the system, particularly where many repeaters in tandem on a

toll circuit each contribute noise to degrade the circuit progressively. It is obvious why the contribution of each system must be minimum.

A toll-quality circuit is defined as one in which the measured noise and crosstalk at the receiving terminal is less than 30 dba at the —9 dbm (decibels referred to one milliwatt) drop level, as measured with a Western Electric type 2B Noise Set with F1A weighting. In other words, the noise at this receiving point in the system must be about—60 dbm as measured with a meter which takes into account the response characteristics of the average human ear.

Open-wire transmission lines are subject to crosstalk due to the coupling between adjacent pairs of wires. Cable transmission lines can contribute crosstalk due to inter-pair leakage and coupling as well as level differentials. Radio systems produce a crosstalk and noise contribution caused by non-linearities, peculiar to electronic circuitry, which generate undesirable intermodulation products ultimately appearing in the output circuit. Control of these factors is a function of the equipment design and adjustment.

Up to 22 db crosstalk improvement can be obtained through use of compandors when they are installed on each voice channel of the system.

Another wire-line and cable problem which sometimes affects radio-carrier systems is that of equalization. Wire lines and cables do not have equal attenuation characteristics for all frequencies. Higher frequencies are attenuated more than those lower in the scale; this inequality is increased on wire lines during periods of rain or sleet. Accordingly, systems for wire lines and cables have regulation circuits which result in an essentially flat characteristic for all frequencies and, therefore, for all channels in the system.

When carrier systems are applied to radio circuits, there is no necessity for equalization unless the radio terminal is located a significant distance from the carrier equipment. In such installations, where the multiplexed channels are extended some distance at carrier frequencies, equalization is ordinarily built into the carrier equipment.

450-MC. ANTENNAS

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member upon the vertical radiation pattern of the base-station array are of interest. Especially important are the effects of various spacings of the antenna from the top of the reflecting member. This is important so that conclusions can

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450-MC. ANTENNAS

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be drawn as to whether such spacing is critical, or if second-order effects only occur and this factor can be disregarded in general. Fig. 3 shows a set of measured vertical radiation patterns for the C-3455 mounted 7.8 ins. (.3 wavelength) from a 10-ft. length of pipe. The vertical pattern of the array in the clear, shown in Fig. 1A, should be compared with the set shown in Fig. 3. Spacings from 6.5 ins. (.25 wavelength) through 27 ins. (1.0 wavelength) from the top of the pipe were tested. In general, the effects of spacing on the vertical pattern shape are very slight. Over the range studied the beam width changed from 28° through 32°. The vertical beam width for the antenna in the clear is 28°. Minor lobe structures are not great enough to cause serious deterioriation in antenna gain. Fig. 4 presents the results of the same tests but with the array-to-pipe spacing increased to 18 ins. (.7 wavelength). Here again, the beam width is fairly constant for the various spacings from the top of the pipe; the overall variation ranges from 26° through 30°. A general conclusion that can be drawn from these measurements is that the vertical pattern remains of the same order of beam width as in the clear, and that the distance down from the top of the support member to the mounting position of the array is not critical.

Sector Coverage: Although the prime object of a study of this nature is the application of the data to general omnidirectional coverage needs, it is felt that there are occasional requirements in the mobile services for sector coverage. For instance, a city located along a waterfront suggests the need for confining radiation to a 180° sector. Some recent practices in systems engineering require that sector rejection be provided by the antenna if successful operation is to be achieved. With the simple support-member reflector arrangement, ratios of some 15 db can be achieved; however, the major lobe is usually too narrow to be of general utility, and such a rejection ratio cannot be achieved except with careful adjustment. Recent work[2] with screen reflectors having angles greater than 180° has resulted in patterns which approach closely the idealized hemiazimuthal 180° coverage diagram. Fig. 5 gives a set of pattern measurements for the C-3455 mounted at various distances off the apex of a 270° corner reflector, constructed of screen mesh 48 ins. on a side and extending about 12 ins. above and below the

[2] E. F. Harris, "An Experimental Investigation of the Corner-Reflector Antenna," *Proc. IRE*, Vol. 41, p. 645; May, 1953.

radiating aperture of the antenna.

Note that the critical spacing is 7.8 ins., or .3 wavelength. For this spacing the radiation is constant within .5 db over a full 180° sector and then falls rapidly to zero. Within 35° beyond the limits of the 180° sector the level has dropped 20 db below that in the forward sector. In the 90° dead zone which the corner reflector shadows, the level is more than 40 db below that in the forward sector. It can be seen that for spacings smaller and larger than .3 wavelength the coverage is no longer uniform; however, the variation is not great, and the shadow region is as dead as before.

Such an arrangement using the high-gain base-station array with the 270° corner reflector is ideal for construction on the corner of a tall building. The reflector can be made from 2-in. mesh screen or smaller. If its use is practical, sheet metal attached directly to the wall of the building is ideal. Various arrangements for attachment to a tower will suggest themselves. Such an arrangement with a high-gain array will provide a full 10 db gain over a dipole in the 180° sector covered.

While the data presented herein is by no means complete, it should provide some workable information for the applications engineer. Additional measurements covering the effects of larger pipes as well as tower structures are needed, and a study of impedance effects would be of value although it has been found that VSWR values have remained within specifications, particularly for the larger spacings. The measurements can be applied to the 150-mc. range if it is recognized that all dimensions given must be multiplied by 3. Thus, the patterns shown for the case of a 2⅜-in. pipe are valid for a 7⅛-in. pipe support at 150 mc.

TOWER RULES

(Continued from page 21)

specify different painting and lighting if it seems desirable or necessary.

Antenna structures must be painted (when painting is necessary) throughout their height with alternate bands of aviation surface orange and white, with orange bands at each end. The width of the bands should be about one-seventh the total height, provided that they are not more than 40 ft. nor less than 1½ ft. in width.

Lighting requirements for various tower heights are shown in the diagram accompanying. Obstruction lights shown must consist of No. 100 A21/TS or No. 111 A21/TS lamps in aviation red obstruction light globes. Beacon lights must consist of two 500 or 620-watt lamps (PS-40, code beacon type) burning simultaneously and equipped with aviation red

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TOWER RULES

(Continued from page 43)

color filters, installed in a 300-mm. electric code beacon. Beacons or obstruction lights at any level must be visible at any angle of approach, so that two beacons must be used at levels where this is necessary for visibility.

Lights must burn continuously or be controlled by a light-sensitive device adjusted to turn on at a north sky light intensity level of about 35 foot candles and to turn off at a north sky light intensity level of about 50 foot candles. Beacons must be equipped with a flashing mechanism operating at not more than 40 and not less than 12 flashes per minute, with a period of darkness equal to one-half the period of illumination.

During construction of an antenna structure for which lighting is required, two temporary obstruction lights must be installed at the uppermost point. As the height of the structure exceeds each level at which permanent lights will be required two similar temporary lights must be installed at each such level. These lights must be positioned so that at least one at each level is visible from any angle of approach and must burn continuously from sunset to sunrise. Alternatively, the permanent lights may be installed at each level as it is reached.

Inspection, Maintenance: Tower lights must be inspected either visually or by means of an automatic indicator, designed to register any light failure, at least once every 24 hours. Alternatively, an automatic alarm system can be used. Any failure of a beacon or top light not repaired within 30 minutes must be reported immediately by telephone or telegraph to the nearest airways communication station or CAA office. Further notification by telephone or telegraph must be made immediately on repair of the defective unit.

All automatic or mechanical control devices, indicators, and alarm systems associated with tower lighting must be inspected at intervals not exceeding three months.

A complete record of maintenance, operation, adjustments, and repairs must be kept.

Towers must be cleaned and repainted as often as is necessary to maintain good visibility. A sufficient supply of spare lamps must be maintained for immediate replacement purposes at all times.

Upon completion of construction or any modification affecting height or location of any tower for which obstruction marking is required, the licensee must fill out and file C. & G.S. Form 844 with the Director, U. S. Coast and Geodetic Survey.

150-MC. RELAY

(Continued from page 33)

Figs. 11 and 12 are front and rear views of a cabinet containing a complete 755C system and a 747 amplifier. Chassis are, from top to bottom, a 755 receiver; a 747 100-watt amplifier; a 755-C transmitter; its power supply; and the 747 amplifier power supply.

PROJECT TINKERTOY

(Continued from page 25)

notches, three on a side. The mechanism brings soldering irons in contact with the unit and bonds the wires to the notches. The unit is turned 90°, and the chain drive carries it to another soldering position where six more wires are bonded to the module. After final electrical inspection, segments of riser wires are severed where circuit isolation is required between wafer-mounted circuits.

During each stage in the production process, provision is made for completely automatic inspection. This consists of both physical gaging and electrical comparison. Printed circuits, resistors, and capacitors are compared with standards both before and after assembly. This is accomplished by electronic computers, bridge circuits, and other comparison devices. The inspection code is contained on the punched cards which were prepared by the design engineer and which accompany the wafers through the production process.

The final assembly operation need not necessarily be considered a part of the MPE process. Normally, a set of modules (as many as ten) is mounted on or between copper-clad base plates. Circuits etched into the copper surface connect with the riser wires of the several modules to form a complete assembly. Several such plate assemblies may form a complicated equipment. One base plate with six modules, for instance, contains all the necessary circuits to make a six-tube radio receiver.

Conclusion: Project Tinkertoy makes possible a rapid conversion from civilian to military products and back again on short notice and, concurrently, facilitates a greatly expanded production capacity. Delays caused by the need for recruiting and training new production personnel and the procurement of new mechanisms and parts are eliminated. Most of the operating know-how is stored in mechanical fingers and electromechnical control mechanisms; even electronic equipment designs can be stored, ready for production, in the form of punched cards and circuit stencil screens.

Because unprocessed or bulk materials are used for the most part, the system

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PROJECT TINKERTOY

(Continued from page 46)

is comparatively free from dependence on particular components in critical supply. Uniformity of electronic products at a high quality level is enhanced by the mechanized production and by 100% automatic inspection. This affords the possibility of repair and maintenance of electronic systems by replacement of unitized packages or entire subassemblies. Performance appears generally equivalent to that obtainable from conventional assemblies. Equipments produced on an experimental basis meet military environmental requirements, passing such tests as shock, vibration, temperature, and humidity established in military specifications. Moreover, the standardization results in production outputs of uniformly satisfactory equipment, whose characteristics both physically and electrically are carefully controlled.

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An expansion and revision of first edition, containing much new material. A simple yet thorough treatment of the electro-magnetic theory.

The Radio Handbook—*Edited by R. L. Dawley.* No. 64 $6.00
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Broadcast Operators Handbook—*by H. E. Ennes.* No. 65 $5.40
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MISCELLANEOUS

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Short-Wave Radiation Phenomena—*Hund.* No. 72 ... $20.00
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Book List Department, RADIO COMMUNICATION, Great Barrington, Mass.

I enclose $ ... for which please send me the books indicated by circled numbers below. (No. C.O.D.'s, please.)

43	44	45	47	48	49	50	51	52	53	54
55	56	58	59	60	61	62	63	64	65	66
67	68	69	71	72	73	95	98	132	133	134

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Established as FM 1940

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9th FCC Chairman

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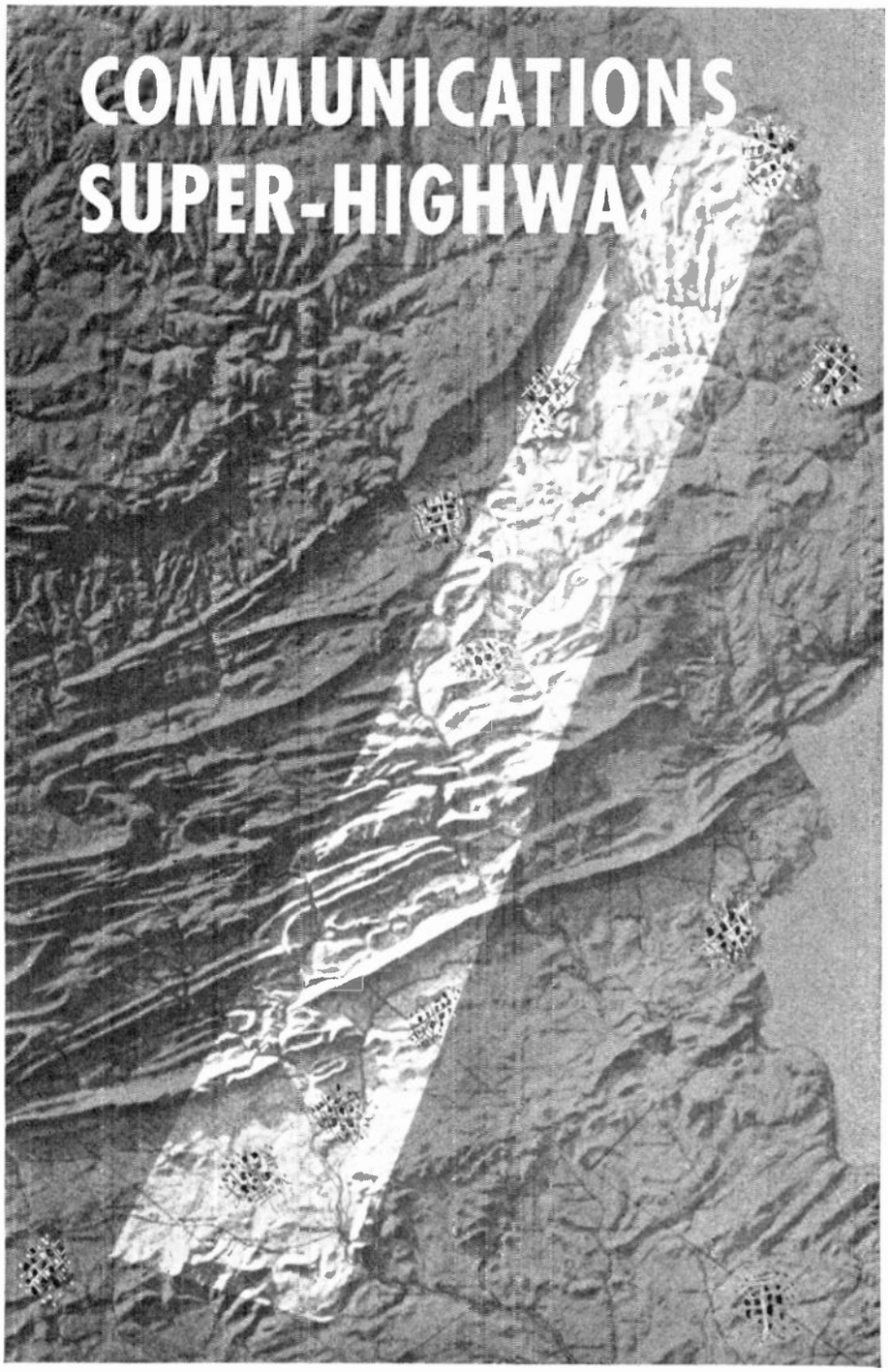

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Communication Engineering

Formerly FM-TV and RADIO COMMUNICATION

Vol. 13 **September-October, 1953** **No. 5**

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Chicago Office: 5449 W. Augusta Blvd., Tel. Columbus 1-1779.

New York Office: 6 East 39th Street, Room 1209, Tel. Murray Hill 5-6332.

West Coast Office: 1052 West 6th Street, Los Angeles, Tel. Michigan 1732.

COMMUNICATION ENGINEERING MAGAZINE is mailed on the 20th of January, March, May, July, September, and November.

Subscriptions: Should be sent to Publishing House, Great Barrington, Mass. Single copies 65c. Sub. rates: 3 years—$6.00; 2 years—$5.00; 1 year—$3.00.

Contributions will be neither acknowledged nor returned unless accompanied by adequate postage, packing, and directions, nor will COMMUNICATION ENGINEERING Magazine be responsible for their safe handling in its office or in transit.

Entered as second-class matter August 22, 1946, at the Post Office, Great Barrington, Mass., under the Act of March 3, 1879. Additional entry at Post Office, Boston, Mass. Printed in the U. S. A.

CPA AUDIT

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

SYSTEMS DATA

IT was hardly reasonable to expect that the number of mobile, base, and portable transmitters shown in this bi-monthly department would increase indefinitely. Nevertheless, a decrease in all three categories comes as a surprise. The significance of the change will not appear until another four months have passed. Then it will be known whether the peak volume has been passed, or if the July-August period was an exception.

This data is the most up-to-date and accurate picture of current activity available since the figures shown are for applications as they are filed at the FCC, and they are compiled from our Weekly Reports of Applications.[1] Totals for the first 8 months of this year show applications filed for 54,570 mobile units, 4,882 base stations, and 3,884 portable units for operation on 30 to 50 or 152 to 174 mc., representing a volume of about 84 million per month. That figure does not include mobile, point-to-point, and relay systems on other frequencies, which may average nearly as much again.

Actual orders for mobile units probably amounted to substantially less than the total of 13,966 shown here, particularly because 1,755 units are listed for common carrier and miscellaneous common carrier service. Thus the figure represents an expected number of subscribers over a period of time rather than the number going into use at once.

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 August and September:

POLICE: 39 speedmeters on 2,455 mc.; 4 interzone CW transmitters on 1.6 to 7.0 mc.; 1 relay on 42 mc., 1 on 75 mc., 5 on 155 mc., and 2 on 450 mc.; 8 control transmitters on 159 mc.

FIRE: 1 mobile relay on 172 mc., relay on 160 mc., 2 relays on 458 mc., 1 control transmitter on 154 mc., 2 on 458 mc.

SPECIAL EMERGENCY: 35 mobile units and 10 temporary base transmitters on 3.19 mc.

FORESTRY CONSERVATION: 2 mobile relays on 172 mc., 1 relay on 159 mc., and 1 relay on 454 mc.; 1 control transmitter on 161 mc., and 1 on 454 mc.

HIGHWAY MAINTENANCE: 1 speedmeter on 2,455 mc.; 4 relays on 72 mc., 4 on 161 mc., and 2 on 454 mc.; 1 control transmitter on 72 mc., 4 on 156 mc., and 1 on 455 mc.

POWER UTILITY: 15 mobile units on 457 mc.; 3 mobile relays on 153 mc.; 3 relays on 72 mc., 1 on 451 mc., and 11 on 1,905 mc.; 4 control transmitters on 153 to 172 mc., 3 on 456 mc., 4 on 1,855 mc., and 72 on 6,585 to 6,785 mc.

(Concluded on page 12)

[1]For information about this weekly reporting service, address Registry Department, COMMUNICATION ENGINEERING, The Publishing House, Great Barrington, Mass.

TABLE OF APPLICATIONS FILED JULY 1 TO AUGUST 30, 1953

	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	2,079	116	82	1,185	67	15	894	49	67
Fire	893	82	153	690	64	16	203	18	137
Special Emergency	280	107	2	191	44	2	89	63	—
Highway Maintenance	276	29	—	226	26	—	50	3	—
Forestry Conservation	786	44	40	541	25	40	245	19	—
Power Utility	1,042	103	5	583	71	5	459	32	—
Pipeline Petroleum	519	102	10	391	82	—	128	20	10
Special Industrial	2,280	232	10	1,643	190	—	637	42	10
Low-Power Industrial	—	—	467	—	—	122	—	—	345
Relay Press	3	—	2	—	—	—	3	—	2
Motion Picture	—	—	4	—	—	—	—	—	4
Forest Products	229	29	3	209	17	1	20	12	2
Taxicabs	1,689	114	—	—	—	—	1,689	114	—
Railroads	1,114	78	20	—	—	—	1,114	78	20
Highway Trucks	761	29	—	761	29	—	—	—	—
Intercity Buses	106	3	—	106	3	—	—	—	—
Transit Utilities	—	—	—	—	—	—	—	—	—
Auto Emergency	164	18	—	164	18	—	—	—	—
Radio Paging	—	26	—	—	26	—	—	—	—
Common Carrier	960	10	—	75	1	—	885	9	—
Misc. Common Carrier	795	11	—	—	—	—	795	11	—
TOTALS	13,976	1,133	798	6,765	663	201	7,211	470	597


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coverage for $700!
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To increase the "talk-back" range of one-hundred cars from 20 miles to 25 miles—corresponding to an increase of 50% in area coverage—one-hundred 15 watt transmitters must be replaced with 60 watt transmitters . . . at an approximate cost of $25,000.
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PRODUCT INFORMATION

Tower Lighting: A 20-page booklet describes methods and materials necessary for installing obstruction lighting equipment on antenna towers. Includes layout drawings and complete bills of material for towers of all heights. Booklet 381-F available free on request to Crouse-Hinds Company, Syracuse 10, N. Y.

Rack-Mounted Oscillograph: Electrical equivalent of type 304-A is now available as a rack-mounted unit, known as type 304-AR. Requires $8\frac{3}{4}$ ins. of rack space. Full 4-inch deflection is obtained with inputs from .1 to 1,000 volts. Frequency response DC to 300 kc. Allen B. Du Mont Laboratories, Inc., Instrument Division, 760 Bloomfield Avenue, Clifton, N. J.

Subminiature Resistors: Type 1106 resistor 3/16 in. diameter by 7/16 in. long, is rated at .10 watt and is anti-humidity impregnated. Maximum resistance is 100,000 ohms when standard winding wires are used; other resistance wires with special temperature coefficients can be used, but maximum resistance is reduced. Tolerance to $\pm .05\%$ can be obtained. The Daven Company, 191 Central Avenue, Newark, N. J.

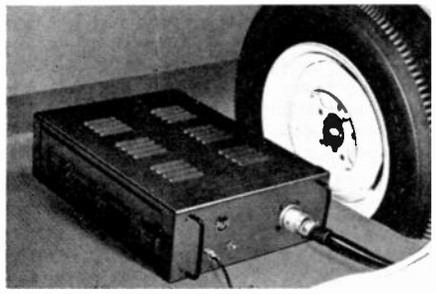
Signal Generator: Providing continuous coverage on fundamentals from 125 kc. to 165 mc., model 292XAL Airline microvolt signal generator is built specifically for aircraft radio

service and maintenance. Can be modulated externally from 15 to 10,000 cycles. Accurate calibration of frequency and output level is claimed. Crystal controlled and temperature compensated. H. D. Johnson, The Hickok Electrical Instrument Company, 10530 Du Pont Avenue, Cleveland, Ohio.

Portable Towers: A new line of aluminum-alloy towers features very fast and simple erection, extreme rigidity. Towers up to 300 ft. high can be assembled from individual sections which fit one on top of another, are put together without tools. Wind loading up to 150 mph. is possible; guys are installed without turnbuckles or cable clamps. Up-Right, Inc., 1013 Pardee, Berkeley, Calif.

Components Symposium: Text of all papers presented at the 1953 Electronic Components Symposium is now available in book form. Thirty papers and three addresses cover General Component Problems; Environment and Packaging; Tubes and Tube Reliability; Component Reliability; Resistors, Capacitors, and Dielectrics; and Devices and Materials. Copies can be obtained from the Symposium headquarters at Suite 1011, 621 South Hope Street, Los Angeles 17, Calif.

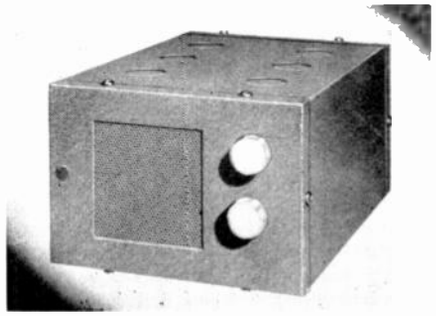
New UHF Equipment: A complete line of 2-way radio equipment for use in the 450 to 470-mc. band consists of the CMU-10A mobile assembly, shown here; the CSU-20A desk console; and the CSU-20ACR and CSU-100ACR



rack-mounted station equipments. Presumably, figures in model numbers indicate power output. Mobile case is $13\frac{1}{2}$ by 5 by 17 ins., contains transmitter, receiver, and dual-vibrator power supply. RCA Victor, Camden, N. J.

Tiny Blower: Production has begun on the Minicube subminiature blower, which weighs 1 ounce including motor, measures only 1 by 1 by 1 inch, and delivers 3 cubic ft. of air per minute. Universal mounting permits application for spot-cooling or general circulation. Temperature range is $-55°$ to $+85°$ C; life expectancy is 1,000 hours. Hysteresis synchronous motor turns at 24,000 rpm; 1, 2, or 3-phase supply; source can be 6.3 volts at 60 cycles or 26 volts at 400 cycles. Sanders Associates, Nashua, N. H.

New Monitoradio: Model FMC1-L is a crystal-controlled fixed-frequency FM radio receiver for frequencies between 30 and 50 mc. New unit replaces model M-51, which was a tunable mobile receiver. Sensitivity has been increased to better than 1 microvolt, and band-width reduced, to make the new model useful as an inexpensive supplement to exist-

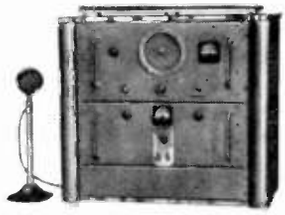


ing 2-way communication systems. Radio Apparatus Corp., 55 North New Jersey Street, Indianapolis, Ind.

Audio Catalog: Recently-issued general

Continued on page 10



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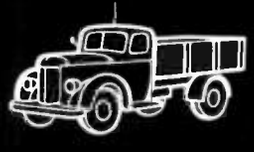



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THIS MONTH'S COVER

The appointment of Rosel H. Hyde as 9th Chairman of the FCC has been very favorably received by all the communication services, and affords well-deserved recognition of his long experience in this field, dating back to 1928, when he joined the FRC. Mr. Hyde was born at Downey, Idaho, in 1900. He was admitted to the bar of the District of Columbia in 1929, and was general counsel of the FCC when he was appointed a Commissioner in 1946. While his present term runs to June 30, 1959, his first appointment as Chairman runs only to May 1, 1954. It is generally expected, however, that he will be continued in his present post after that date.

COMPANIES & PEOPLE

Voice-Radar Identification: Experience with marine radar has shown that it can be used more effectively in combination with 2-way phone communication. Problem when two or more ships are within radar range is to know from which one voice signals originate. Identification device called Radent, developed by Sperry Gyroscope is being tested this summer. Also cooperating in this project are U. S. Coast Guard, FCC, Raytheon, Radiomarine, Federal, Westinghouse, Tropical Radio, Esso Shipping, Jansky & Bailey, Lake Carriers' Association, and National Federation of American Shipping.

Col. Edwin L. White: Chief of FCC Safety & Special Radio Services Bureau: "The number of microwave systems is growing. There are approximately 60 systems over 50 miles in length, in addition to possibly 75 or 80 other systems of 1 or 2 hops only. The longest is that of AT&T, linking both coasts for television and other common carrier purposes. Over 25 are pipeline systems, and over 15 are electric power systems. Eight pipeline systems approximate or exceed 1,000 miles in length. The system under construction by the Bonneville Power Administration, largest of the electric power systems, will extend nearly 1,000 miles."

Registry of Ship Radio Stations: Members of the COMMUNICATION ENGINEERING staff who compile the listings and revisions for our various Registries of communication systems will start work shortly on a Registry of U. S. Ship Radio Stations. This will include ocean-going, coastwise, Great Lakes, and Alaskan ships.

Processing of Applications: FCC has reduced time of processing applications in the transportation service to a matter of 10 days. Petroleum service, however, is building a backlog, with 302 applications filed in June, only 164 grants issued, and 673 still pending. Special industrial, most active service of all, requires 2½ months to process applications

RTCM Fall Meeting: Radio Technical Commission for Marine Services will meet on October 19 to 21 at the Edgewater Beach Hotel, Chicago. Technical papers will be devoted to electronic and navigational aids to shipping on the Great Lakes and inland waterways. Further information can be obtained from R. T. Brown, executive secretary, Federal Communications Commission, Washington, D. C.

List of Approved Transmitters: Now published as an appendix to COMMUNICATION ENGINEERING's revised Registry of Public Safety Systems, now off the press. This has been added because the FCC's list of approved transmitters is

Continued on page 13

MEETINGS and EVENTS

OCTOBER 2 - 11,
NATIONAL ELECTRONIC SHOW
Santa Monica Pier, Santa Monica, Calif.

OCTOBER 14 - 17,
AES CONVENTION, AUDIO FAIR
Hotel New Yorker, N. Y. C.

OCTOBER 19 - 21,
RTCM FALL MEETING
Edgewater Beach Hotel, Chicago

OCTOBER 20 - 22,
COMMUNICATIONS SECTION, AAR
Hotel Plaza, San Antonio, Texas

OCTOBER 26 - 28,
RTMA-IRE RADIO FALL MEETING
Toronto, Ontario, Canada

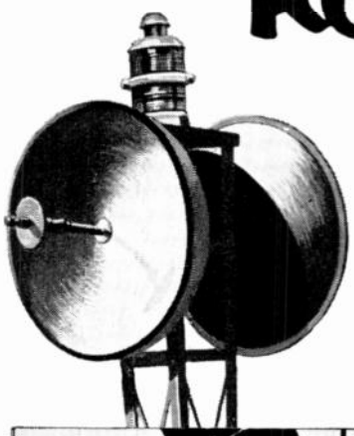
NOVEMBER 2 - 6,
AIEE FALL GENERAL MEETING
Muelebach Hotel, Kansas City, Mo.

NOVEMBER 12 - 13,
IRE PROF. GRP. ON VEHICULAR COMM.
Hotel Somerset, Boston, Mass.

JANUARY 18 - 22,
AIEE WINTER GENERAL MEETING
Statler Hotel, New York City

RCA MICROWAVE

RADIO-RELAY COMMUNICATION AND CONTROL



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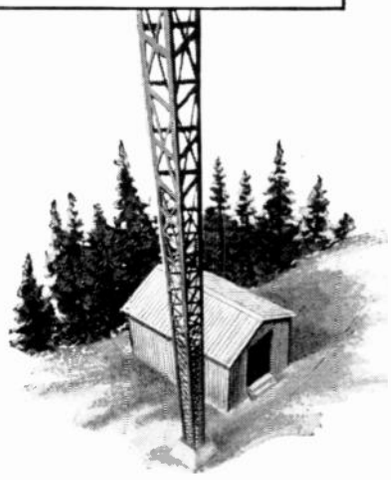
AND REMEMBER, only RCA can provide the nation-wide service facilities of the RCA Service Company.



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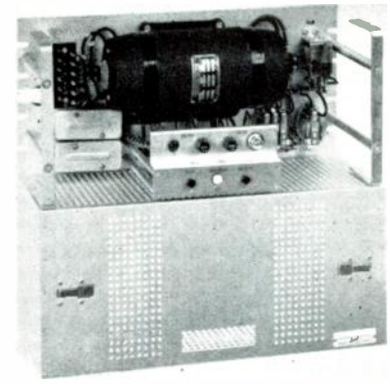
NEW PRODUCTS

(Continued from page 6)

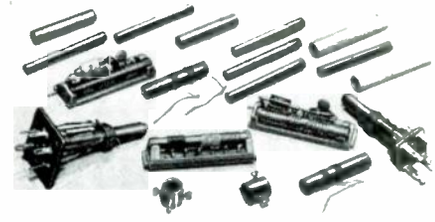
catalog No. 44 has just been revised; catalog 44A now covers microphones, microphone parts and accessories, and wire and tape recording heads. Shure Brothers, Inc., 225 West Huron Street, Chicago 10, Ill.

Emergency AC Supplies: Up to 250 watts of 110-volt AC power can be obtained from 24 or 48-volt storage batteries with types 5060A and 5070A emergency power supplies. Rated load capacity is sufficient to handle



load of a 3-channel carrier terminal or repeater, or a low-power base station. Automatic transfer is completed within ½ second on failure of normal power source; load can be returned to normal source manually or automatically. Unit is wall-mounted or rack-mounted. Complete specs given in Bulletin 5060A-P2, from Lenkurt Electric Company, 1105 County Road, San Carlos, Calif.

Corrosion-Proof Coil Forms: Resin-impregnated coil forms are now available in all colors for color-coding of circuits and components. Volume resistivity, power factor,



and thermal characteristics make Resinite AC forms ideal for VHF and UHF applications involving strenuous operating conditions. Available threaded inside or out, slotted, punched, or embossed. Complete information available from Resinite Corp., Dept. C-7, 2035 W. Charleston Street, Chicago 47, Ill.

AC Generators: Two new HQ engine-driven generators are rated at 10 and 15 kw., and are intended for primary and standby power applications. Both are driven by 4-cylinder water-cooled Continental engines; fuel consumption is said to be less than one quart per kwh. at rated load. Regulation is ±2%. Available in all standard voltages, frequencies, and phase numbers, housed or unhoused. D. W. Onan and Sons, Inc., Minneapolis, Minnesota.

Universal Mike Clamp: Fastening securely to virtually any type of surface ledge, round pipe, or irregularly-shaped stanchion, model SK-1 universal microphone clamp solves many

difficult problems of positioning. A microphone can be attached directly to a 3-in. tube supplied with the clamp. Full information available from Atlas Sound Corp., 1451 39th Street, Brooklyn 18, N. Y.

2 to 4-Mc. Oscillator: Extremely stable and accurately variable frequencies anywhere between 2 and 4 mc. can be obtained with an interesting new direct-reading master oscillator. Last 3 digits of frequency desired are set by switches; then dial is set to rough frequency, and exact desired frequency pulls in and holds with excellent stability. 100-kc. time-base oscillator is stable within .2 parts per million for any 12-hour period, or 1 part per million per month. Readability is better than 2.5 cycles. Northern Radio Company, Inc., 147 West 22nd Street, New York, N. Y.

Tubeless DC Supply: Nobatron MA6/15 DC supply, operating on magnetic amplifier principles delivers 100 amperes at 6 volts (adjustable to 7.7 volts) or 75 amperes at 12 volts (adjustable to 15.4 volts). Regulation is ±1% within rated variation in line and load. Sorenson & Company, 375 Fairfield Avenue, Stamford, Conn.

Polarity Switch: Model MS-1, designed specifically for use with the Simpson 260 tester, plugs into test-lead jacks on the meter and the standard test leads are then plugged

into it. Then, by merely throwing the toggle switch, the polarity of the connection can be reversed. Pomona Electronics Company, 524 East 5th Avenue, Pomona, Calif.

Standby Power Units: Described as "an entirely new concept of communications standby equipment," Micro-Power AC generators maintain continuous, uninterrupted service regardless of main source fluctuation or failure. Production is now under way on 3 and 5-kw. units; larger sizes are in development. Complete information can be obtained from United States Motors Corp., Oshkosh, Wis.

Foamed Resin: Low-density plastic foams made from XR1-543 resin have been found to be highly resistant to thermal shock, and can be foamed in place. Applications are those in which extreme temperature resistance without high compressive strength is needed, such as in vibration damping; electrical, acoustical, and thermal insulation; and buoyancy units. Density is 10 to 14 lbs. per cubic ft. Complete processing information and specifications can be obtained from Dow Corning Corp., Midland, Mich.

DC Bench Supply: A dual-output service bench DC supply, type 12RS6D, is equipped with an ammeter and a voltmeter. Output voltage infinitely variable from 0 to 8 volts at 10 amperes continuous or 20 amperes intermittent; or 0 to 16 volts at 6 amperes con-

Concluded on page 12

SYSTEMS DATA

(Continued from page 4)

PIPELINE PETROLEUM: 46 mobile and 3 base transmitters on 1.62 to 2.39 mc., 40 mobile and 2 base transmitters on 451 mc.; 1 relay on 75 mc.; 1 control transmitter on 75 mc., and 2 on 456 mc.

SPECIAL INDUSTRIAL: 50 mobile units and 1 base transmitter on 2.29 mc., 2 base transmitters on 451 mc.; 1 relay on 30 mc., 3 on 73 mc., 1 on 154 mc., and 8 on 456 mc.; 1 control transmitter on 30 mc., 5 on 75 mc., 3 on 154 mc., and 14 on 457 mc.

FOREST PRODUCTS: 1 relay on 451 mc., 1 on 956 mc.; 1 control transmitter on 456 mc., and 1 on 959 mc.

TAXICABS: 100 mobile units and 2 base transmitters on 452 mc.

NEW PRODUCTS

(Continued from page 11)

tinuous or 14 amperes intermittent. Self-resetting overload protection is provided. P. R. Mallory & Company, Inc., 3029 E. Washington Street, Indianapolis 6, Ind. Inquiries should be addressed to W. H. Dunning.

Tubes & Components: Literature and technical data are available on the following:

CBS-Hytron, Danvers, Mass.— A comprehensive 8-page transistor manual is offered free of charge. Theory, data, and application (with specific circuit examples) are treated in an easily-understood manner.

RCA Tube Department, Harrison, N. J.— Premium tube type RCA-6101, a ruggedized and improved version of 6J6; RCA-5719, high-mu subminiature triode with flexible leads; RCA-5814, medium-mu 9-pin miniature twin triode; and RCA-5840, sharp-cutoff subminiature pentode with flexible leads. RCA-5ABP-1, -7, -11, oscillograph tubes featuring exceptionally high sensitivity and trace detail. RCA-5690, full-wave vacuum rectifier of Special Red type. 12AQ5, 7-pin miniature beam power amplifier for mobile receiver output stages, within ratings, electrically equivalent to 12V6-GT.

Radio Receptor Company, Inc., 251 W. 19th Street, New York 11, N. Y.— JAN type 1N34A germanium diode, in tapered case for easy polarity identification.

Sylvania Electric Products, Inc., Electronics Division, 1740 Broadway, New York 19, N. Y. — Two new point-contact transistor types: a 4-element unit, or tetrode, now available; and a 5-element unit, or pentode, expected later in this year. Tetrode designed primarily for switching and small-signal mixing and modulation applications.

Texas Instruments, Inc., 6000 Lemmon Avenue, Dallas 9, Texas — Hermetically-sealed junction transistors 200 and 201, both *n-p-n* triodes; minimum alpha for 200 is .90, for 201, .95. Bulletin DL-S 310. Also point-contact transistors 102 and 103, differing principally in cutoff time. Bulletin DL-S 312.

Transistor Products, Inc., Snow and Union Streets, Boston 35, Mass.— Type X-25 *n-p-n* junction amplifying photo transistor, first commercially available. Has power output sufficient to operate a relay.

Westinghouse Electric Corp., Electronic Tube Division, Dept. T-329, Box 284, Elmira, N. Y.—A 47-page booklet, RU-020, gives characteristics and ratings of over 300 Reliatron receiving tubes.

COMPANIES & PEOPLE

(Continued from page 8)

not available from the Commission. There are 713 different models from 38 manufacturers in the list as of May 1. Forthcoming editions of the Transportation, Industrial, and Air-Ground & Common Carrier Registries will also carry the list of approved transmitters, with changes and additions made by the FCC up to the time of publication.

Radio Speeds Materials: Mobile radio units are becoming standard equipment on fork-lift trucks and other material-handling vehicles in factories and plant yards. Here again, the investment in radio is being returned quickly by increasing the work capacity of each truck, and by eliminating expensive delays in getting materials and finished products where and when they are needed.

Factory managers who are not acquainted with the successful application of radio in this service seem to assume that reception is affected adversely by steel building construction and the presence of large masses of metal. Fortunately, that is not the case, for metal objects cause reflection and refraction of radio waves, thereby providing complete distribution, free of dead spots. Also there is the audible competition from noisy machines. In such cases, a loudspeaker of the reentrant-horn type, mounted behind the driver, is used for calling, and a handset for communication. When handset is picked up, the speaker is shut off.

Calls for trucks are made by ordinary telephone to the dispatcher. He talks to the truck drivers by radio, determining which one should be routed to the next job. This prevents arguments and accusations that the drivers are loafing. If a driver must leave his truck, he reports that to the dispatcher, and calls when he returns.

Incidentally, it is surprising to see how many women are employed to operate the trucks. Reason is that women are more careful!

Albert F. Watters: Vice president in charge of personnel for RCA Victor division: "Management is meeting the problem of professional recognition in a number of ways. There has been a wholesome revaluation of the basis of engineers' compensation. One approach to the problem is elevating outstanding engineers to staff positions in which their specialized talents will be given full play, but which do not involve administrative responsibilities. This is a tangible recognition, making possible incomes comparing favorably with those at managerial levels. Another way is to designate out-

Continued on page 14

Professional Directory

COMPANIES & PEOPLE

(Continued from page 13)

standing engineers as consultants, with remuneration based on their engineering prestige, rather than on established earning brackets. A third way is to name such engineers to positions of prestige outside the company, such as national and industry committees and agencies."

Transatlantic Telephone: In 1903, Prof. Michael Pupin expressed the opinion that transatlantic telephone service would not be economically successful. His reason was that such service would be used chiefly during a period of 6 to 7 hours on business days, but that would be reduced to a matter of 1 or 2 hours per day because of the 5-hour difference in time between New York and London and Paris.

IRE Vehicular Radio Group: Fourth annual meeting will be held at Hotel Somerset, Boston, November 12 and 13. Conference theme will be: Design, Planning and Operation of Mobile Communication Systems. Further information can be obtained from Col. Edwin L. White, chairman, Chief of the Safety & Special Service Bureau, FCC, Washington, D. C.

Julius G. Aceves, 1888-1953: Passed away in New York City on August 17. A native of Mexico City, he was graduated from Columbia University in 1913, continuing there as an assistant to the late Dr. Michael I. Pupin until 1927. The following year, he joined Ernest Amy and Frank King in organizing the firm of Amy, Aceves & King, specialists in the design and installation of master antenna systems.

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COMPANIES & PEOPLE

(Continued from page 14)

Point-to-Point on 460 Mc.: First license for a 460-mc. point-to-point system was granted to the Swan Rubber Company, for use between its plants at Bucyrus and Carey, separated by 25 miles. It is expected that this band will come into wide use for such service, for it is inexpensive, dependable, convenient, and fast in operation. Motorola equipment was used for this installation.

Short Electric Waves: In a paper presented before the AIEE and IRE in June, 1922, Guglielmo Marconi said: "I feel — and perhaps you will agree with me — that the study of short electric waves, although sadly neglected practically all through the history of wireless, is still likely to develop in many unexpected directions, and open up new fields of profitable research."

Telephone Taxes: Operating and excise taxes paid by Bell System companies in 1952 amounted to more than one-half the amount paid out in wages. Excise taxes on phone calls are in some cases a persuading factor in consideration of installing privately-owned microwave systems.

John Stone Stone: According to Dr. Benjamin E. Shackleford, director of RCA's license department, back in 1904 John Stone Stone filed 47 patent applications in a single day. One was on permeability tuning.

Universal 6 or 12-Volt Units: New mobile units are being designed to work interchangeably on 6 and 12 volts. This means that they can be shifted between 6-volt passenger cars and 12-volt trucks. Also, they anticipate the use of 12-volt car batteries, which may become prevalent before new equipment reaches replacement age.

Col. Thomas Warner: Now back in Chicago, is heading up the National Bus Communication Committee, with offices in the Board of Trade Building. So far, this segment of the transportation radio service has not been particularly active, but it is expected to become so in the immediate future.

Jointly Operated Relay System: FCC has authorized Middle South Utilities Network to operate a communication system on behalf of five power companies. System will extend through Arkansas, Mississippi and Louisiana, and will be comprised of 16 repeaters and 4 terminal stations. The participating companies are already licensees in the industrial service.

TIME PROVED

Eimac 4W20,000A gives 25 kw peak sync power output through channel 13 with only 500 watts driving power

TYPICAL OPERATION
Class-B Linear Amplifier—Television Visual Service
(Per tube, 5 mc bandwidth, 216 mc.)

Load Impedance		650 ohms
D-C Plate Voltage		7000 volts
D-C Screen Voltage		1200 volts
D-C Control-Grid Voltage		—150 volts
	Peak Sync Level	Black Level
D-C Plate Current	6	4.5 amps
D-C Screen Current	230	100 ma
D-C Grid Current	90	45 ma
Peak RF Grid Voltage	280	220 volts
Driving Power	500	300 watts
Plate Power Input	42	32 kw
Plate Dissipation	16	16.5 kw
Useful Plate Power Output	26	15.5 kw

FOR THREE YEARS THE EIMAC 4W20,000A has been proving itself an outstanding power tube in a variety of electronic applications. In VHF-TV operation it gives an easy 25 kw peak sync power output with only 500 watts driving power. This high power output with low driving power requirements is typical of Eimac radial-beam power tetrodes. Rugged 4W20,000A construction includes a ceramic envelope that minimizes losses and increases operational life. In pulse service, FM and TV operation the 4W20,000A is the only time proved tetrode in its power class.

Eimac TUBES

Information about the 4W20,000A or any of Eimac's complete line of electron power tubes can be obtained by writing our Application Engineering department.

The Power for TV

EITEL-McCULLOUGH, INC., SAN BRUNO, CALIFORNIA

COMMUNICATION REVIEW

ALTHOUGH it has not been finalized at this time of writing, it is certain that FCC assignments in the band from 450 to 460 mc. will follow a new plan which has not been employed previously. Each of the five services to occupy this band will have two widely-separated groups of channels. The lower group of each pair will be assigned to both base and mobile transmitters, while the upper group will be for mobile use only, as indicated below.

REMOTE BROADCAST PICKUP SERVICE

Base & Mobile		Mobile Only	
450.05	450.55	455.05	455.55
450.15	450.65	455.15	455.65
450.25	450.75	455.25	455.75
450.35	450.85	455.35	455.85
450.45	450.95	455.45	455.95

INDUSTRIAL SERVICES

Base & Mobile		Mobile Only	
451.05	451.55	456.05	456.55
451.15	451.65	456.15	456.65
451.25	451.75	456.25	456.75
451.35	451.85	456.35	456.85
451.45	451.95	456.45	456.95

LAND TRANSPORTATION SERVICES

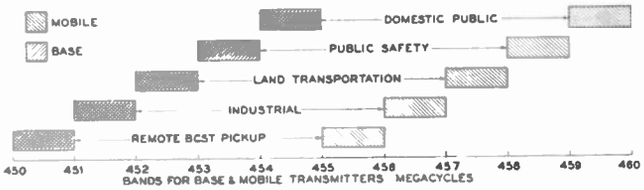
Base & Mobile		Mobile Only	
452.05	452.55	457.05	457.55
452.15	452.65	457.15	457.65
452.25	452.75	457.25	457.75
452.35	452.85	457.35	457.85
452.45	452.95	457.45	457.95

PUBLIC SAFETY SERVICES

Base & Mobile		Mobile Only	
453.05	453.55	458.05	458.55
453.15	453.65	458.15	458.65
453.25	453.75	458.25	458.75
453.35	453.85	458.35	458.85
453.45	453.95	458.45	458.95

DOMESTIC PUBLIC SERVICES

Base & Mobile		Mobile Only	
454.05	454.55	459.05	459.55
454.15	454.65	459.15	459.65
454.25	454.75	459.25	459.75
454.35	454.85	459.35	459.85
454.45	454.95	459.45	459.95



RELATIVE SPACINGS OF FREQUENCY GROUPS FOR THE 5 MOBILE SERVICES

Under this arrangement, systems using the same frequency to talk out and to talk back would be assigned to a channel in the lower group. Those using one frequency to talk out and another to talk back would be assigned one channel in each group. The groups are separated sufficiently to permit simultaneous transmission and reception without interference. This advantage in speeding message traffic is not generally available on VHF because, even when two channels are assigned to one system they are so close, in most cases, as to make duplex operation impractical. It will be very interesting to observe the results under operating conditions of this effort by the Commission to effect an improvement in allocations to the communication services on 450 to 460 mc.

WITH more and more large companies formulating plans to use microwave relay and point-to-point communication systems, the question of interconnecting privately-owned facilities through Telephone Company PBX boards assumes greater importance as a factor of system engineering, initial cost, and operating expense. This, it should be explained, is only a matter of connecting telephone instruments at terminal or relay points over the radio circuits. It does not involve calls placed through the Telephone Company's central offices.

Accordingly, we asked AT&T for official information on Company policy on this subject. In reply, we received what is probably the only official, public statement that has been made by AT&T concerning this important matter:

"The American Telephone and Telegraph Company, Long Lines Department, issued on April 9 to become effective May 13, revisions in its Tariff F.C.C. No. 134 (General Regulations Tariff for Private Line Services and Channels) covering the conditions under which communication facilities of power and pipe line companies will be connected with facilities of the Telephone Company. Similar tariff revisions have been filed by most of the Associated Bell Telephone Companies.

"Power and pipe line companies have special communications requirements since these particular industries involve constant control of operations essential to the public welfare and extending along lengthy intercity physical rights-of-way which are frequently located without regard to hazard or inaccessibility to communication facilities of the Telephone Company.

"In earlier days, the only practicable way of meeting these requirements in many cases was for the power or pipe line company to provide its own communications facilities along its right-of-way which, as indicated, often involved inaccessible, remote, or hazardous locations. In such cases, where connections with Telephone Company facilities were required, these were arranged for under operating agreements.

"These arrangements, which in many instances contemplated exchange and toll connections for the right-of-way facilities, were necessary exceptions to the Bell System Companies' general undertaking of providing and maintaining all facilities required in furnishing exchange and toll telephone service to the public. The tariff provisions covering these connections were filed in the Telephone Companies' exchange tariffs, since the customer facilities were connected with facilities used for exchange service, usually private branch exchanges furnished to the customer by the Telephone Company.

"Today the Telephone Companies are in a far better position to supply the services needed by the power and pipe line companies. The Bell Companies are confident that, in cooperation with their connecting Independent Telephone Companies, they can do so in a manner thoroughly satisfactory to these customers, and they are prepared to take whatever steps are required. This applies to all services which the Bell Companies offer.

"Recently, the general matter of connecting with Telephone

Company facilities under present-day conditions has been discussed with committees representing the power and pipe line companies, as well as with individual companies in these fields, and modernized operating arrangements have been cooperatively developed for application where communication facilities of the power and pipe line companies are to be connected with Telephone Company facilities. These arrangements may be briefly summarized as follows:

"Where a power or pipe line company wishes to have the Telephone Company do the full communications job, the Telephone Company will undertake to do so. In the infrequent cases where it is impracticable for the Telephone Company to provide certain portions of the right-of-way facilities (due, for example, to such factors as inaccessibility, remoteness, or hazard) the Telephone Company will connect with the customer's facilities along such portions, including exchange and toll connections.

"Where a power or pipe line company wishes to have the Telephone Company provide the right-of-way facilities, and time is required to permit an orderly disposition of existing privately-owned facilities, the Telephone Company will provide additions and extensions to, and will connect with, such privately-owned facilities during the interim period, including exchange and toll connections.

"Where a power or pipe line company wishes to use its own right-of-way communications systems, whether wire or radio, the Telephone Company will connect for PBX station or private line use, but not for exchange and toll use except in emergencies.

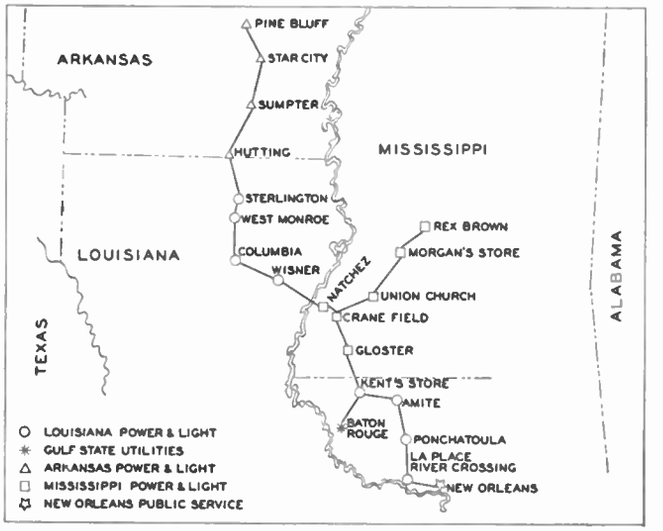
"The tariff modifications recently filed cover these revised connection arrangements applicable to power and pipe line companies."

The tariff referred to above does not set forth any specific requirements or performance standards, but it covers that subject in these general terms:

"The magnitude and character of the voltages and currents impressed on the Telephone Company channel by the customer-owned equipment and wiring, and the operation and maintenance of such equipment and wiring shall be such as not to interfere with any of the services offered by the Telephone Company or interfere with others. The characteristics of the customer-owned apparatus shall be such that its connection to the Telephone Company channel does not interfere with service over other Telephone Company circuits or channels, or impair privacy of conversations over such circuits or channels. In cases in which additional protective equipment is required, this shall be provided by the customer or by the Telephone Company at the customer's expense. Such equipment shall be suitable to avoid hazard of damage to Telephone Company plant or of injury to Telephone Company employees or to the public because of the character or location of customer-owned apparatus and of sources of power to which it is connected.

"The Telephone Company may, upon suitable notification to the customer, make such tests and inspections as may be necessary to determine that the above requirements are being complied with in the installation, operation, and maintenance of customer-owned equipment. The Telephone Company may interrupt the channel if at any time such action should become necessary in order to protect any of its services because of departure from these requirements."

TWO papers on microwave systems, now in course of preparation for COMMUNICATION ENGINEERING, will merit special attention from readers concerned with system engineering. One will describe the Freeport Sulphur installation on the Mississippi Delta. In addition to many unique operational features, this installation is unusual in that so much of it extends over water.



MIDDLE SOUTH MICROWAVE SYSTEM WILL SERVE FIVE POWER COMPANIES

The second paper will detail the system planning for the new $500,000 microwave relay to be installed by Gulf States Utilities and Middle South Utilities. A total of 16 repeaters and four terminals will extend over 490 miles, but multiplexed circuits will provide 11,700 channel miles. These will be used for private and party-line telephone, teletype, telemetering, supervisory control, and communication with mobile units. Some 40 unattended substations will be operated by remote radio control. The accompanying map shows the extent of the system.

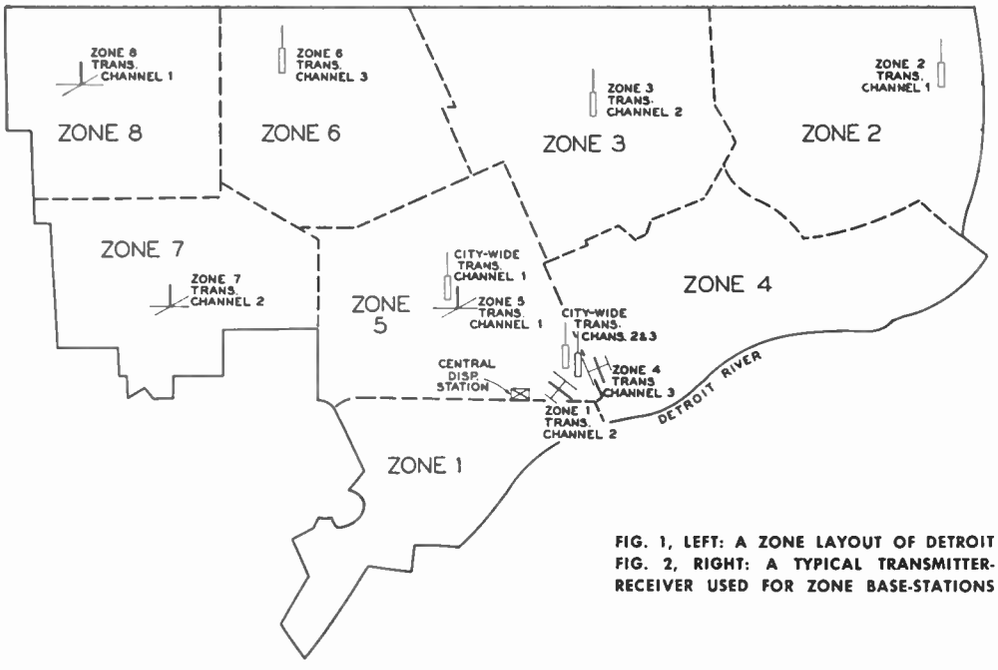
OFFERS by the Telephone Company to purchase public utility and pipe line radio systems, and to then rent such radio facilities to the original owners have more recently been extended to excursions into public safety and other special services. Such proposals have aroused strong opposition particularly among supervisors, chief engineers, and the maintenance men of state and municipal systems.

Principal argument against operation by the Telephone Company is that those now employed to operate and maintain radio systems would lose their jobs. That attitude is understandable, but it is not altogether realistic. If Bell System companies purchase and lease back such facilities, they will have to set up extensive radio installation and service departments, and they would undoubtedly find places for all the capable men displaced from their previous positions. As for wages—they would probably be higher. Thus, it does not appear that any reasonable objection can be raised on the basis of loss of employment.

There is, however, a totally different reason why each public safety, industrial and transportation radio system should be operated independently.

Presumably, strikes against the Telephone Company would affect the radio communication systems. In such an event, police protection of lives and property, and the operation of public utilities and transportation could be virtually paralyzed.

For example, municipal police radio plays an important part in quelling disorders. It would be such a simple matter to render a headquarters transmitter inoperative. State police and state highway patrol systems have many remote, unattended, and highly vulnerable transmitters. Public utilities, pipe lines, and industrial systems are using radio to an increasing extent as a means of operating remote, unattended controls. Fire and taxi systems are of vital importance under emergency conditions, particularly when any area must be evacuated. All these considerations add up to emphasize the necessity for independent, local operation.



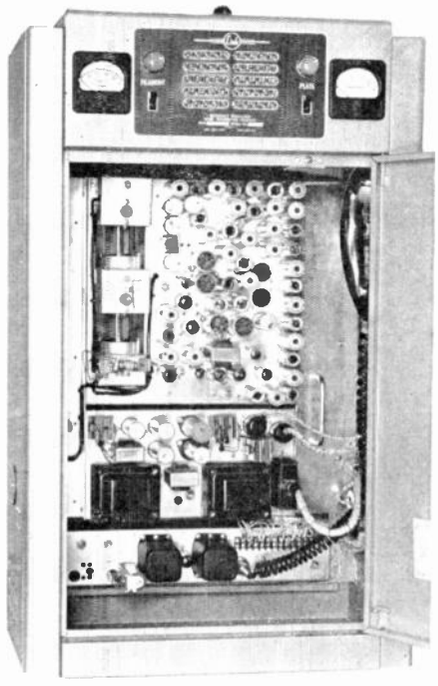


FIG. 1, LEFT: A ZONE LAYOUT OF DETROIT
FIG. 2, RIGHT: A TYPICAL TRANSMITTER-RECEIVER USED FOR ZONE BASE-STATIONS

Dispatching a Large Taxi System

HOW THE PROBLEMS OF LARGE FLEET DISPATCHING WERE SOLVED FOR THE DETROIT CHECKER COMPANY — SYSTEM DESCRIPTION — *By* JAMES A. CRAIG*

A little more than two years ago, the Link Radio Corporation was engaged by the Checker Cab Company of Detroit, Michigan, to design and install a 2-way radio system capable of handling the expected traffic. This was not a simple requirement to meet, since the fleet was made up of 897 taxicabs with an exceptionally high ratio of dispatched calls to cruising pickups. Our solution, therefore, may be of interest to others concerned with dispatching large fleets, and is accordingly narrated here.

System Facilities: Assuming that each cab worked two shifts per day, and handled 15 dispatched calls per shift, the radio system would have to be capable of handling 30 calls per cab per day, or a total of more than 25,000 calls per day.

However, since each day has its short peak-load period and longer slack periods, such a figure is not normally to be expected on a 24-hour basis. On the other hand, even if a 24-hour load of one half 25,000 calls per day were taken as representative, this would still mean over 500 calls per hour, or almost 10 calls per minute. Since peak loads could be easily double the average hourly rate, it became apparent quickly that this would be no ordinary radio system. One base station could not begin to handle such an amount of traffic. More important, the work load would have to be split up among many dispatchers. But to realize any advantage, dispatchers would have to be provided with simultaneous access to the radio facilities without mutual interference.

Working closely with cab company officials, we divided the city into zones. The ultimate number of zones and the area included in each zone was predicated on Checker Cab's traffic experience in Detroit. Every effort was made to distribute the traffic so that the present busy zones would not be overloaded and, at the same time, to provide zones in the outer fringes of the city that could absorb traffic growth to be expected from population shifts and the increased business accruing because of the advantages of taxi dispatching by radio.

After many changes in the quantity of zones and shifts in zone boundaries, the arrangement shown in Fig. 1 was made. It can be seen that eight zones are utilized and that three 425-mc. taxi channels are employed. Initially, two channels were planned, but it was impossible to arrange zones so that the same channel was not used in any adjacent zones. With three channels, zones operating on the same channel are always separated by a zone operating on a different channel.

Two requirements were given greatest importance in the development of the zone system: first, complete coverage of each zone by its associated transmitter; second, minimum signal overlap between common-channel zones. These requirements are virtually in direct opposition. A certain amount of overlap in one zone from another same-channel zone could be tolerated if unavoidable, provided that each transmitter signal would completely capture a receiver within its zone.

Meeting these rquirements involved many experimental checks on antenna heights, locations, and configurations, and variations in transmitter powers. It soon became obvious that transmitter power played a minor role in determining coverage at 450 mc. If line-of-sight transmission existed on a given circuit path 2, 20, and 40 watts produced nearly the same results. Therefore, the zone transmitters were all made standard 20-watt equipments.

Pattern-shaping was attempted, using phased coaxial and ground-plane arrays, to provide coverage without overlap according to individual zone shapes. Here also the results were unimpressive, for the same reason that transmitter powers made little difference in coverage. In using phased arrays to produce figure-eight, cardioid, or other patterns, a boost in power in some directions is gained at the expense of a power loss in other directions. Such arrays are not intended to form a beam or to completely eliminate radiation in any sector. Even though power had been thus reduced in a certain direc-

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tion no loss was noticed in mobile contact within the affected area, since power in itself is relatively unimportant.

The most important factor affecting coverage, in virtually all cases, was antenna height. Indeed, at antenna elevations of 60 to 75 feet, the coverage could be tailored in terms of 4 or 5 city blocks by changing antenna elevation 4 or 5 feet.

While this discovery solved a lot of problems, each zone had still to be evaluated on its own merits and peculiarities. Referring to Fig. 1, in zones 7, 8, 6, 3, and 2, non-directional antennas are used at elevations of 60 to 110 feet. Zones 7 and 8 use unity-power gain ground-plane antennas. However, in zones 6, 3, and 2, available transmitter locations with proper antenna height are not centered in the zones. These zones employ stacked coaxial arrays, which produce low-angle radiation at a power gain of 3 times.

Zones 1, 4, and 5 all intersect in the loop area of Detroit. There are many tall buildings which produce propagation shadows. For that reason the zone 5 transmitter is located as shown on the map, at an elevation of some 300 feet. Overlap into zones 2 and 8 occurs to a minor degree, but this is offset by the fact that complete coverage of zone 5 including its loop area is accomplished with almost no dead spots. In the cases of zones 1 and 4, no structure of comparable height existed in zone 1 although one was available and used temporarily in zone 4. In either event, antenna elevation would have increased overlap difficulties, particularly from zone 1 into zone 7. The final decision in the cases of zones 1 and 4 was to locate both transmitters at the top of the 400-foot David Stott Building, located at the center of the loop district. These transmitters excite yagi antennae trained down the centers of the respective zones. Each yagi is equipped with a vertical V-shaped metal screen, to minimize leakage in back and to the sides of the array.

City-Wide Transmitters: In off-load periods such as the early-morning hours, when traffic can be handled by possibly 2 or 3 dispatchers, the simple zone system would necessitate switching on the part of the dispatchers in selecting the zone transmitter proper for each call. To eliminate this objection, three 100-watt city-wide transmitters, one on each of the three channels and each capable of city-wide coverage, were provided. At first, all three transmitters were placed on the same building in the loop district where the zones 1 and 4 transmitters are located. Situating the city-wide transmitters at the same location with two zone transmitters was permissible since, by the nature of the dispatching technique, the zone transmitters would not be used when the city-wide transmitters were in use, and vice-versa. However, the roof of the Stott Building shadowed the channel 1 signal in the extreme northwest

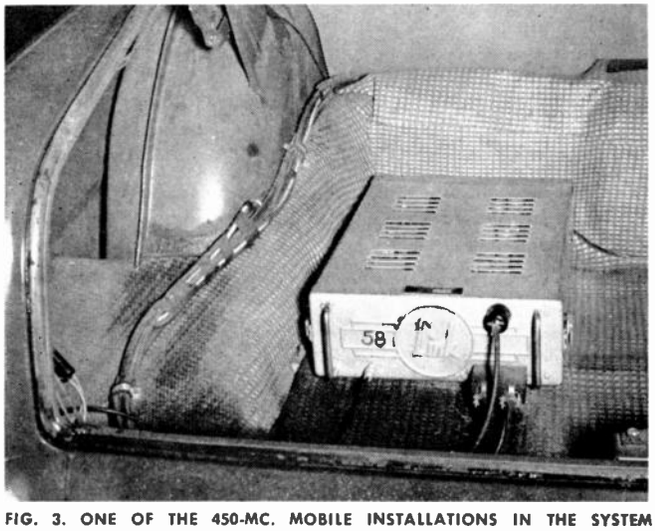


FIG. 3. ONE OF THE 450-MC. MOBILE INSTALLATIONS IN THE SYSTEM

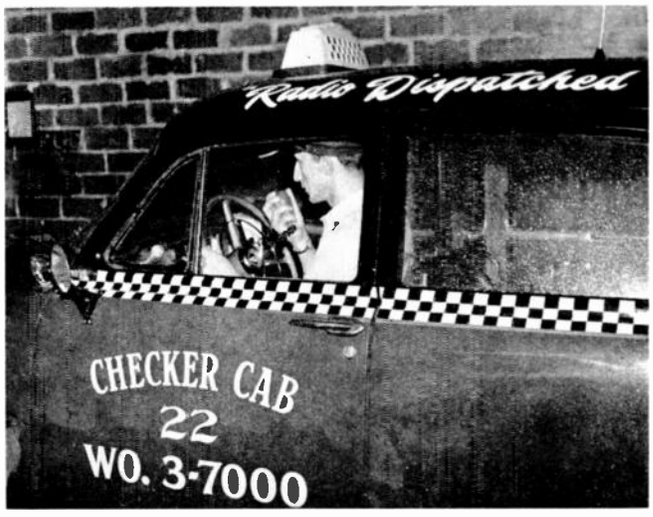


FIG. 4. ROOF-MOUNTED MOBILE WHIP IS LITTLE MORE THAN 1 FT. HIGH

corner of the city. This problem was overcome by the simple expedient of shifting the channel 1 city-wide transmitter to the location used for the channel 5 zone transmitter.

The three city-wide transmitters are used to provide three methods of operation: single-frequency coverage of the city on channel 2; east-west coverage on channels 1 and 2; and sector coverage, east, middle, and west, on channels 1, 2, and 3. This permits complete off-load servicing of the entire fleet by 1, 2, or 3 dispatchers, as required. In practice the east-west method of operation is normally used, although a city-wide transmitter can be temporarily pressed into service to cover for a disabled zone transmitter.

All city-wide antennas are stacked coaxial beacons with power gain of 5. No overlap problem exists under city-wide operation.

Equipment and Operation: The zone and city-wide transmitters are housed in 34 and 68-in. cabinets respectively. They are remotely controlled via leased two-wire lines from the central dispatching office, but can be operated locally by service personnel. A selector switch on the control panel of each transmitter is used to select remote or local operation, and also permits wire intercommunication between service personnel at the transmitter and the dispatching office. A zone transmitter-receiver cabinet can be seen in Fig. 2.

As required by the FCC, automatic instantaneous peak limiting circuits prevent deviation in excess of ± 15 kc. or any desired value below ± 15 kc.

All of the taxicabs are equipped with 10-watt transmitters using vibrator power supplies. Power drain is such that no heavy-duty generators or alternators are required. Each mobile transmitter-receiver is equipped with a selector switch located on the control head convenient to the driver. By means of this switch, a driver can instantaneously select any one of the 3 channels used in the system, depending upon his zone location. The operating frequency of the transmitter and the receiver are shifted simultaneously. Change of frequency is not accomplished by crystal switching, but by activating separate crystal-controlled oscillators through grounding the cathode of the desired oscillator. Fig. 3 shows a mobile installation in a taxicab luggage compartment. Mobile antennas are short whips mounted on the rooftops, Fig. 4.

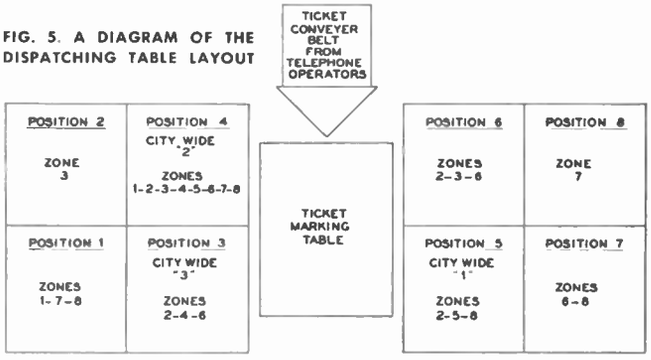
In practice, each driver is given a zone map similar to that shown in Fig. 1 so that he will become acquainted with the zone boundaries and will use the proper channel corresponding to his location. After a period of about a week the driver has memorized the boundary streets of the zones, and the map is no longer required. Boundaries were so arranged as to neces-

sitate a minimum of channel switching in the cabs when traveling down most main streets or avenues.

As traffic loads decrease from a peak period when the zone system has been in use, and the intent is to shift to one of the three modes of city-wide operation, each zone dispatcher broadcasts a general call to that effect to all cabs under his control. A similar procedure is followed for any other mode shift.

Considerable study was devoted to the dispatching and remote-control facilities associated with this system. In addition to providing normal switching and audio facilities, it was necessary to furnish means whereby the proper zone and city-wide transmitters could be made available to dispatchers as required by hourly traffic changes. Fig. 5 shows the dispatching table layout in its final arrangement. It can be seen that position 4 is the master position, at which one dispatcher can control one city-wide and all eight zone transmitters. At positions 3 and 5 are tied in one of the other two city-wide transmitters and three zone transmitters. Three zone transmitters can be controlled at each of positions 1 and 6, and two transmitters at position 7. Since all eight dispatchers will be working when positions 2 and 8 are in use, only one zone transmitter can be controlled at these positions.

FIG. 5. A DIAGRAM OF THE DISPATCHING TABLE LAYOUT



At all multiple positions the dispatcher has a turret before him on which appears an upper row of green lamps. These light upon receipt of a call from a cab, so that the dispatcher can tell in which zone the cab is located at the time. Rectified audio from the received call is utilized to operate a relay which, in turn, lights an associated lamp at all positions at which this zone transmitter can be controlled. The master position and a four-transmitter position can be seen in Figs. 6 and 7, respectively.

Below the green lamps are receiver selector pushbutton switches. The dispatcher can operate any or all the buttons and listen to cabs in any or all zones whose transmitters are controllable from his position. The extreme right-hand button in this row trips all depressed buttons, cancelling prior selections.

Transmitter selector buttons are located in the next lower row, each with its corresponding red lamp in the bottom row.

By depressing a transmit button the dispatcher can elect to use any transmitter controllable from his position. No more than one transmit button can be depressed at a time, since each button releases any other previously depressed. Thus, it is impossible for any dispatcher to put more than one transmitter on the air at a time.

Each dispatcher is supplied with a personal Western Electric type 52-AW operator's headset and microphone, which may be plugged into any table position. Each position also has a parallel jack to accommodate a supervisor's operator's set, if so desired. A volume control at each position makes it possible for each dispatcher to regulate the earpiece volume to suit his own hearing acuity. Foot switches are used to key the selected transmitter, leaving both hands of the dispatcher free to handle call cards, to notate which cab took a call, and to time-stamp and file the cards. Calls taken by telephone operators are carried by conveyor to markers, who distribute them to the radio dispatchers according to the zone in which each call is to be serviced.

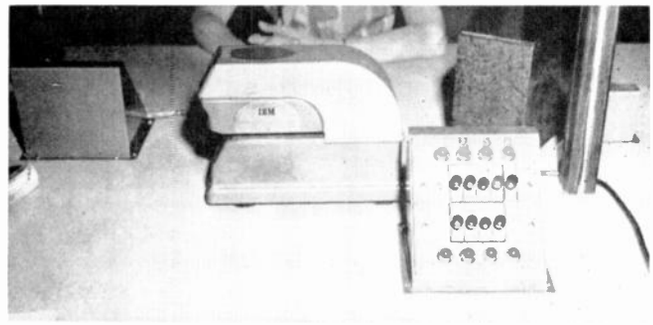


FIG. 7. TOP BUTTON ROW SELECTS RECEIVER, BOTTOM ROW TRANSMITTER

The remote-control units proper are located in a separate room. Eleven units, one for each transmitter in the system, are mounted on an open rack adjacent to the leased line terminations. Spare units are available to replace quickly any remote chassis in case of trouble.

Cables connect the remote-control chassis to the dispatching table and are so arranged at the table that terminations can be made at any given positions quickly and without tools. This was incorporated in the design so that the zone control terminations could be redisposed at the various positions to meet any future changes in traffic and dispatching patterns.

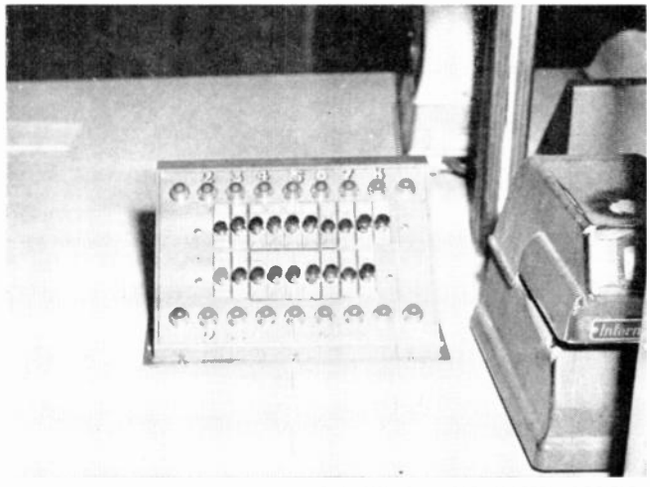


FIG. 6. CONTROL BOX AT THE DISPATCHING TABLE MASTER POSITION

Maintenance: The radio service shop, operated directly by the equipment manufacturer, is located in the Checker Cab Building. Facilities to repair and service all the equipments are available.

As is the case with almost all such systems when initially installed, the servicing problem was severe during the first few weeks of operation. Any latent defects in tubes, vibrators, or other components showed up then. However, after such a break-in period the servicing became a matter of periodic frequency checks and preventive maintenance. In fact, even though this system now has equipments in service for almost two years, the maintenance problem has turned out to be much simpler than expected for 450-mc. equipment.

As an example, the transmitters all use AX-9903/5894A tubes as tripler-amplifiers and power output tubes. Certain doubts existed as to the life expectancy of these tubes, particularly in mobile service. It has been found that they are much

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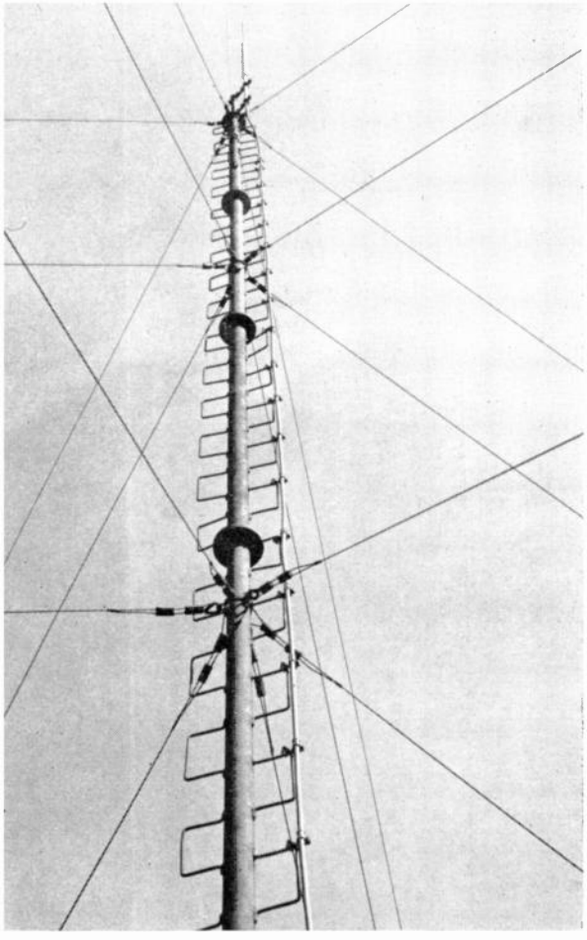

FIG. 2. THE SIXTY-FT. TOWER HOLDING MAIN DIPOLE HAS 18 GUYS

Construction of a Mountain-Top

Remote Base Station

OPERATING EXPERIENCE REVEALS FACTS OF LIFE ABOUT REMOTE TRANSMITTERS-*By* H. V. CHURCH*

THE Central Vermont Public Service Corporation installed a two-way radio system in the summer of 1946. This company serves the state on both sides of the Green Mountains, as shown in Fig. 1, and some sections of New Hampshire along the Connecticut River. Sixty-watt remotely-controlled fixed stations were installed at Bennington, Cavendish, Bethel, and Bradford, Vt., and at Claremont, N. H. The system is tied together by a 250-watt main station on Pico Peak, 4,000 ft. above sea level and northeast of the operating headquarters at Rutland. Mobile equipment was installed at first in 12 trouble trucks; since then, 2-way units have been put in all trouble trucks, all division superintendents' cars, several heavy five-man cab line trucks, a radio maintenance car, and two pick-ups, bringing the number to thirty-five. Additional fixed stations have been built at St. Johnsbury, Brattleboro, Springfield, Middlebury, Poultney, Randolph, and Rutland to obtain complete coverage of Central Vermont's territory.

Day-to-day operations consist of directing trouble and construction crews, handling switching orders to cut down service interruption time, and dispatching purchased power when wire communication is inadequate. Emergency communication during such disasters as the flood which struck Rutland in June, 1947, and the hurricane of November, 1950, put a premium on reliable two-way communications. In each case the radio system paid for itself many times over in property, time, and possibly human lives saved by fast restoration of the power system to normal operation.

The system has now been in operation for 7 years, so that we have amassed a great deal of operating experience and have learned much about remote mountain-top transmitters, the hard way. This article is written primarily for those who may be concerned with such remote transmitters.

Surveys and Procurement: Plans were made to establish a 250-watt main station on Pico Peak after a survey indicated that several smaller but more accessible hills nearer Rutland were not high enough to provide coverage into the Connecticut Valley. Although a temporary station in Sherburne Pass at 2,190 ft. gave fair coverage into the Connecticut Valley and good coverage into the Otter Valley west of the Green Mountains, the higher land north and south of the pass cut off coverage in those directions.

A test from the top of Pico was conducted in 1946, using for power a portable motor-generator set, and a 60-watt station transmitter. The equipment was transported a difficult 2½ miles on snow up the Long Trail with a horse and bobsled. A half-wave antenna was rigged a few feet above the ground, and communication was conducted with a mobile unit which traveled most of the outlying sections of Central Vermont's territory. Results indicated that Pico was indeed an ideal location, since there were very few areas where solid communication could not be obtained.

The idea, quite common at the time, that propagation in the frequency range of 40 mc. followed strict line-of-sight principles was soon abandoned. It was found that radiation was apparently diffracted over the horizon and reflected among the hills in such a way as to give good reception where it was not expected. One such location is along U. S. Route 5 on the Connecticut River, 3 miles above Fairlee, Vt. The road there is at the base of a 500-ft. cliff, cutting off completely any view toward Pico 44 miles away. A strong signal is received in this area from the present Pico transmitter, apparently reflected back from the New Hampshire hills across the river. The outer limit of satisfactory communication between mobiles and the Pico station is indicated by the heavy solid line in Fig. 1.

The survey convinced our Engineering Department that a 250-watt station on Pico was needed if the CVPS system were to be tied together reliably under all conditions. Preliminary plans were drawn up for a station which would be remotely controlled from Rutland by land-line over a distance of 12 miles. This required the construction of 2¼ miles of company-owned telephone line from the road at Pico Ski Area to the summit, and a power line of the same length. As an antenna tower, it was decided to re-erect a sixty-foot steel anemometer tower which had been used by the company some years earlier for a wind-survey program. This tower can be seen in Fig. 2. For a structure to house the radio equipment on the summit it was proposed at first to use a metal box at the base of the tower, which would be serviced by reaching inside. But engineers who had mountain-top experience in winter at the com-

FIG. 3. EQUIPMENT BEING BROUGHT TO THE MOUNTAIN TOP BY TRACTOR

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FIG. 1, ABOVE: COVERAGE OF CVPS AREA FROM THE PICO PEAK STATION

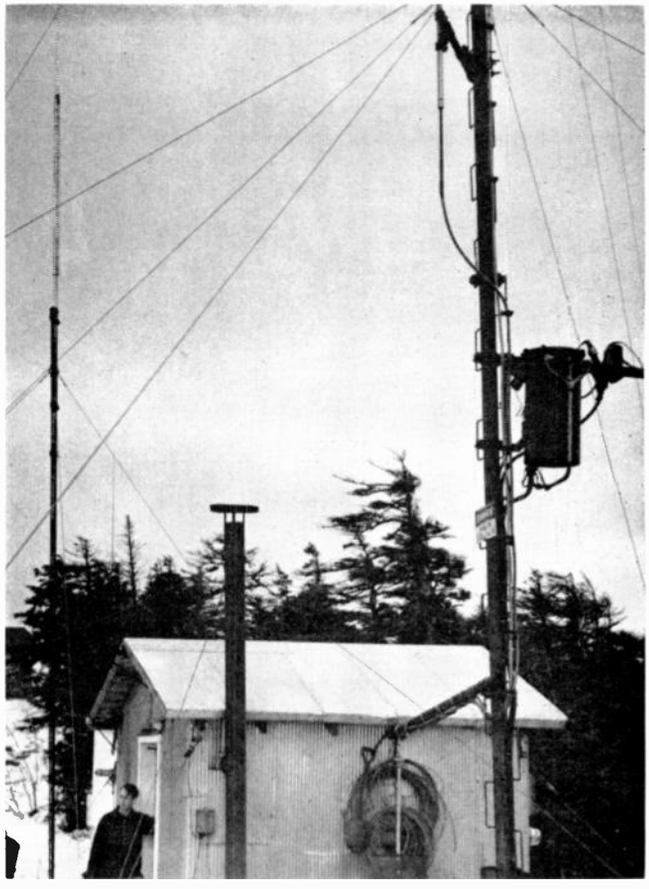


FIG. 4, RIGHT: EQUIPMENT HOUSE AND LIVING QUARTERS ON THE PEAK

pany's Grandpa's-Knob wind-turbine installation decided that the minimum requirements for safety of maintenance personnel, as well as the equipment, would be a fair-sized cabin capable of being heated and with room for emergency living quarters. An eight by ten-foot cabin seemed adequate.

Permission to use the land at the summit was secured from the owner on a yearly rental basis, including the right to bury cables under the ski trail leading to the summit. A contract was let to bury the cables, erect the tower, build the cabin, and transport all equipment to the top of the mountain. Work was completed in the autumn of 1946.

The equipment was hauled to the summit by tractors, in the manner shown in Fig. 3, using a heavy bobsled or dray. It was necessary to winch the tractor up the steepest places, then turn the tractor around and winch the dray. Later experience showed that the Sno-Cat was an excellent means of hauling supplies, equipment, and personnel up the mountain in winter. One trip was made in 15 minutes running time, as compared to two hours climbing on foot, or a full day with a tractor.

FIG. 5. EMERGENCY GENERATOR SHACK IS BUILT ON STILTS FOR WINTER

Line Installation: A heavy, tractor-drawn plow dug a trench some 18 ins. deep to receive the cables. In difficult places, including the top half-mile, most of the digging was done by hand and at times involved hacking out loose rock. Twelve thousand ft. of armored, grounded cable of 7,200-volt rating, with a No. 6 copper center conductor, was buried in the trench. Junction boxes were installed on posts at the side of the trail. Plastic-covered mine cable for the control circuit was buried at the same time and brought out each 1,000 ft. to junction boxes with removable disconnects for testing. Standard protective telephone equipment was installed at each end, consisting of carbon blocks and 7-ampere fuses. Loop resistance of the entire control circuit — 2¼ miles of buried cable, 10 miles of telephone company open wire, and a few blocks of enclosed cable — was 3,600 ohms.

The distribution line available at the foot of the mountain was a 2,300-volt ungrounded system; two 2,300/110-volt transformers were installed back-to-back to obtain 2,300 volts grounded for the cable, which was connected to a suitable step-down transformer on the summit. A grounded line is desirable in an installation of this kind for several reasons: 1) It is less costly to bury the cable in an existing trail or road than it would be to run open wire, which would involve clearing a right-of-way; 2) the problem of maintaining open wire is much more severe, entailing exposure to wind, falling trees, brush, lightning, and frequent heavy icing for several months in the winter. Grounded cable, on the other hand, has none of these difficulties, is fairly simple to install, and gives an excellent ground for lightning protection of the radio equipment. Disadvantages of a grounded cable are the possible hazard of uprooting by tractors on the right-of-way and the relative difficulty of locating troubles that do occur. We consider that both are far outweighed by the advantages of a properly-installed underground cable.

The two-wire control circuit worked out quite well for a year or so, then troubles began to appear in the form of leaks

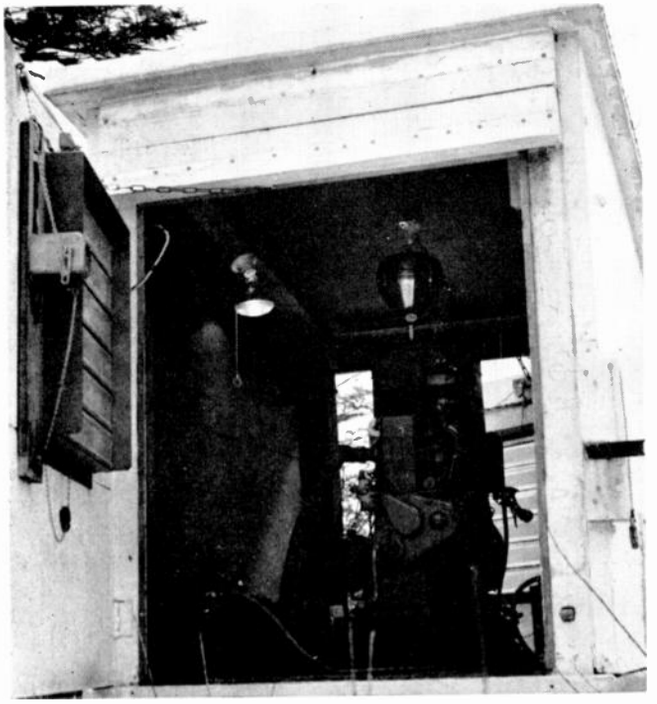
to ground. These caused an unbalance which produced a 60-cycle hum on received and transmitted signals. Eventually they resulted in enough leakage so that the DC control voltage necessary for relay operation dropped below the critical value, and Rutland was unable to put the station on the air. The upper ¾ mile of cable was laid in very rocky ground; the leakage was apparently caused either by the frost action grinding the cable between rocks (with which it was mostly covered) or by abrasion of the insulation when the cable was uncovered. Most of the control line was replaced eventually by twisted-pair field telephone wire strung through the brush in 1,000-ft. lengths between test points, which proved to be much more reliable than the underground cable. Still later, to avoid the loss of communications that resulted from troubles on the 12-mile telephone circuit, radio relay equipment in the 72 to 76-mc. band was installed.

Station Facilities: The building erected to house the radio equipment at the summit is of frame construction and is covered with one-inch boards, with corrugated aluminum sides and a sheet-aluminum roof. Fig. 4 shows this clearly. The roof is double-boarded to withstand falling ice from the antenna mast. In this case, aluminum was the ideal covering material, because it was easily transported and affords protection against the weather. Additionally, it frustrates porcupines which like to gnaw on wood around camps and outlying buildings. The structure is guyed at each corner against the wind.

With the building covered by metal, a 60-ft. mast a few feet away, a network of guy-wires overhead, and all equipment grounded to the sheath of the power cable, the station is well protected from lightning and has never been damaged by it. Another station in a similar location lacks the metal-covered building and adequate grounding arrangements, and has experienced repeated cases of severe lightning damage in the last several years.

A 1,500-watt gasoline motor-generator is furnished to supply emergency power to the station. It starts automatically if the power from the cable fails. This generator was housed in the main building for several years, but had to be moved to another enclosure in 1950 to make room for the relay equipment. The generator house was built in Rutland as sections, which were assembled on the Peak. The framework is of 2 by 2-in. pine covered with masonite, Fig. 5. Rock wool was used for insulation. The house has a door at each end with fixed louvres, behind which are a wire-mesh insect screen and movable light aluminum ventilator louvres 18 ins. square, which can be seen in Fig. 6. These are operated by furnace damper controls, which in turn are controlled by a thermostat adjusted to 70° F. Either positive opening or positive closing against the weather is obtained.

FIG. 6. VIEW OF GENERATOR SHACK THAT SHOWS VENTILATING LOUVRES



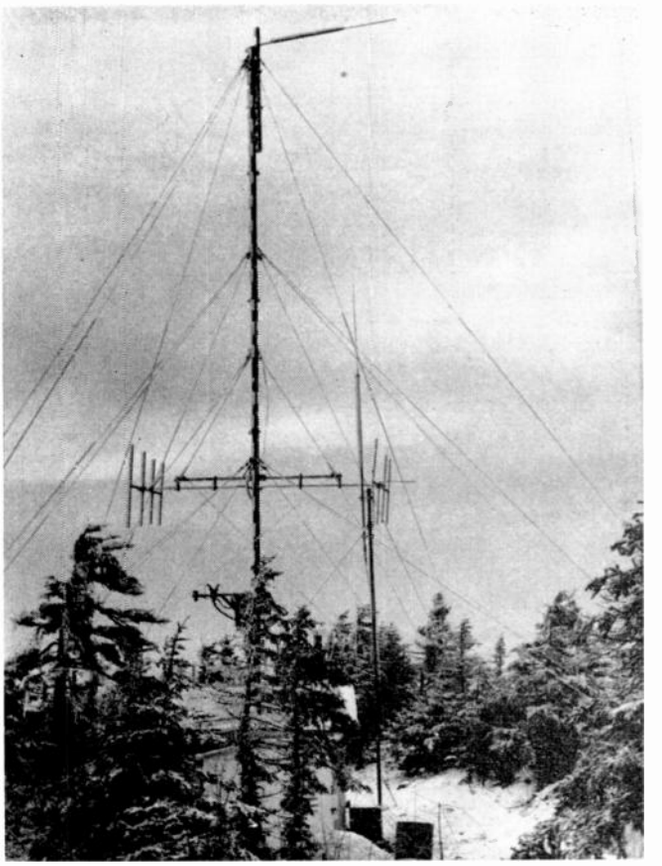


FIG. 7. DIPOLE AND YAGI ANTENNAS BROKEN BY SEVERE WINTER STORM

The generator house, which was taken up the trail on a horse-drawn sled and assembled on the summit, is set up on legs so that it will be more accessible in the snow season. The motor-generator, its 28-volt starting battery, a time-clock controlled charger, heat lamps, and an automatic fire extinguisher set for 212° F. are installed in the building. An alarm circuit is connected to key the relay transmitter and modulate it with an 800-cycle tone for five seconds every five minutes, indicating that the station is on auxiliary power. The plant will operate the station on an emergency basis for a day on less than ten gallons of gasoline, which is stored underground in a 55-gallon drum. It has been found that if the generator is called on to operate more than an hour or so at a time on very hot summer days, the ventilation louvres are inadequate, and either an exhaust fan or larger ventilators are needed. At present an arrangement has been made with a State employee who occupies a camp nearby, to open the doors of the generator house when necessary.

Tools and equipment kept at the station include tackle for rigging antennas and guys, safety belts, hard hats for working outdoors when ice is falling from the mast, work gloves, rubber gloves for any work on the transformer or cable, a complete set of small hand tools, 100-watt and 500-watt soldering irons, a blow torch, a saw for cutting firewood or making repairs, a dirt shovel and a snow shovel, an axe, a digging bar, hardware guy wire and clamps, a spare 10-kva transformer, cutout, and lightning arrestor, and a few items of spare clothing. There are a tube tester-analyzer unit, spare tubes, fuses and small components, replacements for all relays, front-end transformers for the receivers, $^3/_8$ and $^7/_8$-in. flexible coaxial cable and fittings, antennas, whips, and mounting hardware. In case it becomes necessary to maintain a crew overnight or for several days, as has happened in the past, there is a week's supply of canned and dehydrated foods and drinking water, adequate for two men, as well as folding

cots and sleeping bags. An electric circulating heater and hotplate are supplied. However, a small sheet-iron stove, a supply of dry firewood, and a one-burner gasoline stove for cooking are on hand for use when the station is on auxiliary power.

Maintenance Considerations: In 1947 a severe flood occurred and some of Central Vermont's generating, transmission, and substation facilities were damaged, as well as the Rutland operating headquarters. The dispatching office in Rutland was under water and, without a radio control unit or power with which to run it, communication was maintained by means of a mobile unit which dispatched orders to Pico, where company personnel relayed them to the rest of the system. The station was on emergency power for five days, during most of which time the traffic averaged two messages a minute. The motor-generator set was indoors then, and the heat and fumes were so severe that the operator had to spend most of his time just outside the doorway. During this period the radio was used to call in crews from other divisions and coordinate the work of restoring electric service to the Rutland area. Radio again proved indispensable during an unusually heavy sleet storm on December 31, 1948, when land-line communication facilities were disabled and many power lines failed. November 25, 1950, was the day of the great land storm that swept northern New England and attained the proportions of the worst hurricanes, but did not originate over the ocean and accordingly was not expected to be so severe as it was. Some local areas were struck by winds as damaging as those associated only with tornadoes; many houses and large dairy barns were destroyed as well as hundreds of miles of wire lines in Vermont, New York, and New Hampshire.

During the resulting emergency and clean-up periods, FM radio was the only communication facility available to CVPS and it was used to the utmost. The rural distribution line from our East Pittsford generating station, which serves the cable to the summit of Pico, was covered with several hundred fallen trees and was out of operation for a week. Also, the main antenna and later Nos. 1 and 2 emergency antennas were carried away. Two men were sent to try to keep the station on the air. No. 2 emergency antenna, consisting of a mobile whip mounted on the peak of the roof, was still in place when the men arrived. This was connected to the main transmitter and the station was operated on emergency power. During the night even the mobile whip carried away, and it was necessary to replace it at the height of the storm. The men who were on the mountain that night felt that the guys on the corners of the building were a fine idea; the building rocked and strained at the guys, and the window was reinforced on the inside when it appeared that it was about to be blown in.

On the 26th, the wind calmed down considerably. As the air became warmer the ice on the mast began to fall off, with several large masses landing squarely on the roof of the building. The emergency dipole antenna, which is on an 18-ft. length of pipe, was let down and the whip was replaced. This, of course, gave the station much better coverage. On the 28th the station was still on emergency power, the weather had become colder, and the dry wood for cooking and heating the cabin was all gone. Distribution lines to the foot of the mountain were still in bad shape. A government-surplus 10-kw. motor-generator, located with the assistance of the State Police and the Civil Air Patrol, was connected through a 120/2,300-volt transformer to the feed cable leading to the summit. This supplied power sufficient that the nearby State Police radio was able to get back on the air, and the CVPS emergency power plant was shut down. The men stationed on the mountain were kept there two days more until the distribution line was restored. Fig. 7 shows the broken main antenna and the damaged Yagi, which was being used at that time for the relay receiver. The broken dipole and its clamp are shown in Fig. 8.

Perhaps the biggest problem in maintaining this station has been that of keeping antennas up during the winter. We are of the opinion that the combination of high wind and heavy icing is too much for any commercially-available antenna. While some antennas are guaranteed for ½ in. of clear ice loading and 100-mph. wind velocity, and will undoubtedly stand it, the specifications for this climate and altitude should be 10 ins. of rime ice loading and 200-mph. wind velocity, with a suitable safety factor for gusts and metallic fatigue. Winds in excess of 200 mph. have been measured on Mt. Washington, N. H., which is about 2,000 ft. higher than the highest of the Green Mountains; ice coatings of 10 ins. occur *frequently* at 4,000 ft. Rime ice builds up during a storm to great thickness on one side. Then, the wind shifts as the storm clears, and the sail area presented by this ice causes too great a wind load on the antenna.

Another maintenance problem, and the greatest limitation of the station during bad storms, was the land-line control circuit used originally. This often failed when it was needed most. When power company lines are down, telephone lines are usually down too. Troubles were frequent, particularly on our underground phone line, and repairs were slow. It was finally decided to install 72 to 76-mc. radio relay equipment. Two frequencies are used: one receiver on the mountain operates a squelch relay which keys the main transmitter, and the main station receiver has a squelch relay which keys the relay transmitter to Rutland.

At first it was believed necessary to use directional antennas for the relay. Two heavy brass Yagis, vertically polarized, were placed at the ends of a 15-ft. pipe, which was rigged as a yardarm about 25 ft. up the main mast. The Yagi antennas would presumably permit us to operate at the lowest possible power and help to obviate possible television interference to Channel 4. When the equipment was first energized it was found that the frequency assigned for reception at Pico was being used by a New Hampshire system, with several mountain-top stations. The Utility Radio Association of New England, the frequency-coordinating group for our service, has all it can do to keep the base station and mobile frequencies under its cognizance, and makes no attempt to coordinate relay frequencies. Apparently the FCC assigns relay frequencies on the basis of recommendations of the equipment manufacturers, who often help their customers with system engi-

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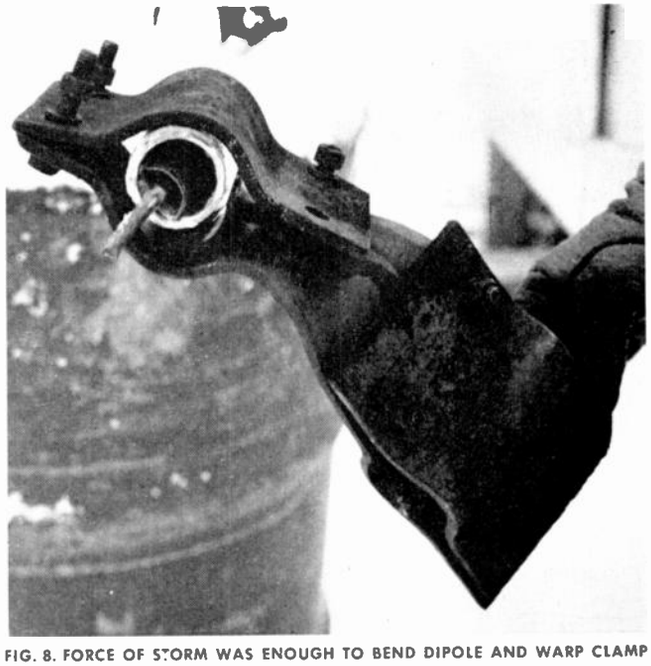


FIG. 8. FORCE OF STORM WAS ENOUGH TO BEND DIPOLE AND WARP CLAMP

N1 Carrier Equipment Design

DESCRIBING FEATURES OF N1 CARRIER EQUIPMENT EMPLOYED BY BELL LABORATORIES TO EFFECT PRODUCTION ECONOMIES — *By* W. R. STEENECK*

Progress in telephone apparatus and radio equipment design seem to follow converging paths, each contributing something to the other. Bell Laboratories started in the telephone field and adopted radio as an accessory means of transmission. More recently, radio manufacturers have borrowed telephone-circuit techniques for remote controls and multiplexing. The N1 equipment, described by Mr. Steeneck, while it looks more like radio than telephone apparatus, is a most interesting example of economy in manufacture, testing, service, and also in cubic contents. And those gains have been achieved, it should be noted, as part of a program to increase reliability and to reduce the duration of outages.—EDITOR.

A basically new approach in telephone equipment design has been introduced in the development of N1 carrier. Instead of following the conventional practice of using a number of relatively large panels arranged for permanent relay rack mounting, the major transmission components are packaged as small, lightweight, compact units which plug into a common framework to form a complete system terminal or repeater assembly.

This fundamental concept has made possible a design that has a number of distinctive features and advantages. These include the extensive use of die castings, a new method of mounting pigtail type apparatus, application of plug-in design to essentially all transmission elements, maximum use of available space, and the assembly of complete terminals or repeaters in single packages convenient for engineering, installation, and testing. These features have made possible a twelve-channel cable carrier system sufficiently low-priced to permit widespread use on short routes formerly outside the economic range of carrier facilities.

Use of aluminum die castings instead of fabricated designs for the relatively complex chassis required, and the new method of assembling pigtail components are large factors in the reduction of assembly and wiring costs. The advantages of aluminum die castings, in addition to the cost reduction factor, include dimensional uniformity, which provides interchangeability of parts; light weight, so essential in a plug-in design; chassis of complex construction that would not otherwise be obtainable; and the incorporation of equipment identifications in the dies, thereby eliminating subsequent stamping or adding this information as a separate operation.

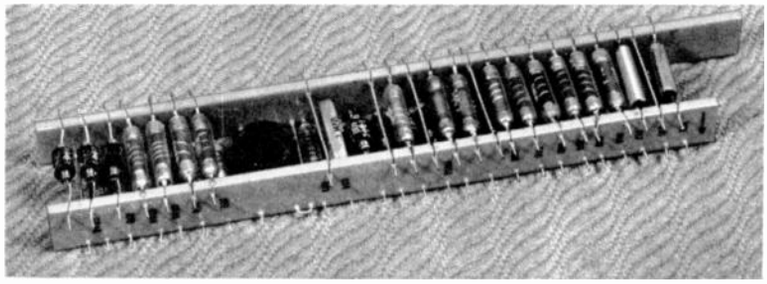


FIG. 1. SMALL COMPONENTS ARE MOUNTED EMBEDDING LEADS IN PLASTIC

Mounting of pigtail components, such as resistors and capacitors, is accomplished by imbedding the leads of these components in two parallel thermoplastic strips, as shown in Fig. 1. Simple assembly jigs position the strips and components so that the terminal leads rest on the edges of the strips. The jigs are then placed in a machine which, by applying a slight pressure to a heated shoe, imbeds all the terminal leads into the plastic material, and at the same time shears off the excess length of the leads. The entire operation is completed in a matter of seconds. As indicated in Fig. 1, components can be assembled on both edges of the strips by turning over the assembly and repeating the process. Such assemblies in type N contain as many as 40 or 50 parts, but the process can be expanded for larger assemblies if necessary.

Use of small, lightweight apparatus components has made possible a compact plug-in unit that can be removed from service when not operating properly, and replaced by a satisfactory unit, thereby restoring service with a minimum of lost circuit time. The defective unit can then be removed to a cen-

*Transmission Systems Development, Bell Telephone Laboratories, 463 West Street New York 14, N. Y. This text appeared originally in the *Bell Laboratories Record*.

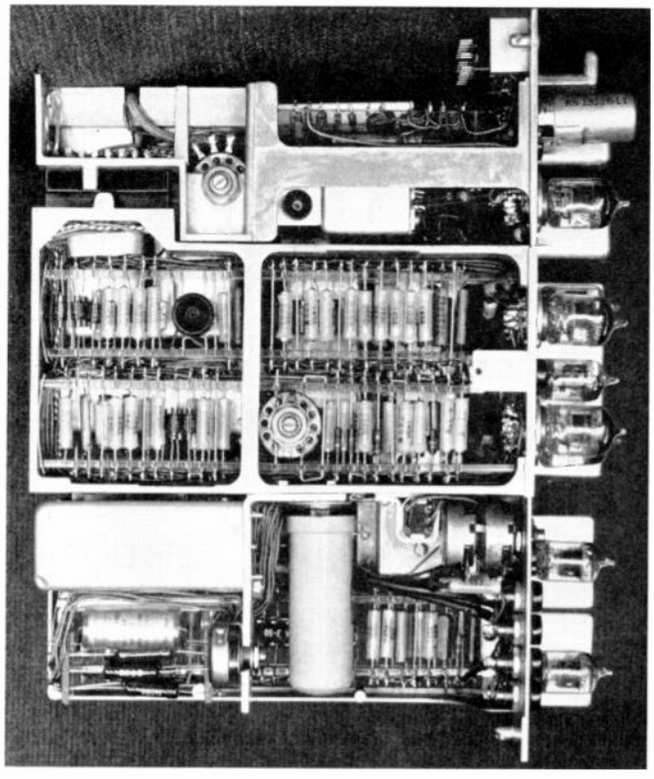
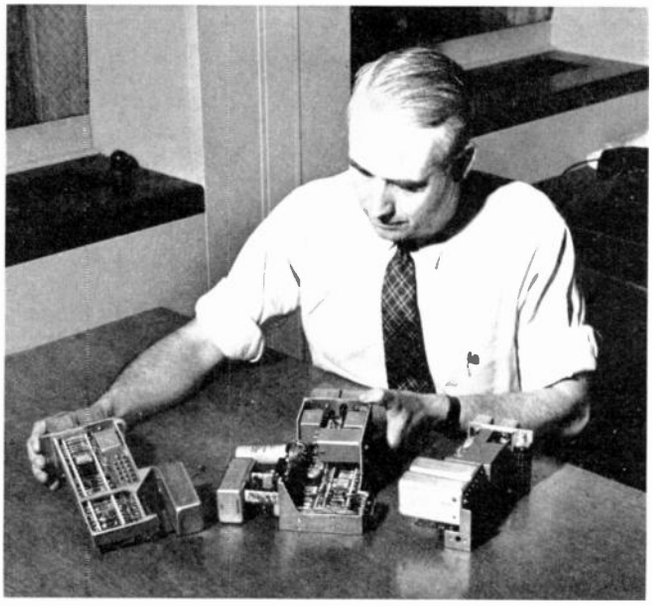


FIG. 2, LEFT: COMPLETE CHANNEL UNIT; 12 PER TERMINAL ARE REQUIRED
FIG. 3, BELOW: THE THREE SUBASSEMBLIES MAKING UP A CHANNEL UNIT



trally located maintenance center for repairs. At these maintenance centers complete tools, testing equipment, and experienced personnel permit efficient servicing at lower cost than if repairs were made at the equipment location.

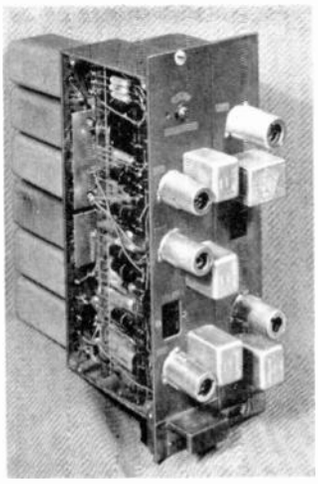
Miniaturization, although providing the advantages mentioned, introduces a more severe problem in obtaining adequate accessibility of all parts for shop assembly and field maintenance than had existed previously on permanently-mounted equipment in which the apparatus is located on flat panels. The solution of this problem was to make the various plug-in units in the form of two or three subassemblies, each of which consists of a logical circuit subdivision. Each subassembly is completely assembled, wired, and tested in the shop, and it is terminated in plugs and jacks to provide ready assembly into a complete unit.

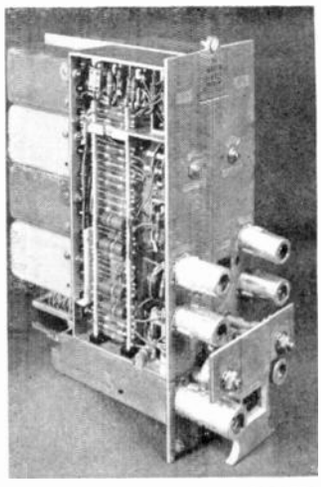
It was realized from the beginning that the use of compact, miniaturized construction would introduce heat dissipation problems. Many type N repeaters are pole-mounted, where there is no power available for cooling fans that could otherwise be used. Large terminal installations pose a particularly serious problem in this respect. In these installations, blowers are provided at the bottom of the racks, with ducts to carry the air up each side of the rack. These ducts are slotted so as to direct the cooling air toward the heat producing areas.

To minimize heating effects, all plug-in units are so designed that heat-producing apparatus, such as electron tubes, power-adjusting resistors, and potentiometers are mounted on the faces of the chassis, and non-heat producing and heat sensitive apparatus at the rear. Heat-producing apparatus has also been arranged to permit the natural flow of heat from floor to ceiling to be as unimpeded as possible.

Plug-in units consist of the channel, group, and repeater units. Twelve channel units are required for each N terminal; these are all identical except for the receiving filters and the crystal unit that determines the channel carrier frequency. There are four types of group units. For a terminal that transmits high-group frequencies and receives low-group frequencies, there is a high-group transmitting unit (HGT) and a low-group receiving unit (LGR). For a terminal that transmits low-group frequencies and receives high-group, there is a low-group transmitting unit (LGT) and a high-group receiving unit. (HGR). There are two types of repeater units, the high-low repeater (H-L) which receives high group frequencies from the line and modulates them with 304 kc. to low-group frequencies, and the low-high repeater (L-H), which translates low-group frequencies to high-group.

The channel unit shown in Fig. 2 contains all the apparatus, including that required for signaling, for one channel. This unit is made of three die cast subassemblies: 1) the compressor, or voice-frequency transmitting subassembly; 2) the expandor, or voice-frequency receiving subassembly, and the signaling equipment; and 3) the carrier frequency subassembly. The first two subassemblies are identical for all channels and are now wired and equipped so that they can be used also for channel units in the type O carrier system. These subassemblies are terminated in plugs and jacks so that they can all be connected together to form one complete unit. A partially disassembled view of the channel unit is shown in Fig. 3.



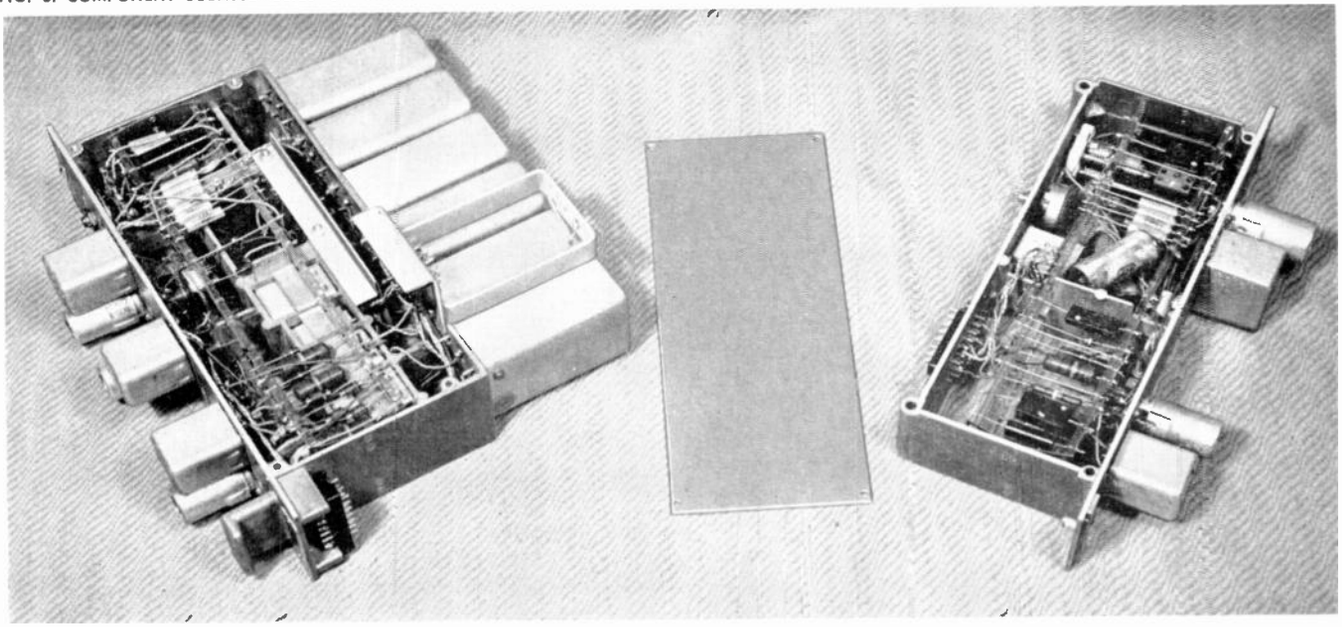


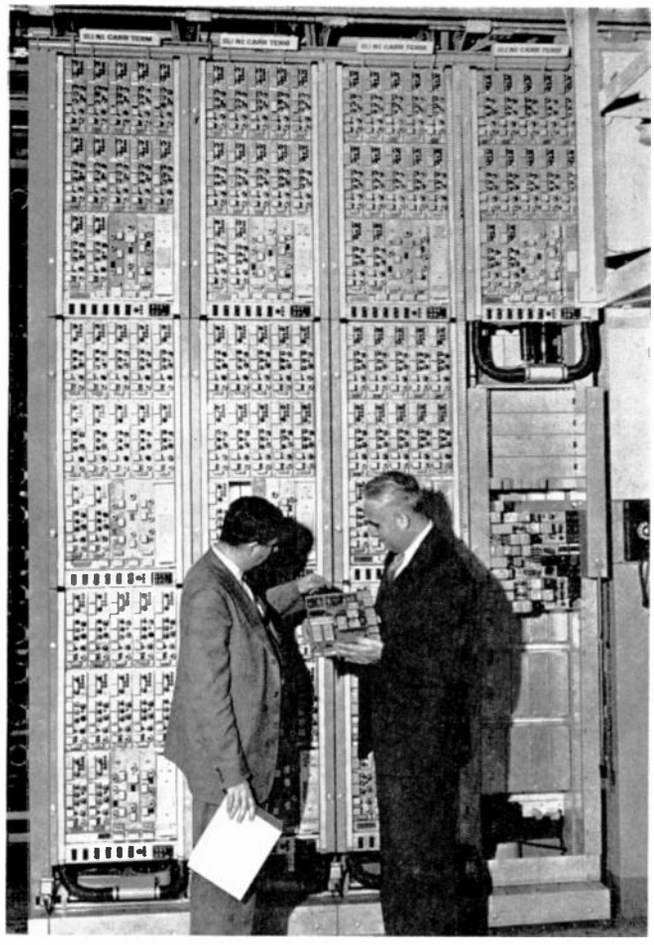
FIGS. 4, LEFT, AND 5, RIGHT: GROUP RECEIVING UNIT AND A REPEATER

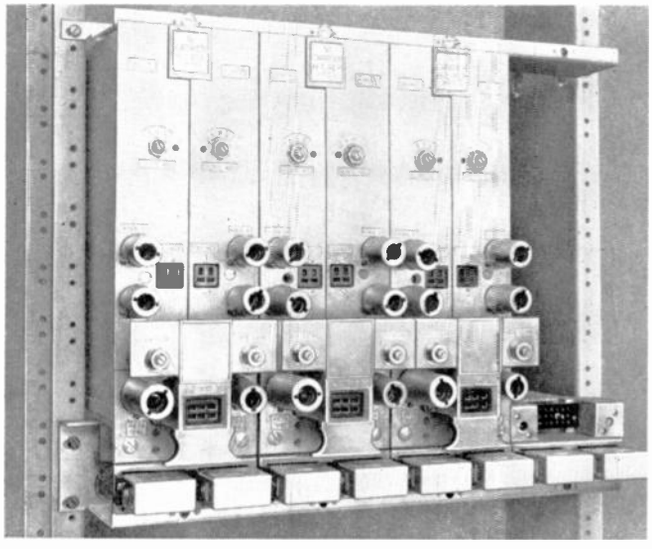
Transmitting and receiving group units combined contain the transmitting and receiving amplifiers, the group modulator, which can be used either in the transmitting or receiving branch, the signaling oscillator, and the carrier alarm circuit. A single group unit consists of a combination of three of the following die cast subassemblies: 1) high-group transmitting, 2) low-group transmitting, 3) high-group receiving, 4) low-group receiving and 5) oscillator. The oscillator subassembly contains the 304-kc. carrier oscillator and the 3,700-cycle signaling oscillator. It can be plugged into a low-group transmitting subassembly or a low-group receiving subassembly, the combination being provided with a common cover to form an LGT or LGR unit. High-group transmitting and high-group receiving subassemblies are not associated with an oscillator, since the required frequency band is received directly from the channel units. With their individual covers, therefore, they are complete HGT and HGR units. Fig. 4 is a view of an LGR group unit. Fig. 6 is a partially disassembled view of this unit.

The H-L and L-H repeaters each consist of three subassemblies. In the H-L repeater a West-to-East high-to-low amplifier and modulator subassembly, and a similar East-to-West subassembly, are plugged into a common 304-kc. oscillator and voltage regulator subassembly, all mounted under a common cover. The L-H repeater is similar to the H-L

FIG. 6. COMPONENT SUBASSEMBLIES OF GROUP RECEIVING UNIT, USED AT A TERMINAL THAT TRANSMITS A HIGH GROUP AND RECEIVES A LOW GROUP







repeater except that the amplifier and modulator subassemblies are designed for low-to-high conversion instead of high-to-low. An assembled repeater is shown in Fig. 5 and a partially disassembled view in Fig. 7.

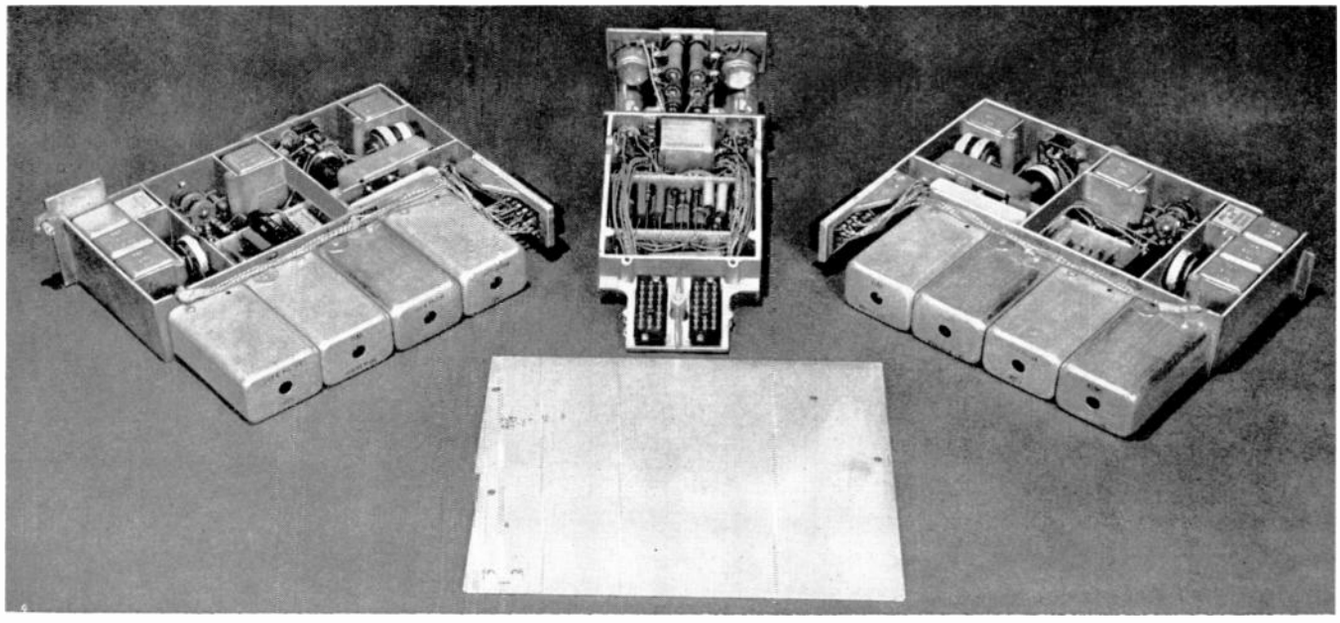
A complete N terminal, as shown in Fig. 8, consists of twelve channel units, a group transmitting unit, a group receiving unit, and miscellaneous equipment such as power fuses, voltage-adjusting facilities, alarm lamps and relays, and test power jacks. The terminal assembly consists of a fabricated aluminum framework that contains the jacks required for the associated plug-in units. These jacks are wired to terminal strips for external connections, and also to the power supply fuses and alarm circuits.

Installation, therefore, only requires making the outside connections and plugging the proper units into their associated jacks. Channel units for channels 1 to 5 are plugged into the top row of jacks, channels 6 to 10 into the middle row, channels 11 and 12 at the left side of the bottom row, and the transmitting and receiving group units to the right of channels 11 and 12. Additional jacks are associated with the group unit jacks, so wired that these units can be tested and replaced without interruption in service. Mounting can be accomplished on any relay rack that will carry 19-in. panels, and three complete terminals can be mounted on a standard 11½-ft. bay.

Repeaters are designed to mount four across a 19-in. relay rack bay. The jacks which the repeaters engage, instead of being located on the mounting framework are assembled on a die-cast bracket, which is fastened to the rack by screws. Fig. 9 shows three repeaters in position and space for one additional repeater. In addition to the regular repeater jacks, the bracket contains two additional jacks for testing and replacement of the repeater without interrupting service, an arrangement similar to that provided for group units. The bracket also mounts span pads, or artificial lines for building out the line loss to the required value, all completely wired to a terminal strip. Use of plug-in repeaters and the assembly of all associated elements on a removable bracket provides accessibility, and permits complete maintenance of an individual system without the hazard involved in working on or near other equipment in service.

Throughout the development of the N1 carrier system, accent has been placed on small, compact, inexpensive plug-in units requiring a minimum of installation effort and capable of immediate replacement, when necessary, with a minimum of lost circuit time. The result of these efforts has been a high-quality carrier system that has proved economically feasible on short routes.

FIG. 8, TOP: A COMPLETE N TERMINAL, OCCUPYING FOUR 19-INCH RACKS
FIG. 9, LEFT: SPECIAL BRACKET USED TO MOUNT FOUR REPEATER UNITS
FIG. 7, BELOW: DISSEMBLED AMPLIFIER AND MODULATOR IN A REPEATER



FCC Philosophy Underlying the Regulation of

Safety and Special Radio Services

PART 2: WHILE POLICIES REFLECT PAST EXPERIENCE, THEY ANTICIPATE GREAT EXPANSION AND TECHNICAL PROGRESS — *By* EDWIN L. WHITE*

It is clear that recommendations from industry groups assist the Commission's staff materially, since otherwise a detailed investigation would have to be made in each community in every case. Even if the Commission were staffed so that such investigations could be made, which it is not, it is believed that it would still be desirable to seek the advice of local groups as to the assignments of frequencies. For example, there are many communities that are equally entitled to police radio frequencies who are traditionally and politically always at dagger's point. On the other hand, in the same area there may be communities that have always worked together and supported each other in every municipal project. Certainly, if sharing must be resorted to, it would be better for the latter to share rather than the former. The Commission could never know all these factors unless it made actual field investigation and perhaps not even then, as sometimes these jealousies are not obvious. Although the sharing pattern as developed under the guidance of industry committees may not be the best in the world from an engineering point of view, it probably is the best practical pattern that can be worked out.

The licensee must assume responsibility for working out interference problems with those sharing his frequency, and for anything that he does which infringes on the rights of others. If he does not adjust and maintain his equipment properly, he may create interference in areas where otherwise good communication would be possible. If he sends messages by radio that either need not be sent at all, or could be sent by means other than radio, he is depriving someone else of the opportunity to send necessary traffic. If he fails to train his personnel, and permits the use of unnecessary words and involved procedure, or if he does not organize his communications system efficiently, he will take an unwarranted amount of time on the air, at the expense of others. In short, in these services the licensees must realize that the use of radio is on a party line basis, and that it is not a tool of competition except in the sense that those who do not avail themselves of the privilege of using radio may find that their operations are not as efficient as the others. In spite of the fact that two industries sharing the same frequency may be bitter competitors for business, they must cooperate in the use of the radio spectrum to obtain utmost efficiency in its use.

As has been stated, the purpose of the Commission's rules is to specify those who are eligible to obtain authorizations, to define the services which they are authorized to render, and to provide those technical standards necessary for various services to share a limited frequency spectrum. There should be no over-regulation. However, it is a continual struggle to avoid it. There is a large number of persons in this country who seem to think that to meet any type of circumstances, "there ought to be a law." For example, the Commission has been urged to establish standard operating procedures for various industries. These proposals have been made by those who have felt that their rights were being infringed by wasteful operating practices of others sharing the same frequencies. The responsibility for clearing up situations of this kind lies best in the hands of the licensees themselves. The problems faced by industry are manifold, and the Commission's staff cannot become experts in all the details involved. Should the Commission endeavor to write procedures and dictate practices, it is certain that the Commission would give relatively little importance to some practices that the industry would consider of crucial importance, and would emphasize other matters which, as far as industry is concerned, could be eliminated entirely.

The Commission was not organized merely for the purpose of issuing licenses. It is basically a planning organization to provide order in the use of the radio spectrum, and to promote the widest possible use of radio in the public interest. The authority to issue licenses in given so that the Commission may have a means whereby its policies can be put into effect.

The license is issued as an evidence that the licensee is eligible to hold such an authorization, and that his plans are in accord with the rules and regulations of the Commission. The Commission can assure itself of continued maintenance of its policies by revoking or not renewing individual licenses. It can be said, therefore, that the main purpose of a license is to provide something the absence of which precludes the use of radio by the ignorant, the irresponsible, or the incorrigible. This applies equally to station licenses and those operator licenses which are issued without examination. In the case of the higher grade operator license, where an examination is prerequisite, the document additionally attests to the possession of minimum knowledge and in some cases, to minimum skill.

The Commission has an essential responsibility with respect to progress. The communication industry is relatively young, and new developments are appearing on the scene every day. In addition, with all segments of industry in a period of growth, new problems appear every day, many of which can be simplified if not solved by communication techniques. The Commission has specific responsibility to maintain close contact with those industries using communication as well as those developing communication devices so that the new techniques can be applied most effectively to the communications problems of the people of the U. S.

The Commission has, as a consequence of this responsibility, the duty to revise continually its rules. In the usual case, at the time provision for a service was made, the requirements of the new service as to frequencies and operating practices were strictly from the crystal ball. Even the best educated guess can be wrong. As a result of the evidence before it at the time of service initiation, the Commission may have been either too strict or too liberal in its rules prescribing the service. Should the Commission be too strict, many would be deprived of the opportunity to use radio. If the Commission's rules are too liberal, too many are authorized to say too much and congestion occurs. To meet these situations the rules must be changed.

For example, at one time 500 kc. was authorized to ship and coast stations for all purposes. As the number of radio-equipped ships increased, it was restricted to calling, distress,

Continued on page 42

*Chief Safety and Special Service Bureau, Federal Communications Commission, Washington, D. C.

Improved Frequency Stability of

Oscillators with Dual Crystals

STABILITY IS IMPROVED BY EMPLOYING TWO CRYSTALS WITH OPPOSITE TEMPERATURE COEFFICIENTS —*By* DOUGLAS A. VENN & GEORGE W. ARNOLD*

FOR the past several decades electronic-equipment installations on naval vessels have increased greatly, both in variety and bulk. Space limitations, therefore, must be a primary consideration in the design of new equipment or the modification of existing installations. An investigation was initiated to determine whether or not quartz-crystal oscillator plates having opposite temperature coefficients might be utilized in combination to obtain a unit possessing low thermal drift characteristics over a very wide temperature range or, conceivably, an extremely stable unit with a temperature characteristic of not more than 0.0001% over a temperature range of 10 or 20°C. Such a unit would obviate the necessity for bulky oven control, now used where high stability is required of high-frequency crystal units, and this would be valuable not only to the Navy but to other users of communication equipment.

The possibility of using crystal oscillator plates in this manner seems to have been first reported by Koga[1] in 1936. He employed two crystals of about 4,860 kc., placed one on top of the other in a suitable holder. The temperature coefficients of the individual plates were -7.8×10^{-6}/°C. and $+8.7 \times 10^{-6}$/°C. The combination gave a maximum deviation in frequency of only 50 cycles from 36° to 77°C., which corresponds to a variation in frequency of less than 10^{-6}/°C. A search of the literature failed to reveal any further investigations along these lines by Koga or any others.

Simple Theory: Considering the case for two crystals in parallel, as in Fig. 1 where L_1, C_1, R_1 and L_2, C_2, R_2 represent the inductance, capacitance, and resistance of the motional arms of the individual crystals, and C_t represents the sum of the crystal static capacities plus the circuit capacity, the frequency of operation can be approximated.

If terms in the impedance equation containing resistance are neglected, as they can be for crystals in the 5 to 15-mc. range, it can be shown that the frequencies of anti-resonance are given by

$$(1) \quad \omega = \left(\frac{(\omega_{1a}^2 + \omega_{2a}^2)}{2} \pm \left\{ \frac{(\omega_{1a}^2 + \omega_{2a}^2)^2}{4} - [\omega_{1a}^2\omega_{2r}^2 + \omega_{1r}^2\omega_{2a}^2 - \omega_{1r}^2\omega_{2r}^2] \right\}^{\frac{1}{2}} \right)^{\frac{1}{2}}$$

where ω_{1a}, ω_{1r} and ω_{2a}, ω_{2r} are the anti-resonant and resonant frequencies of crystals 1 and 2, respectively. It should be noted that the anti-resonant frequency of each crystal should be measured with the entire value of C_t across it.

*Naval Research Laboratory, Washington 25, D. C.

[1]Koga, I., "Notes on Piezoelectric Quartz Crystals", *Proc. IRE*, 24:510-531, March, 1936.

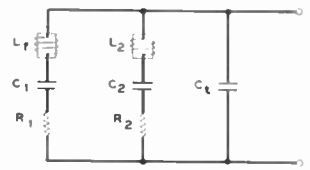


FIG. 1. EQUIVALENT NETWORK FOR 2 CRYSTALS CONNECTED IN PARALLEL

The resonant frequencies of the circuit will be closely approximated by

$$(2) \quad \omega = \sqrt{\frac{1}{L_1C_1}} \doteq \omega_{1r}, \quad \omega = \sqrt{\frac{1}{L_2C_2}} \doteq \omega_{2r}$$

The case in which two crystals are placed in series and shunted by the circuit capacity will give frequencies very nearly the same as those just obtained, except that the resonant and anti-resonant designations will be reversed. There will be a slight modification of frequency because of the different capacity distribution in this arrangement.

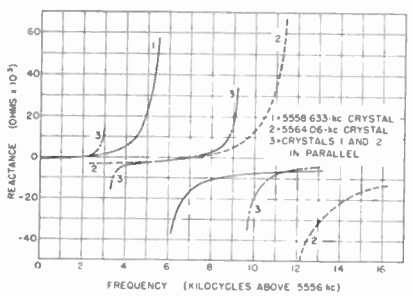
It should be emphasized that these equations have been derived for crystals having nominal frequencies lying in the lower portion of the high-frequency range. The general applicability of the equations is limited because of the increasingly great effect of C_t as the frequency is increased beyond this range.

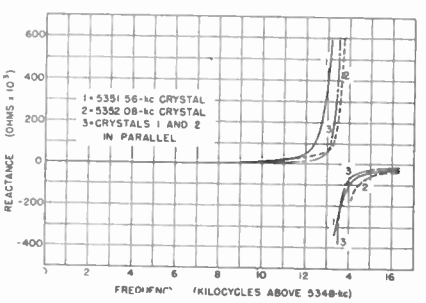
Reactance vs. Frequency Response: Figs. 2 through 4 are reactance *vs.* frequency curves for crystals, both singly and in parallel. These data were obtained by means of aural null impedance bridges and a variable-frequency generator having an instability not greater than plus or minus one cycle. Fig. 2 represents the case in which the individual crystal units differ in nominal frequency about 6 kc. The difference in impedance magnitudes of the parallel combination at the frequencies of anti-resonance becomes greater as the anti-resonant frequencies of the individual crystals approach one another.

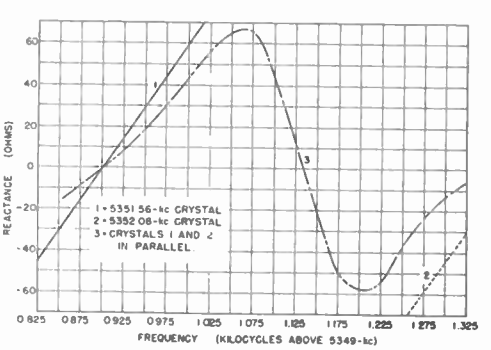
From the point of view of the oscillator circuit, both frequencies of anti-resonance are possible operating points; in a tuned oscillator with sufficient selectivity, it would be possible to obtain either frequency. As the separation in nominal frequency becomes less or the selectivity of the oscillator decreases, the oscillator tends increasingly to operate at the frequency of highest impedance.

Fig. 3 shows the results for the situation in which the difference in nominal frequency is only 500 cycles. For these particular units the method of measurement of reactance value was not precise enough to permit obtaining the first anti-resonant peak of the parallel combination, since the series resonant frequencies of the individual units were almost coincident.

Two different crystals of the same nominal frequencies as in Fig. 3, but having greater separation in series resonant fre-







FIGS. 2 AND 3. REACTANCES OF CRYSTALS SINGLY AND IN PARALLEL. FIG. 4. ANTIRESONANT PEAK

quency, were used for the data represented in Fig. 4. Here, the reactance of the parallel combination is so small that the impedance is of the same order of magnitude as the impedance of the individual units at series resonance. Because of the linear character of the individual crystal reactance curves in this region, the slope of the reactance curve is not great. The difference between series resonant frequencies is about 400 cycles; the reactance peak of the parallel combination is only about 70 ohms.

Several points of interest concerning the data presented in the graphs are evident. The reactance for the parallel case is zero at each of the series resonant frequencies of the individual crystals. As the positive reactance of the lower-frequency crystal increases from its series resonant value it approaches in magnitude the negative reactance of the higher-frequency unit. The positive reactance of the parallel combination rises rapidly as this point is approached, reaches a maximum at the frequency for which the two individual reactances are equal and opposite, and then becomes a maximum in the negative direction. Where the lower-frequency crystal reaches its anti-resonant peak, the reactance curve for the parallel crystals crosses the reactance curve for the higher-frequency crystal. The parallel combination then goes through its second anti-resonant peak as the magnitudes of the reactances of the lower and higher-frequency units again approach and become equal to each other. There is another crossover point when the higher-frequency crystal goes through anti-resonance, after which both units and the parallel combination approach zero reactance asymptotically. The parallel reactance is, of course, less than that of either unit alone. By operating two crystals in parallel, therefore, a unit is obtained which has a greater change

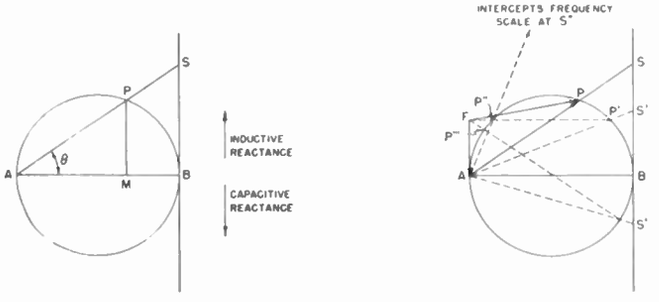


FIG. 5. IMPEDANCE AND ADMITTANCE OF R1L1C1. FIG. 6, SAME, C_t ADDED

in reactance for a given change in frequency in the region of anti-resonance.

Graphical Analysis: At frequencies above 15 mc., the effects of the series resistance and the shunt capacity of the crystal become increasingly important. Equation 1 is not adequate for such frequencies, since it is derived on the assumption that the series resistance is negligible in comparison with the reactive component of the impedance. However, at frequencies above 15 mc. an exact analysis of the circuit shown in Fig. 1 can be made only by using the complete network equation, which is a biquadratic in ω^2 with cumbersome coefficients. But in many cases a qualitative analysis, in which the effects of variations in the crystal parameters can be observed, is all that is desired. A convenient means of making such an analysis, which employs the circle diagrams used in circuit analysis, has been described by Cady [2,3] and the following discussion is based in part upon his work.

Referring to Fig. 5, let AB represent R_1, the resistance of crystal No. 1 in Fig. 1. If the radius of the circle is ρ_1, then

$$s = \frac{R_1}{2\rho_1} \text{ ohms/unit distance.} \tag{3}$$

Reactance is plotted along the perpendicular to AB through B, with inductive reactances above B and capacitive reactances below. In Fig. 5, BS represents an inductive reactance given by

$$X_1 = s \times BS \text{ ohms.} \tag{4}$$

where X_1 is the reactance of L_1C_1. The impedance of $R_1L_1C_1$ is then

$$Z_1 = s \times AS \text{ ohms.} \tag{5}$$

Since it is desired to investigate circuits containing elements in parallel as well as in series it is decidedly advantageous to represent admittances and impedances on the same diagram. It will be noted that

$$Y_1 = \frac{1}{Z_1} = \frac{\cos\theta}{R_1} = g_{01}\cos\theta, \tag{6}$$

where Y_1 is the admittance of $R_1L_1C_1$, and g_{01} is the conductance of $R_1L_1C_1$ at the series resonant frequency, which is given by

$$g_{01} = \frac{1}{R_1}. \tag{7}$$

But Equation 6 is the polar equation of a circle with the diameter given by Equation 7. By letting AB represent $1/R_1$ at the series resonant frequency, the admittance scale value is

$$s_y = \frac{\left(\frac{1}{R_1}\right)}{AB} = \frac{1}{2\rho_1 R_1} \text{ mhos/unit distance.} \tag{8}$$

Clearly, the circumference of the circle in Fig. 5 is the locus of $Y_1 = 1/AS$ as the frequency varies. The expressions for admittance, conductance, and susceptance are given by

$$Y_1 = s_y \times AP, \tag{9}$$

$$g_1 = s_y \times AM, \tag{10}$$

and

$$b_1 = s_y \times MP, \tag{11}$$

where

$$Y_1 = g_1 - jb_1. \tag{12}$$

It is apparent that for each reactance BS there corresponds a different frequency, and it would be desirable to calibrate the reactance scale in terms of frequency. This derivation is also due to Cady, and it is found that

$$f_0 - f_1 = \sigma \times BS \text{ cycles,} \tag{13}$$

where

$$\sigma = -\frac{R_1}{8\pi\rho_1 L_1} \text{ cycles/unit distance.} \tag{14}$$

f_0 is the series resonant frequency of $R_1L_1C_1$, and f_1 is the frequency corresponding to the impedance represented by BS. Frequencies above series resonance lie above B, corresponding to an inductive reactance; frequencies below series resonance lie below B, corresponding to a capacitive reactance.

Other network elements can now be taken into consideration. In Fig. 6 the admittance of C_t, the total shunt capacitance, is represented as AF where

$$Y_t = j\omega C_t = s_y \times AF. \tag{15}$$

F is now the origin for the network consisting of C_t in parallel with $R_1L_1C_1$, the admittance of the network being represented by the vector FP in Fig. 6, both in magnitude and in phase. Over the usual range of frequencies considered AF can be regarded as fixed, which simplifies greatly the use of the graphical method. It is to be noted that, for purposes of clarity, AF is shown larger than is generally the case. Fig. 6 reveals very

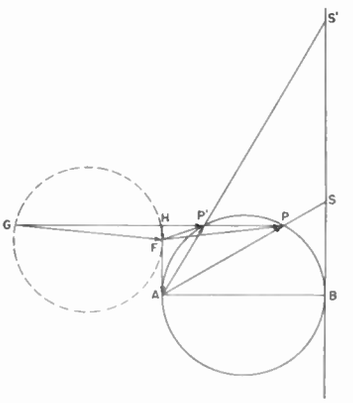
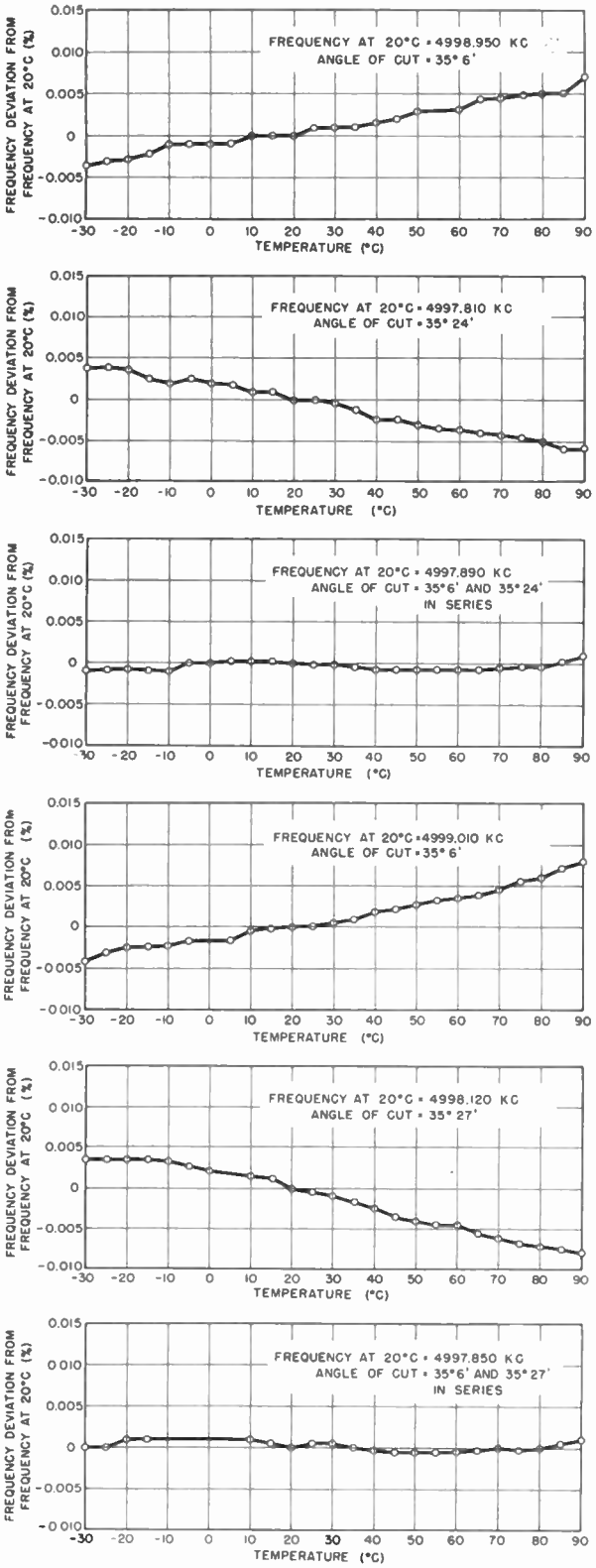


FIG. 7. A REPRESENTATION OF R2C2L2 ADDED TO THE CIRCUIT PARALLEL WITH R1C1L1 AND C_t

[2]Cady, W. G., *Piezoelectricity*, McGraw-Hill Book Co., New York, 1946.

[3]Cady, W. G., "The Application of Methods of Geometrical Inversion to the Solution of Certain Problems in Electrical Resonance," *Proc. AAAS*, 68:383–409 1933.



FIGS. 8 THROUGH 13. CRYSTAL STABILITY SINGLY AND IN PAIRS

clearly the effects of variations in the shunt capacity upon the frequency of the crystal. It is apparent that the series resonant frequency is increased with an increase in the value of C_t, the limiting value being that at which

$$|\Delta F| = \frac{1}{2R_1} \text{ ohms.} \tag{16}$$

The change in series resonant frequency given by S′, Fig. 6, is quite small, as can be seen from Equation 14. The anti-resonant frequency would be that given at S″ if the vector through ΔP″ were extended, and decreases with an increase in C_t. The frequency of minimum impedance is that obtained at S‴, and the frequency of maximum impedance is that represented by the intercept of the vector through ΔP‴ and the frequency scale.

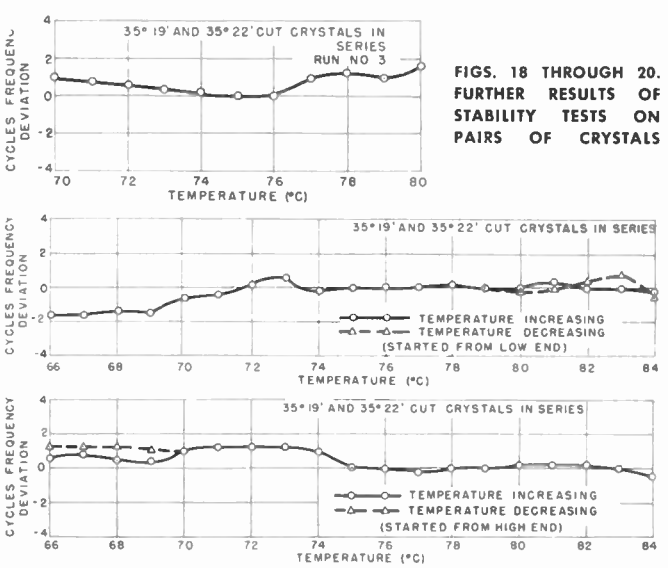
The effect of adding another RLC chain, i.e., another crystal, in parallel with $R_1L_1C_1C_t$ can now be observed. The situation that obtains with $R_2L_2C_2$ in parallel with $R_1L_1C_1C_t$ is represented in Fig. 7.

Since, as shown in Fig. 6, F is the origin for the admittance vector for $R_1L_1C_1C_t$, the admittance vector for $R_2L_2C_2$ must be drawn to the same scale and so that its terminal point is always at F. To insure the same scale value for admittance an adjustment is made in P_2, the radius of the admittance-impedance circle for $R_2L_2C_2$, so that the same value of s_y is obtained. This presumes that R_2, which can be easily measured, is known. The dotted circle in Fig. 7 is the locus of all admittance vectors of $R_2L_2C_2$. The admittance vectors GF and HF are those which would make the entire circuit a pure conductance at the frequency corresponding to the reactance BS. For this arbitrary choice of frequency, which is slightly above series resonance for the $R_1L_1C_1C_t$ combination, admittance GF results in a total admittance GP, and HF in a total admittance HP.

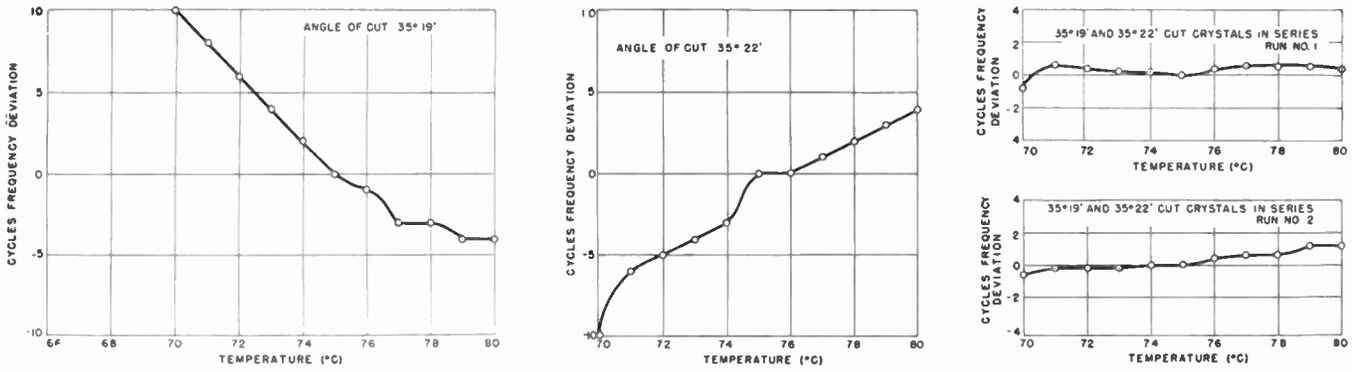
Admittance HF is that of a crystal very near its anti-resonant peak. Admittance FP, however, is for a crystal very near series resonance so that the total resultant admittance HP is approximately the same for this crystal as was obtained in the discussion of the curves in Fig. 2. Operation such as this would not be satisfactory because the high-impedance crystal would become inductive or capacitive with a small change in frequency, and there would be no compensating reactance change in the other crystal. An unstable composite frequency would be obtained.

Admittance GP is about twice that of either crystal alone. This is analogous to the situation described in the discussion of Fig. 4, wherein the series resonant frequencies of the two crystals are very close together. In a parallel resonant oscillator with sufficient selectivity and gain to operate at this low-impedance peak rather than at the higher impedance peak encountered at a higher frequency, such a point of operation is possible. It is pointed out, however, that a combination of this type could not be operated satisfactorily in a series resonant oscillator because, even though the impedance of the combination is low, it still represents a peak of impedance and a series resonant oscillator would operate between the individual series resonant points and would be likely to jump between the two points in an erratic fashion. It is clear from the preceding discussion that if the crystals are connected in series, then series resonant oscillator operation would be appropriate.

At the frequency corresponding to the Point S′ the admit-



FIGS. 18 THROUGH 20. FURTHER RESULTS OF STABILITY TESTS ON PAIRS OF CRYSTALS



FIGS. 14 THROUGH 17. FREQUENCY STABILITY OVER LIMITED TEMPERATURE RANGE OF TWO CRYSTALS OPERATED ALONE AND AS A PAIR

tance of the first crystal unit plus the susceptance AF is represented by FP′. The same values of admittance GF and HF for the second crystal unit would again make the combination of crystals a pure conductance. The conductance values would be less than for the case just discussed; otherwise, the same remarks apply. A much more detailed discussion of these graphical methods and the relationship of the inverse points of admittance and impedance is given by Cady in the reference cited.

Temperature vs. Frequency Response: In order to determine the advantages of dual-crystal operation, a group of AT-cut crystals of the same nominal frequency (5 mc.) was selected, in which the angle of cut with respect to the Z-axis was varied from 35° 6′ to 35° 27′, the nominal AT cut being about 35° 18′. This was done in order to obtain crystals possessing the proper temperature-frequency coefficients. All the temperature runs were made in a cathode-coupled type circuit, in which the crystal is operated as a low impedance. No experimental runs were made for the combination looking like a high impedance because of the nature of the oscillator circuits currently employed with the temperature-frequency testing equipment. It should be apparent, however, that parallel crystals in the appropriate circuit, i.e., one in which the crystals look like a high impedance, would perform in the same manner as the series crystals.

Figs. 8 and 9 show the temperature-*vs.*-frequency response of two crystals in this group, for which the angles of cut were 35° 6′ and 35° 24′, respectively. The 35° 6′ crystal had an overall

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Installation of

Buried Cables

HOW CABLES, GROUND WIRING CAN BE BURIED EASILY- *By* GERALD W. LEE*

INSTALLATION of buried cables or ground systems is an extremely difficult task in rough or wet ground, unless special methods are used. In level ground that has been cultivated no difficulty is encountered; the dirt is removed with a cable plow, the wire is dropped into the trench, and the furrow is then replaced over the trench, effectively burying the wire or cable. But in ground recently cleared of heavy bush and undergrowth, or in marshy terrain, it is not such a simple matter. On recently-cleared land the plow shear either clogs up with sod or breaks on hidden tree roots, and in marshy ground the shear sinks out of sight. These circumstances necessitate different installation methods, one of which is outlined here.

Bulldozer Plow: On the site of a newly-constructed station there is usually a bulldozer available. This can be used for plowing the wire or cable into the ground in one operation. First, a plow shear or digger is built as shown in Fig. 1 and is then welded to the blade. When the blade is lowered and the bulldozer driven forward a narrow trench is dug; wire or cable is fed into the trench automatically, and the trench is filled in by the bulldozer treads as they pass over it.

The shear parts can be cut from ¾ to 1-in. sheet steel and welded together. The bottom shoe, as Fig. 1 shows, keeps the shear from digging in too deeply, and the brace of 4 by 1-in. steel holds the shear firmly in place and supports the welds

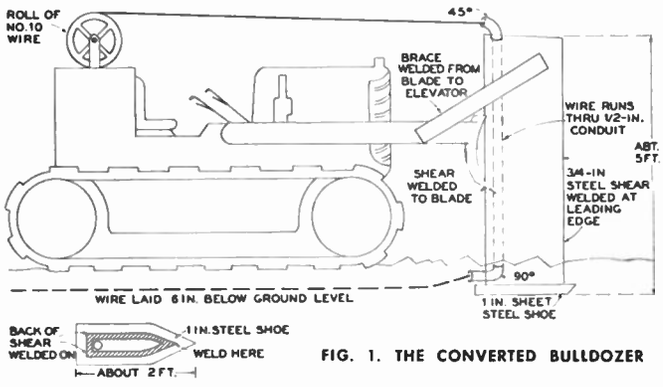

FIG. 1. THE CONVERTED BULLDOZER

fastening it to the bulldozer blade. While the shear is being fabricated a piece of conduit of the desired diameter, with a right-angle fitting on the bottom end and a 45° angle fitting on the top end, is welded inside to ensure a smooth passage for the ground wire or cable. The spool of wire is mounted on the bulldozer where it can be freely unreeled.

Recommended procedure in ground-system installation is to thread the wire through the conduit, pull the wire end out underneath the bulldozer, and anchor it to the tower base. The bulldozer is started forward, the blade is lowered gently until the shear has dug into the ground from 6 to 8 ins., and then the shift is made into high gear. Ground wire can be laid both to and from the tower, provided the system has been staked out properly so that the operator knows where to drive. After the wire radials are buried, the ground system is finished in the usual manner by soldering the radial ends to a wire ring around the tower and connecting the tower base to this ring. A load or two of earth is necessary to cover the radial ends which are too near the tower to be buried by the bulldozer.

While this method and apparatus may seem complicated and expensive, some such gimmick becomes a necessity when rough, extremely hard, or marshy ground is encountered. It will usually turn out to be less expensive and much faster than conventional methods.

*Professional Engineer, Canada House, Trafalgar Square, S. W., London, England.

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REMOTE STATION

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neering, and according to proper geographic spacing. TVI is, of course, taken into account. At any rate, a strong signal was received on our newly-assigned frequency. Various attempts were made to discriminate between it and the signal received from Rutland. A mobile whip was cut to ¼ wavelength and mounted under the eaves of the building in the hope that the metal sheathing would shield it from the New Hampshire side, which is the side away from Rutland. Despite this attempt and the use of full authorized power at Rutland, it was impossible to obtain enough difference in signal levels to establish the capture effect and retain some margin of safety. Accordingly, application was made for another frequency.

The Yagi antennas lasted only a few days. One was hit by falling ice which sheared off the driven element and bent a director.

The new frequency assignment proved much better; no interference has been experienced. The mobile antenna under the eaves of the building was retained for receiving and a hurricane-model half-wave antenna was rigged for transmitting, with the top 30 ft. up the main mast and two ft. away from it. It has not thus far been damaged by ice or wind, although it may be somewhat vulnerable to falling ice.

The next difficulty with the relay equipment was occasional cutting out of the relay-controlled main transmitter. This effect was accompanied by background crackling and some distortion. It was traced to energy from the main station transmitter being picked up by the relay receiver circuits, because of the proximity of the antennas and close harmonic relationship of the two frequencies. The solution was to locate the receiving relay antenna on the side of the building in a vertical position, and to de-tune the first stages of the receiver slightly. The de-tuning was more effective for the undesired signal. These measures corrected the situation. It was found then that audio distortion, to the point of complete loss of intelligibility, could be caused by advancing the threshold control of the carrier-operated relay too far and thus overloading the squelch tube. Since these initial difficulties have been ironed out the relay link has given very satisfactory service, with a reduction in control circuit failures of about 75% from those experienced with land-line control. During the first years of operation the Pico installation cost more to maintain than all the rest of the communication system. The cost has now been reduced to little more than that of maintaining one of our low-altitude stations.

The main station equipment has been subject to very few failures of a purely electronic nature. Most frequent trouble has been arc-back of the 5R4 rectifier supplying the exciter, which blows a fuse. This has been offset by installing a power supply with two parallel 5R4's, slow-blow fuses, and a 10% bucking transformer in the 120-volt AC supply. Although the radio equipment is supplied from a small induction regulator set for 120 ± 2 volts, it has been found that tube lives are greatly increased and filament burnouts virtually eliminated if this is reduced to 110 volts. It is desirable for other reasons, however, to operate the rest of the equipment at 120 volts, and to take our chances with tubes. We are now using the new rugged-service tubes where applicable; this is expected to improve continuity of service considerably.

Relays have been relatively common causes of trouble. Little can be done to estimate when a relay finger will break due to metallic fatigue, or a dirt particle will settle in the contacts of a relay. Cleaning telephone-type relays operating normally has often *caused* trouble when dust, stirred up during servicing, settles later on the contacts. This trouble has been so frequent that telephone relays are

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left alone except when it is certain that the maintenance man can observe their performance for several hours after cleaning them. Relays with larger contacts are cleaned occasionally and inspected at least every three months. A complete complement of spare relays is kept at the station.

In 1947 a State Police radio unit was installed about 150 ft. away from the CVPS station, with antennas mounted on the fire observation tower. Strong interference to the power company receiver was encountered, and field engineers from the manufacturers of both installations were called in. A filter was installed in the antenna lead of the State Police antenna on the power company frequency, and an entire receiver, much more selective than earlier models, was built and installed in our station. The interference was entirely eliminated, and later on a similar case was cleared up by installing the same shielded RF transformer used in a present-day receiver on one built in 1946. The special receiver at Pico was later replaced by a new mobile receiver converted to AC operation, which was bench-tested with its carrier-operated relay for a month.

Recommendations: On the basis of our own and others' experiences with radiotelephone stations at 4,000 ft., some conclusions have been reached as to the limitations, possible errors, and benefits to be expected by a new user contemplating such an installation. It will be assumed, first, that some reasonable means of transportation is available, such as truck, tractor, or horses. A building of tarred cinder blocks, sheathed with aluminum, clapboards, or cedar shingles would be desirable. It was found on Mt. Washington, N. H, that rain-water was forced through cement blocks by the wind pressure, with subsequent danger to equipment, as well as the risk of trapped water freezing and bursting the blocks near the ground. The building should be as near fireproof as possible, with a ceiling of asbestos tile if wood is used in the roof.

For lightning protection, the building should be placed within a 45° cone whose apex is the top of the antenna mast, but as close to the circumference of the cone as possible to avoid the effects of ice falling from the mast in winter. A fairly steep roof of corrugated iron is recommended, with a single slope away from the tower.

Unless other living facilities are available the building should provide enough space, in addition to that occupied by the radio equipment, for built-in bunks, a

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heating unit, and a food supply. Storage space for tools, tackle, spare tubes, parts, and antennas may be needed, according to the accessibility of the particular station and the form of transportation used. If a stand-by power plant is to be used, as is the case with most remote installations, a separate fireproof room, leanto, or other enclosure will be needed. Fire hazard to the rest of the station is thus reduced, and the possible corrosive effects of gases during charging of the starting battery are obviated. It has not been necessary to heat our radio building when not occupied, since the 866 mercury-vapor rectifiers formerly used have been replaced with the 3B28 high-vacuum rectifier.

With respect to the main-station antenna; a coaxial half-wave dipole appears to be the only design for the 30 to 40-mc. band which can stand up under heavy icing and wind conditions. If thick icing is anticipated, some consideration should be given to constructing an antenna with a stainless steel support pipe and whip, and with an extra heavy header assembly. Because the skirt of the antenna contributes little to the strength it may be made of aluminum or dural. The antenna must be mounted high enough to give adequate coverage but no higher, since ice formation and wind increase rapidly with height. Where weather conditions are not very severe a ground-plane antenna with resistance heating cable has been used successfully. This form of antenna also gives good lightning protection since it is entirely at DC ground potential. A ground-plane antenna does not waste energy at angles high above the horizon, and can be mounted at a lower level than a dipole to give the same coverage. Relay antennas for short-range operation are sometimes mounted indoors, and in most cases need not be exposed to severe weather. It has been found that a copper coaxial cable to feed the main antenna was too difficult to maintain. Very satisfactory operation is obtained with flexible RG-17/U cable.

The relative difficulties of maintaining a remotely-located mountain-top station can be reduced considerably by careful planning and construction, with particular attention to the tower and antennas. These must be built with the worst weather conditions in mind, with suitable safety factors. Our mast is guyed at three levels with six guys at each level. One or two guys at one level have broken without serious danger; but if sets of three or four were used, the strain of ice and wind would almost certainly have been too great.

Adequate grounding of all equipment to an underground power cable has proved to be very effective in eliminating lightning damage. Although underground cable is desirable, in some cases power service must be supplied by overhead lines. It is a peculiarity of open-wire power lines that the end of the line is most severely affected by lightning surges, so all possible protection will be needed if open wire is used.

Finally, electronic equipment should be the best available, operated conservatively, and given regular preventative maintenance. Since the failure of a relay or tube in a remotely-controlled station can put the transmitter on the air, a means must be provided for shutting down the station, either automatically or by remote control. One well-engineerd mountain-top station will provide excellent service and reduce substantially the cost of covering the same territory with several lower-powered transmitters in more accessible installations.

DUAL CRYSTALS

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frequency deviation of about 0.01% over the range from —30 to +90°C. when operated singly, and the 35° 24′ crystal also had an overall deviation of about 0.01%. The overall frequency deviation for the two crystals in series was about 0.002%, or approximately five times better than either crystal alone, Fig. 10.

It should be noted that under current

military specifications for allowable frequency deviation, each of the individual crystal units would have been rejected.

Figs. 11 and 12 represent temperature-frequency characteristics of crystals cut at 35° 6′ and 35° 27′, respectively. The overall frequency deviation for the 35° 6′ crystal was a little more than 0.01% over −30 to +90°C. range and the overall deviation for the 35° 27′ crystal was of the same order. The overall deviation for the two in series, Fig. 13, is about 0.0015%, which is an improvement of about seven times. These crystals also would have been rejected separately.

The entire group of crystals was tested over the temperature range from +70 to +80°C., which is a restricted temperature range often stipulated in procurement specifications, in order to find crystals which could be paired to give cancellation of temperature coefficients. Figs. 14 and 15 show the frequency *vs.* temperature characteristics of two such crystals. The overall deviation for both crystals is 14 cycles over the restricted range, or 0.00028% of the nominal 5-mc. frequency. Figs. 16 through 18 show the results for three repeated runs over the 70 to 80°C. range, with the crystals in series operating as a low impedance in a series-resonant circuit. Fig. 19 reveals the result when the temperature was brought up from below 70° through 80°C. and then reversed. Fig. 20 shows the result when the crystals were raised to higher temperatures than 80°C., then brought down in temperature through 70°C. and then reversed. It can be seen that for the worst case the deviation was only about 1.8 cycles from 70° to 80°C., or 0.000036%. This is an improvement of about eight times over that of either crystal alone. It can be seen also that the general shape of the curves is not maintained from one run to another. This indicates that the small frequency deviations obtained could very well be due to oscillator circuit changes or to interpolation oscillator short-term deviations. It is felt that the actual gain realized is much more than that indicated, the crystal fluctuations being much less than that of the circuit itself and of the interpolation oscillator.

Conclusions: According to the theoretical and experimental data, it is clear that significant improvements in frequency stability can be realized by the use of quartz-crystal combinations. A crystal unit can be obtained in this way which is five to seven times better, over the temperature range of −30 to +90°C., than the production crystals making up the unit.

Such crystal combinations could be considered seriously as possible substitutes for precision crystal units used as secondary standards. In the event of a critical quartz shortage, this method provides a means of salvaging oscillator plates

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which would be rejected on the basis of excessive frequency shift with temperature.

Acknowledgments: We wish to thank the Hunt Corporation of Carlisle, Pennsylvania, for their materials and cooperation in regard to crystal combinations. They were responsible for giving the investigation renewed impetus.

TAXI SYSTEM

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cheaper to replace than other types, such as lighthouse tubes, and service records show an average life in this installation of approximately 5,000 hours; this is 5 times better than would have been acceptable.

Even if no trouble occurs in a taxi radio, it is brought to the radio shop every 6 to 8 weeks for a routine check of frequency, power output, and other performance qualities. Experience indicates that this maintenance period apparently can be further increased without service degradation.

Conclusion: Since the system has now been in operation for better than $1\frac{1}{2}$ years, it is possible to evaluate results not only from a radio performance standpoint but on a business basis as well. Needless to say, a decrease in dead mileage and a general increase in efficiency was inevitable as a result of radio dispatching. It is also interesting to note a definite increase in business volume due to other factors indirectly resulting from the use of radio. Checker is gaining back customers from smaller radio-equipped competitors. They are also gaining new customers because of the more rapid servicing of calls. In addition, business is increasing in the fringe areas of the city, including zones 2, 6, 7, and 8. This can only be attributed to the fact that previously, cab drivers always avoided these areas, since cruising pick-ups were infrequent; but with radio they can handle service calls in the city outskirts at a constantly increasing rate. The mere availability of cabs in these areas automatically produces new business.

It should also be stated that this system became a possibility only through the combined efforts of the Checker Cab Company and the Link Radio Corporation. Mr. Carl H. Anderson, president of Checker Cab, and his associates contributed not a little in the form of practical suggestions from an operating standpoint. This made possible the thorough analysis of their problems, the solution of which resulted in a superior radio dispatching system tailored to handle efficiently the high traffic density involved.

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and the transmission of single short messages. Today it is for calling and distress only. It should be pointed out that, in every case, the rules apply equally to the existing licensees and to the latecomers. If it is necessary to restrict the activities of the existing licensees to make room for new-comers, that must be done. If the rules may be relaxed, they are relaxed for all.

Mention has been made of the procedure used in allotting frequencies to industrial groups. It might seem, at first glance, that the allocations are unduly specialized. For example, the highway trucks, the buses, and the taxicabs could all be grouped in the land transportation allotment. Similarly, the fire departments, water departments, police departments, and other like services could be grouped in a public safety allotment. As a matter of fact, the latter was actually proposed during the course of one of the allocation proceedings. However, it was pointed out that if sharing is required, it is much more satisfactory from the point of view of the operators to share with others in a like business. It was felt that, in the case of communications problems resulting from sharings, it would be much easier to reach a satisfactory agreement if those involved speak the same language, encounter the same problems, and have a mutual appreciation of the dilemma in which each found himself. In some competitive industries, feelings were expressed that call-pirating would result, in spite of the Communications Act, if competing industries in the same locality shared the same frequency, as is the case in the taxicab service. This may have occurred. However, experience through the years indicates that such practices die out automatically. For example, the taxicab system that pirates calls of an another finds that it loses as many calls as it gains, since piracy results in reprisal. In addition, such cabs have found that piracy builds up customer resistance since a customer calling for a "Fresh Air Cab" is disturbed when a "Smoke Filled Room Cab" answers the call.

In the microwave point-to-point service there is a probability that, contrary to the practice in the mobile fields, allocation of frequencies to separate industrial groups will not be made. Systems of this kind are essentially of a type that require interference-free operation since the operation is a continuous carrier, and multiplex systems are used to derive a number of communication channels over one radio-frequency assignment. There is and will undoubtedly continue to be a sharing of identical frequencies by sys-

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tems of this kind in single geographical areas. To solve this apparent impasse, it is necessary to achieve interference-free operation through excellence of engineering design and the maintenance of high standards of engineering and operation. For this reason, the emphasis in the rules will have to be on system design and operation, rather than on what industrial group uses the system.

As stated previously, the Commission's Rules provide those technical standards necessary for the various safety and special radio services to share a limited frequency spectrum. In the broadcast field, there is an additional consideration not present in either the common carrier or industrial fields. That is in relation to the business of broadcasting, the Commission is in a sense the representative of the general public. A broadcast station is granted a franchise, through its license, upon the assurance that it will serve directly a particular segment of the public in a specified geographical area. Sharing patterns among broadcast stations are so established that if prescribed powers and specified antennas are used, one segment of the public and none other will be served by a particular broadcast station. If a broadcast station operates with less power than prescribed, it fails to serve its public, and does not carry out the obligations of the licensee; if it is operated with more than the specified power, it interferes with the ability of other broadcasters to carry out their responsibilities. For this reason, in the broadcast service technical standards must be more detailed and more complete than in other services, and each application for new facilities must be given individual attention and study.

In the case of the common carrier service, if, for example, a station is licensed to transmit from New York to London with 80 kw. of power, and with a high-gain directional antenna, it is not required to use full power when communications conditions are good and all messages can be handled with requisite speed at much less power. However, the sharing pattern on that frequency is so adjusted that in case of necessity the point-to-point station can use 80 kw. without destroying the service rendered by some other similar user else in the world.

Generally speaking, in the safety and special services the standards are much like those described as applying to the common carrier. Maximum limits are set, and the licensee is permitted to use only what is necessary to accomplish his end, provided the limits are not exceeded. The sharing pattern is designed so that if

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the maximum limits are not exceeded, the plan of sharing can be worked out successfully in practice. In a few cases in the safety services, such as coastal and airdrome control stations, additional limits are prescribed since in these cases, as in broadcasting, the FCC has a special responsibility to the general public. For example, the airdrome control station is licensed for specified power and specified hours of operation. Airmen plan their flights relying upon the published schedule of that station for communication service, and if the schedule is not maintained an airman may find himself in trouble for lack of a communication service he expected to find available.

Although in general rules of the Safety and Special Radio Services prescribe only limits, in the microwave point-to-point system there is a possibility that the technical standards will be as detailed if not more detailed than those applied to broadcast stations.

In every case and in every service, over-regulation is undesirable. Only those standards should be adopted which are required to insure the rendition of the service by the licensees in the manner contemplated by the rules and regulations, and on the basis of the representation made by the licensee in his application.

Suggestions have often been made that the policy of making service allocations is wrong; that the Commission should study every individual community to insure that maximum use of radio is made in that community. This proposition seems to be very attractive at first glance, particularly when it is considered that there are very few users or potential users in many of the sparsely settled parts of the country. It may be that in those sparsely-settled areas licensees might be authorized to use radio in fields not permitted in the more congested areas. For example, in the City of Washington, it is impossible to provide frequencies for oil burner service men to use for their own purposes. Such organizations are required to obtain radio service from common carrier radio facilities. However, there are many small towns in the Midwest where there are very few if any industrial services. So, from a physical point of view, the oil burner service man in such towns might have a frequency. Unfortunately, this does not work in practice since the oil burner man in the small town does not seem to want a radio system. In general, if the communications needs of the congested areas can be solved, the communications problems of less congested areas have been solved also.

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There is another objection to this method of treatment. Suppose that, in the city of New York, Industry A feels that it needs additional communication facilities so it looks over the field and finds that the frequency assigned to Industry B is not in use in that area. Thereupon, Industry A applies for that frequency. The minute his application appears, Industry C says, "Wait a minute, if another frequency is available in New York, we need it much more than Industry A." On top of that, Industry B protests: "While it is true we are not in New York now, we expect to be there next year." The end result would be all the industries down the alphabet, including XYZ, would get into the argument over the question as to who gets what frequency. The Commission would then be faced with a frequency allocation hearing on the New York problem alone. Further, no such allocation proceedings could, as a practical matter, be restricted to any locality. Since radio knows no boundaries, what is done in one locality affects other areas. If you try to allot frequencies in New York City, you would certainly have to take in greater New York. What you do in greater New York would effect what you do in Philadelphia. What you do in Philadelphia would affect what you do in Baltimore, and what started as a study of the New York problem would end as a restudy of the national problem. For these reasons, it appears best to retain the course now charted, and to continue service allocations.

Finally, the situation described has a major affect upon the nature of the staff of the Commission and its activities. The issuance of licenses in the Safety and Special Radio Services should become a routine task if the allocation of frequencies are reasonable, if the rules and regulations are intelligently conceived and well understood, and if the Commission's forms are appropriate to the service requirements. If these forms are filled in correctly by an applicant, the comparison of the application with the norm is a simple task, and the issuance of authorization in such cases is reduced almost to a mechanical operation. It is because of this fact that it is possible to process applications in some of these special services at an average rate of one every fifteen minutes or less, and still give adequate consideration to each. If on the other hand, the Commission's planning is inadequate, and the needs of industry are not understood and met by reasonable regulations and adequate forms, there will be a constant stream of irregular applications requiring individual

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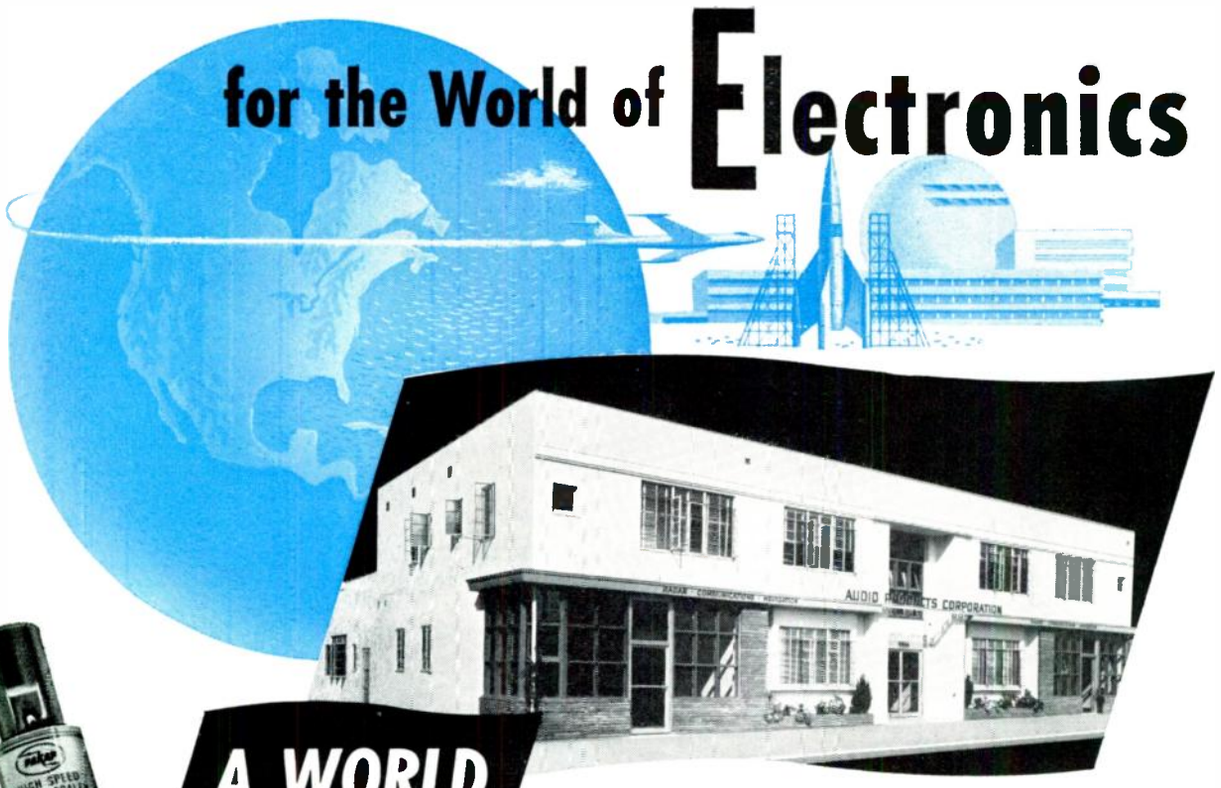

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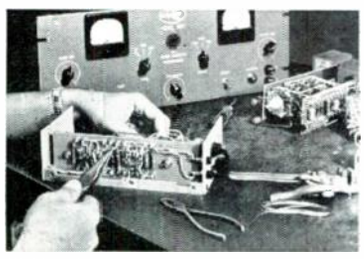

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FCC PHILOSOPHY

(Continued from page 46)

study. Even if a staff could be provided to consider applications on a case by case basis, the end results would undoubtedly be unsatisfactory. Since it would not be the result of a plan, inequities would result.

In view of this situation, it should be expected that those segments of the Commission's staff which act on applications would be largely administrative and clerical, and it should be possible to handle a large volume of applications with a minimum number of people. On the other hand, those segments of the Commission's staff involved in planning should consist of highly qualified experts in the field of engineering and law, and they should be furnished with adequate clerical staffs. Those men must have imagination and administrative ability as well as basic technical skill, since their work is in the field of planning for the use of radio rather than in the development of radio apparatus or circuits. Such a staff should not only be competent in the field of communications, but must be familiar with the non-communication problems of the industry and the proposals for the use of communications in solving them. How can the Commission's staff make recommendation as to the justice of claims that taxicabs need more frequencies as against the cries of the buses for additional assignments unless it has a working knowledge of how taxicabs are handled, and how the movements of buses are managed.

Communication is a service. The most successful communication engineer is he who knows the most about the business of the clients whom he serves. The Commission is charged by the Congress to administer the communications policies of this government so that all the people of the United States will have a rapid, efficient, nation-wide and world-wide wire and radio communication service, with adequate facilities at reasonable charges, both for the purpose of national defense, and for the purpose of promoting safety of life and property. The degree to which the Commission succeeds in carrying out this mandate depends, in a large measure, upon the degree to which its staff becomes familiar with the methods of operation of all the industries of the United States, and as to how communications techniques can be applied most effectively to the problem of those industries for the benefit of all.

NOTE: *This concludes Col. White's discussion of assignment philosophy. Next issue, Merle E. Floegel of the FCC staff will present the FCC's side of the form 400 issue, and will interpret some of the major sections.*—EDITOR.

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