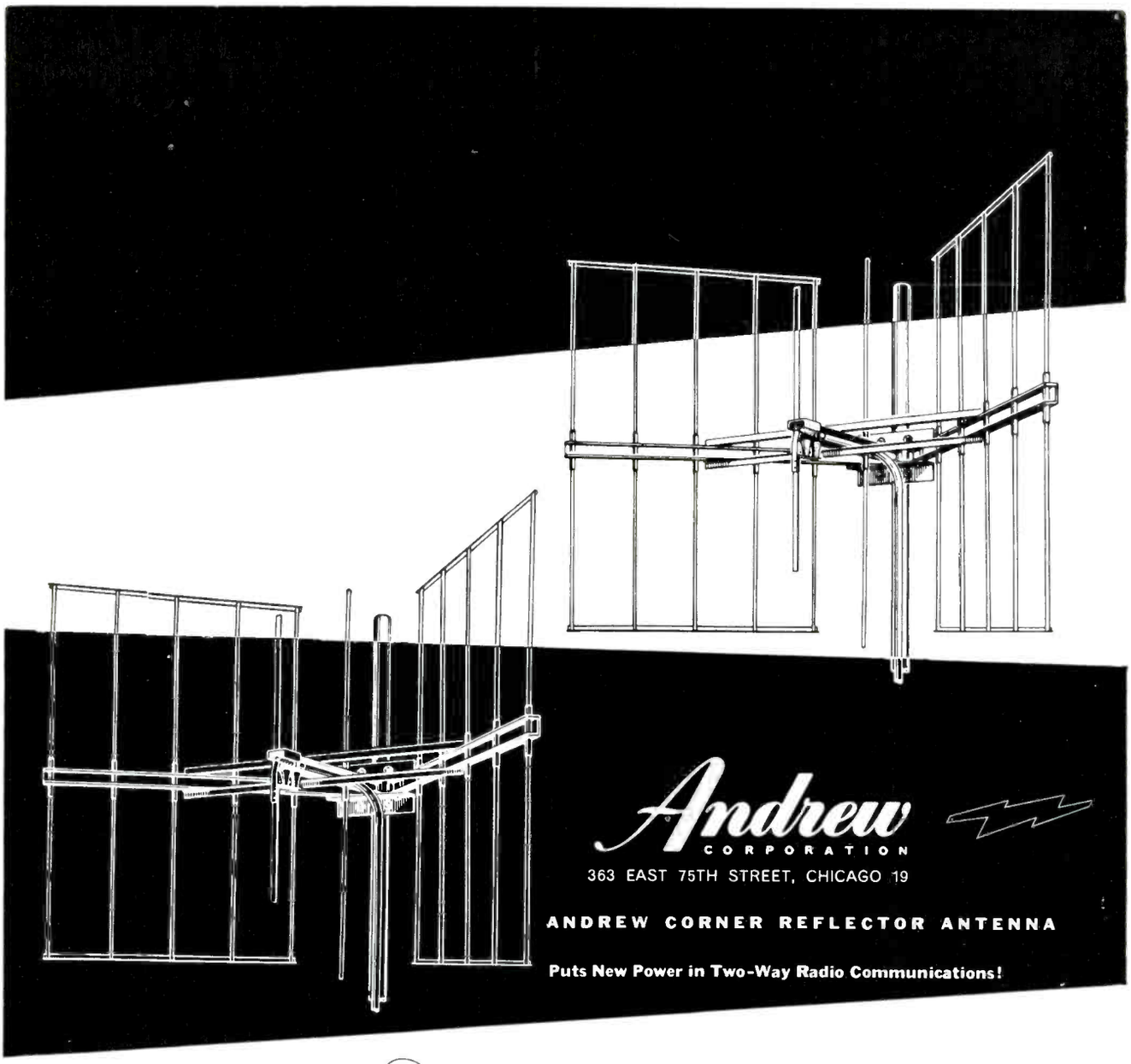
Communication Engineering

'53-6

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



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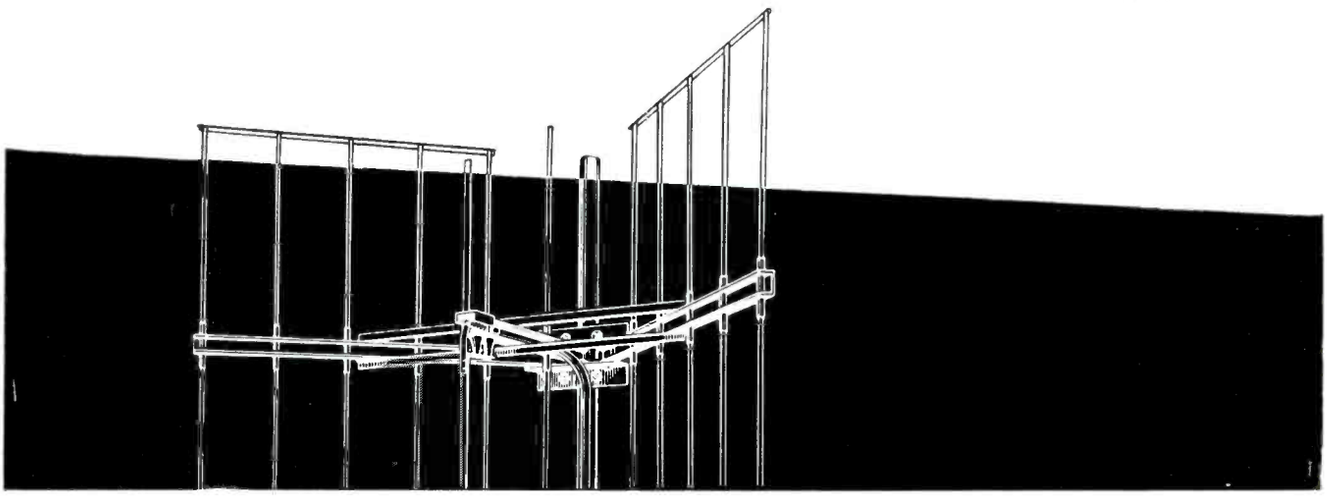
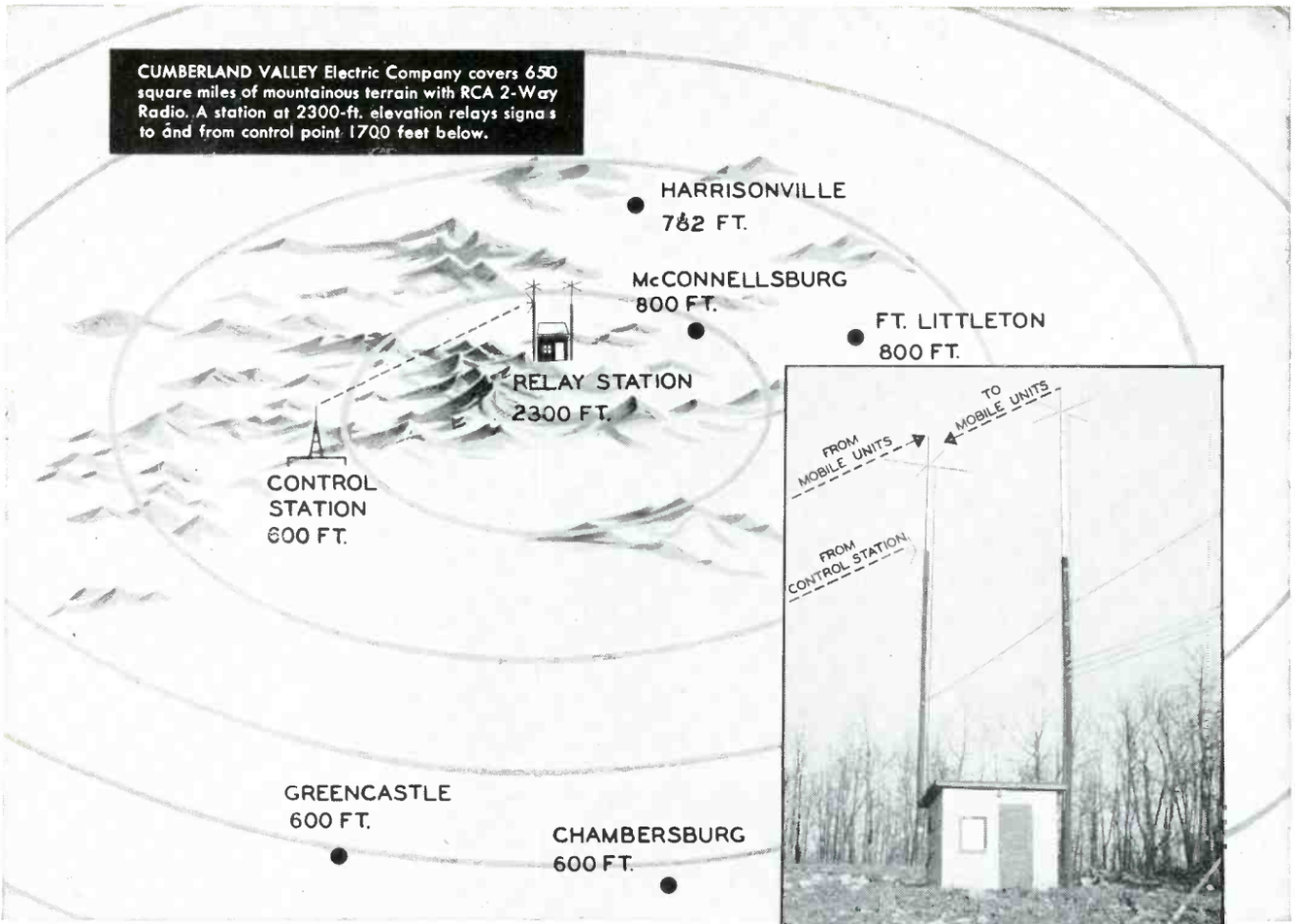
Stronger signals at greater distances are **BUILT-IN** this new narrow-angle antenna. Ideal for serving long stretches of highway, rail or pipe lines, it is equally effective for point-to-point communications, or back-to-back with other services. Gains up to 12 DB can be achieved by stacking. Vertically 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.

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

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

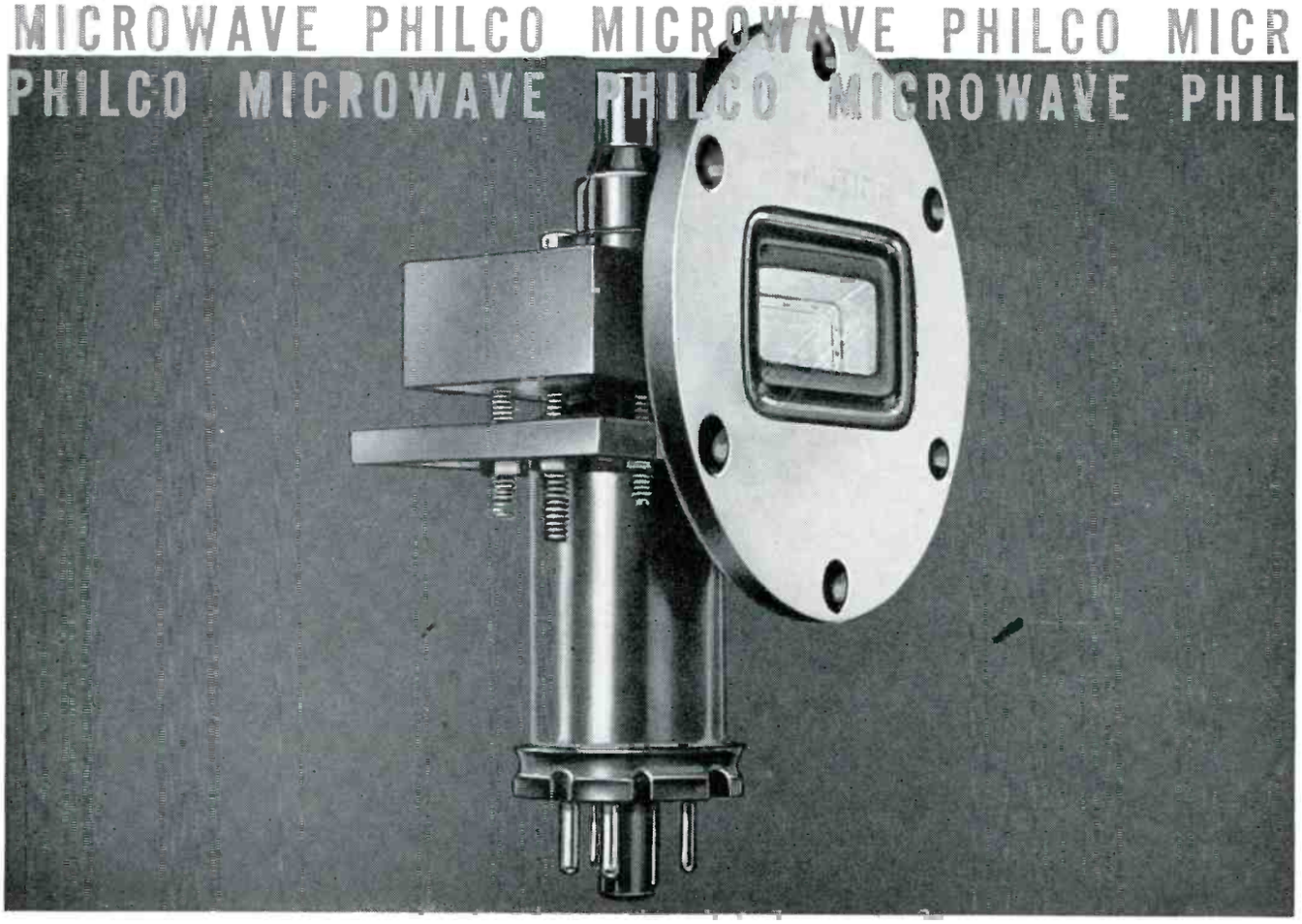
☐ Please send me information on RCA 2-Way Radio.

☐ Please have an RCA Communications Specialist call on me.

Name_____ Title_____

Company_____ Address_____

City_____ Zone_____ State_____



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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

ROY F. ALLISON, *Editor*

Published by RADIOCOM, INC.

Fred C. Michalove, *Eastern Manager* — Charles Kline, *Western Manager* — Edward Brand, *West Coast Manager*

Claire Eddings, *Production Manager* — Lillian Bendross, *Accounting*

Warren Syer, *Promotion Manager* — Eleanor Gilchrist, *Art Director*

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.

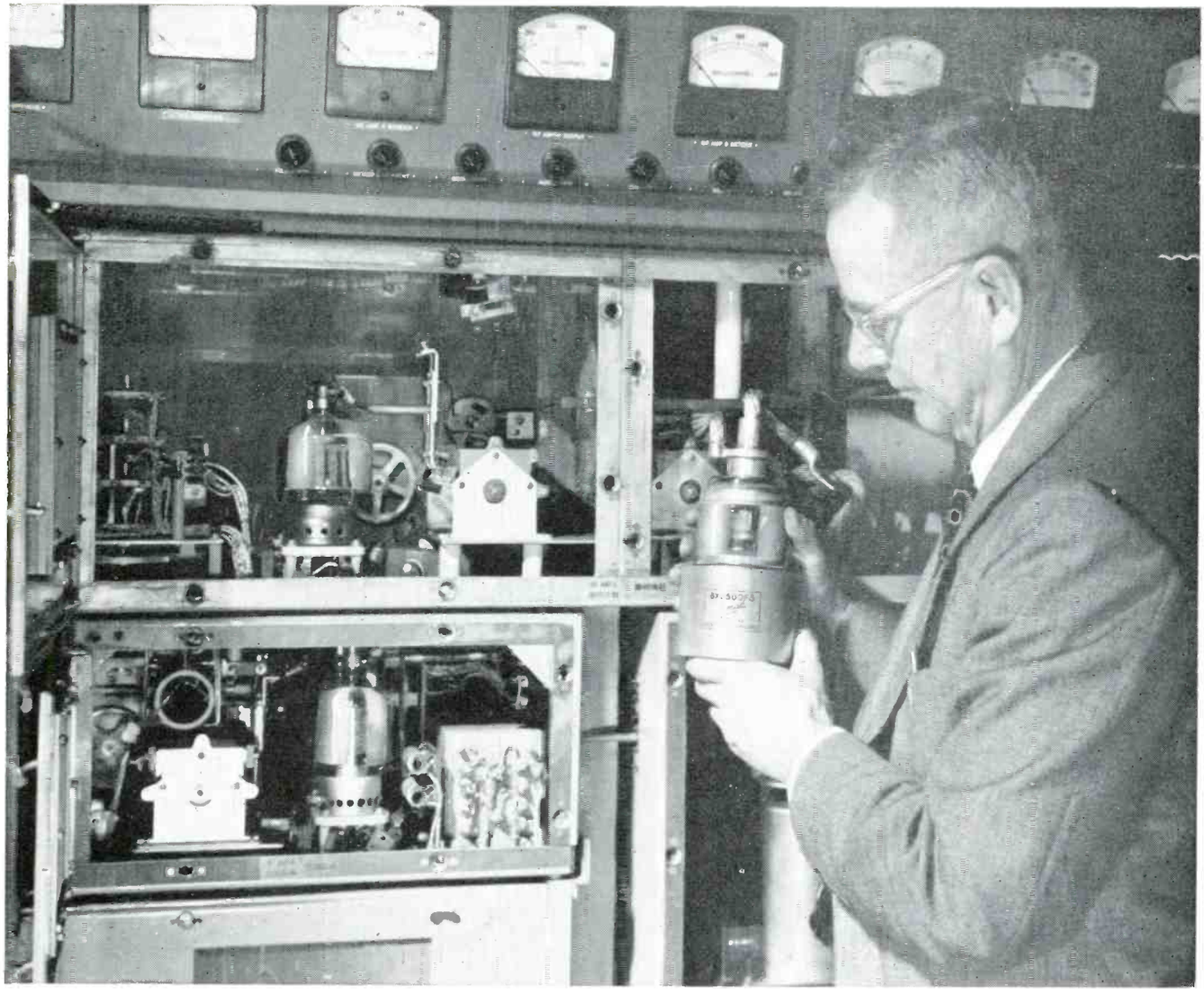
RELAY PRESS: 2 relays and 1 control transmitter on 162 mc.

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.

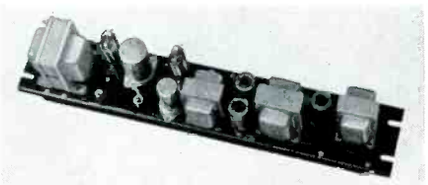
Eimac TUBES

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

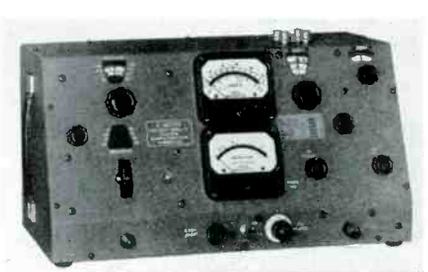


fixed-frequency tone input by AC voltage from a frequency or impulse-type telemeter transmitter. Thus, low-frequency FM telemeter signals are superimposed on an AF carrier. Unit is built on a 3½-inch standard rack panel. Hammarlund Manufacturing Company, Inc., 460 W. 34th Street, New York 1, N. Y.

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.

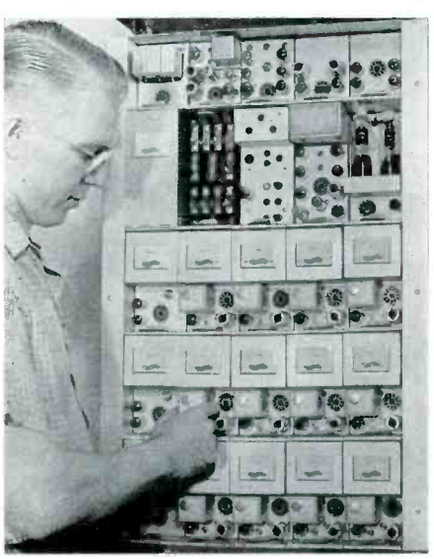


and permits readings as low as 10. A delta-*Q* scale is furnished to indicate changes in *Q* resulting from variations in test-circuit parameters. Accuracy is better than ± 1%. Range switch actuates a mask which exposes correct dial calibration. Voltage injection system is completely new, and the monitor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

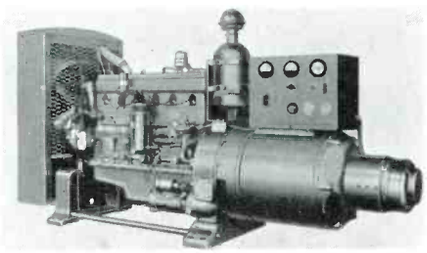
NEW PRODUCTS

(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

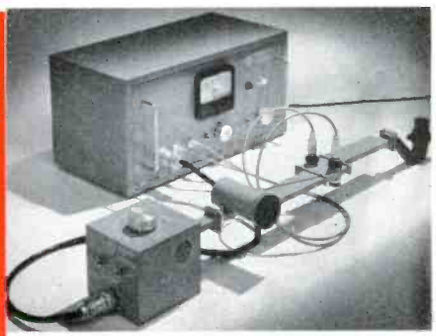
Continued on page 14

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

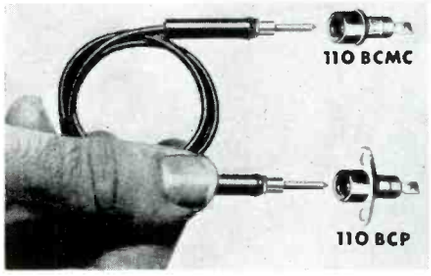
Continued on page 11

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

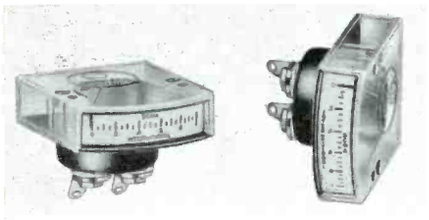
Continued on page 13

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.

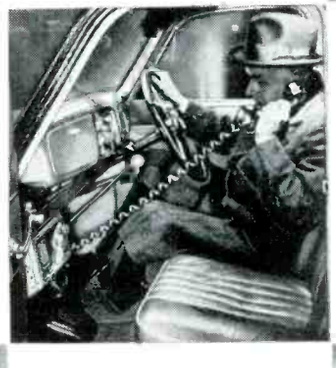
Bradford, Pennsylvania: Bradford Components, Inc., has opened a plant at 27 Bishop Street to manufacture precision wire-wound resistors, coils, and subassemblies. F. Gordon Schermerhorn, formerly manager of Speer's resistor division, is president. Other executives are John G. Cumming, Jr., vice president 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

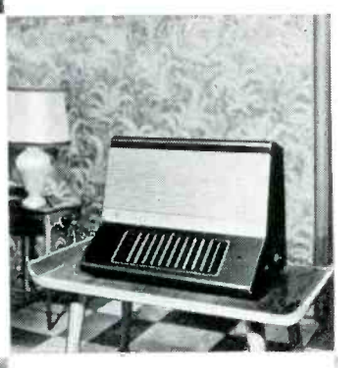
Products of Pye scientific research cover ever-widening fields of application. Information gained through experiment on each project is constantly used to develop and improve all allied manufactures. Through advances thus achieved Pye lead the world in quality and design of radio, television and telecommunications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

TELEVISION CAMERAS

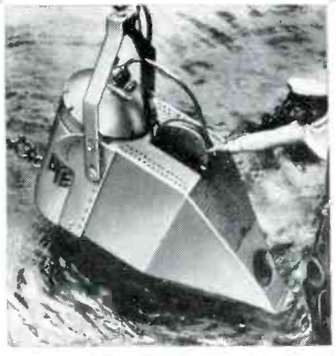


" REPORTER " MOBILE V.H.F. RADIO-TELEPHONE

INFRARED SPECTROMETER



MULTI-WAVEBAND RADIO RECEIVER



UNDERWATER TELEVISION CAMERA

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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.

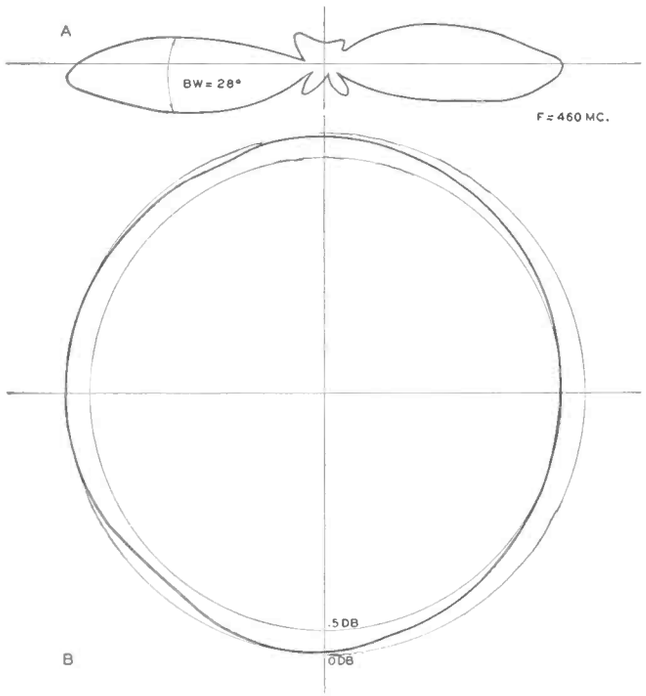


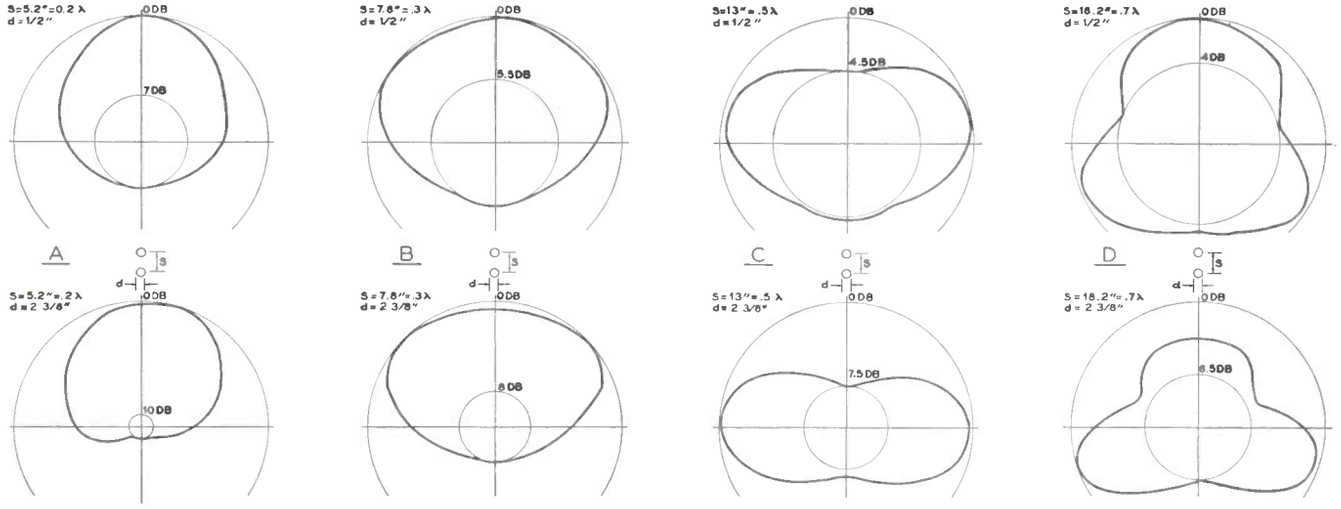
FIG. 1. RADIATION PATTERN OF GAIN ANTENNA MOUNTED IN THE CLEAR

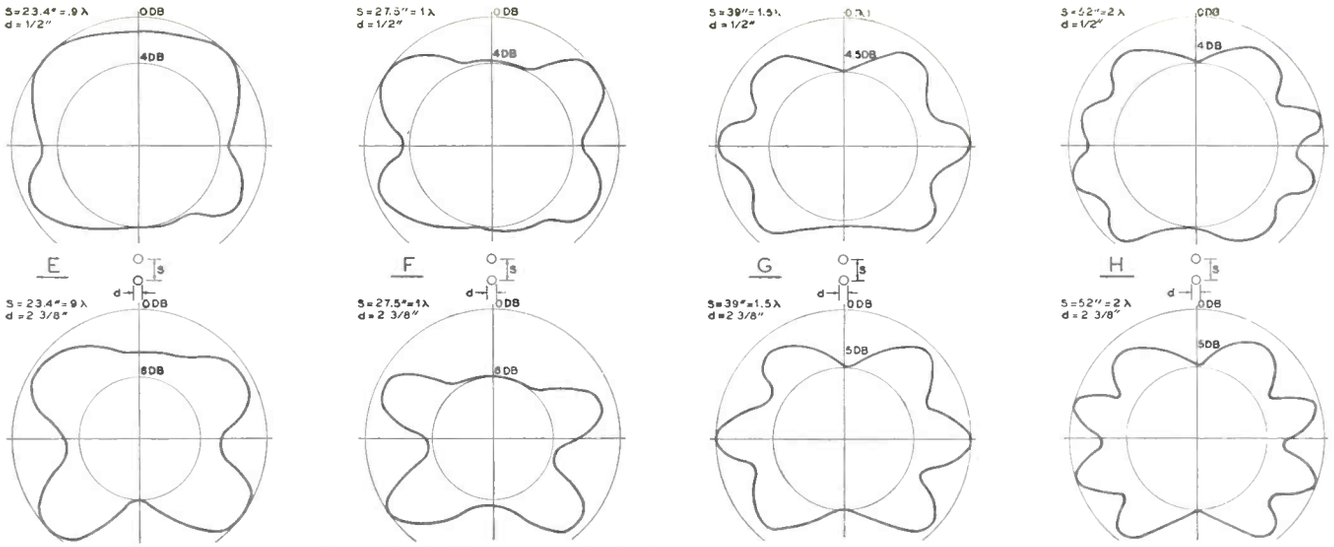
Fig. 2A through 2H is the complete set of measurements reproduced directly from the original patterns as run on an automatic polar recorder. The spacing both for the ½-in. reflector and the 2⅜-in. reflector is varied from about .2 wavelength through 2.0 wavelength. At .2 wavelength the pattern is decidedly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

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

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

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





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.

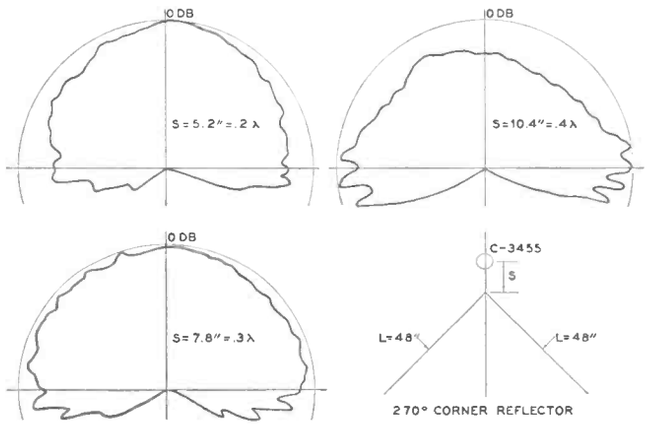
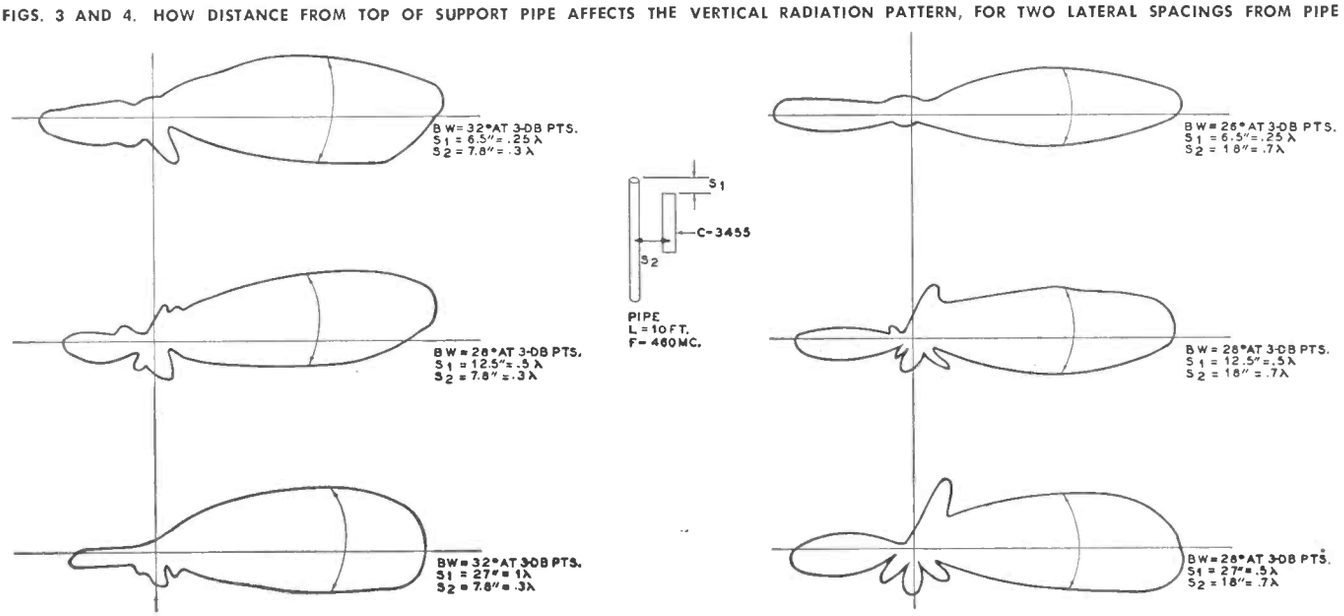


FIG. 5. EFFECTS OF 270° REFLECTOR MOUNTED AT VARIOUS DISTANCES

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

Continued on page 41

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.

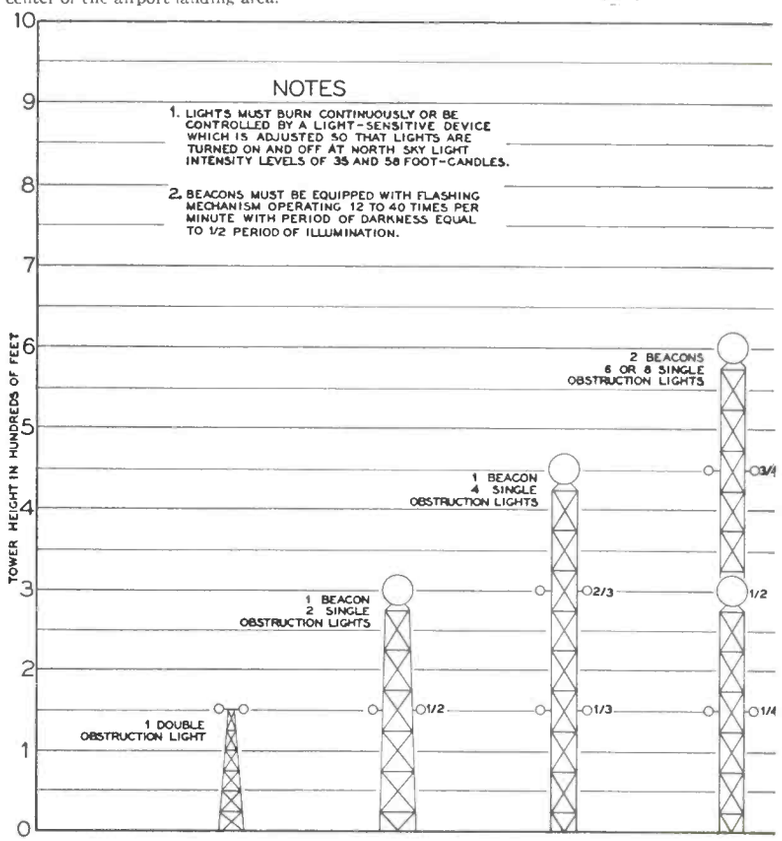
[3,4]Aerial routes and traffic control areas designated by the Administrator of Civil Aeronautics. Information can be obtained from CAA publications and regional offices.

[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

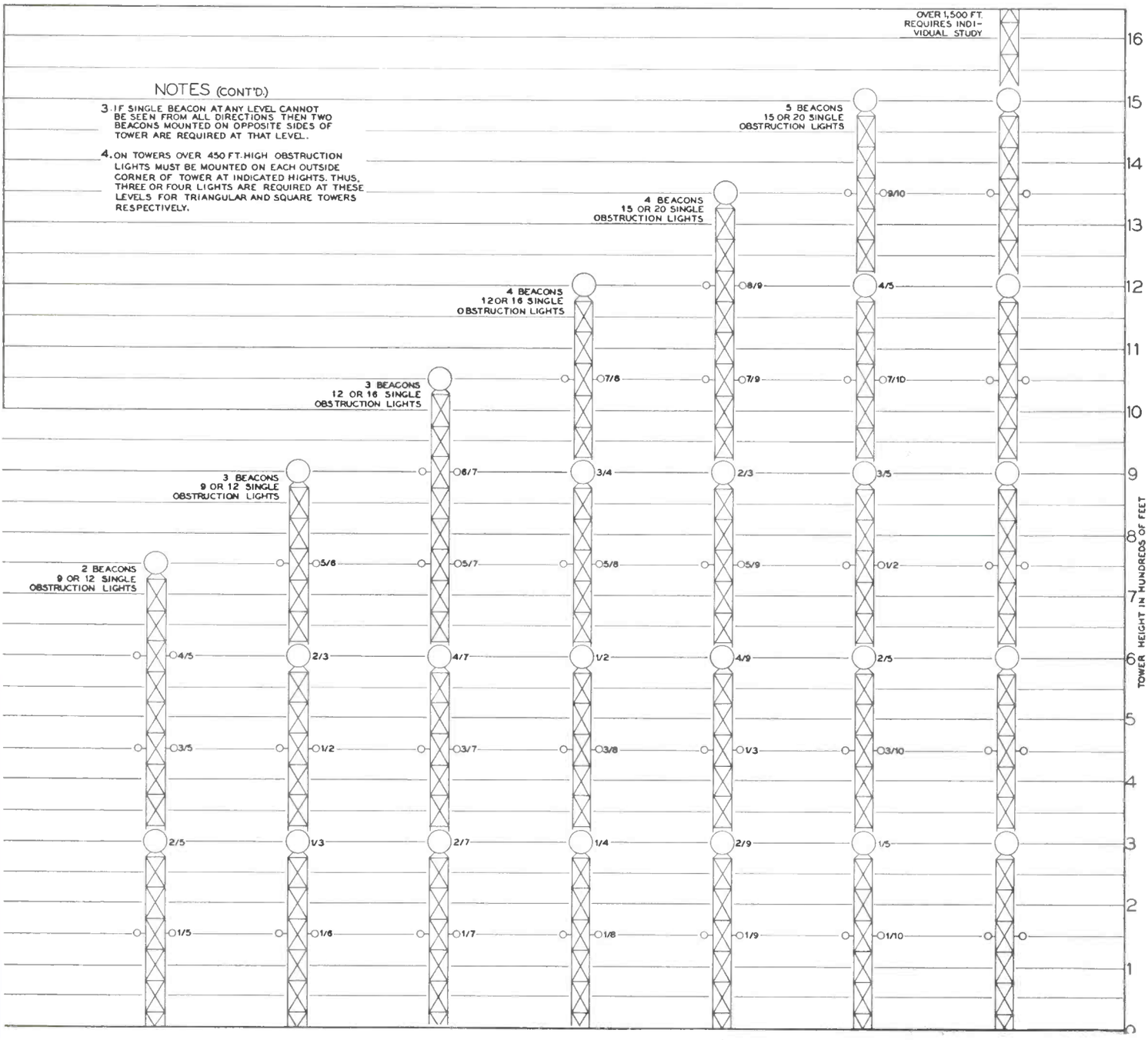
Continued on page 43

[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

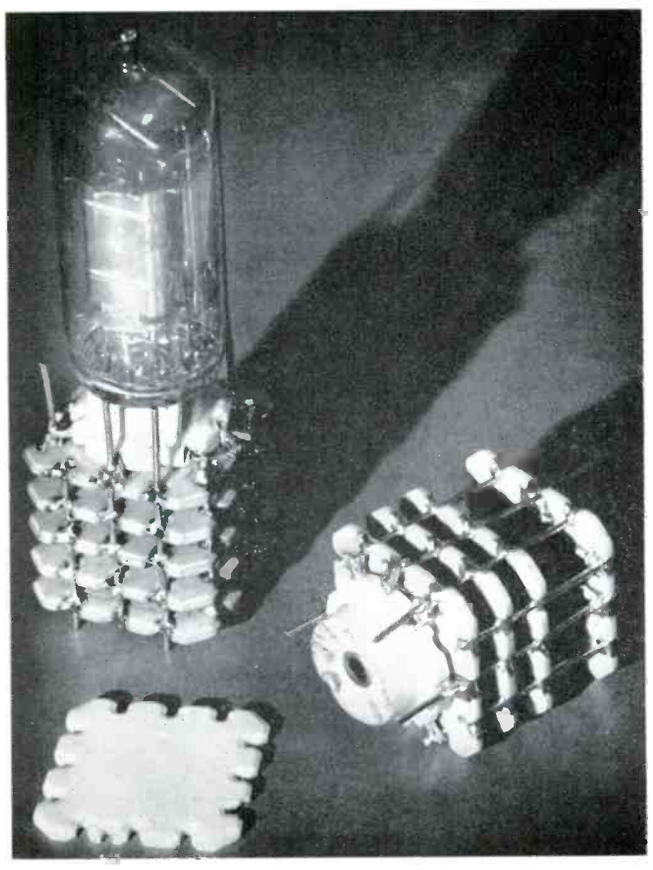
DESCRIBING A NEW CONCEPT OF MECHANIZED PRODUCTION, AND THE TECHNIQUES WHICH HAVE MADE IT POSSIBLE OF REALIZATION IN PILOT RUNS

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

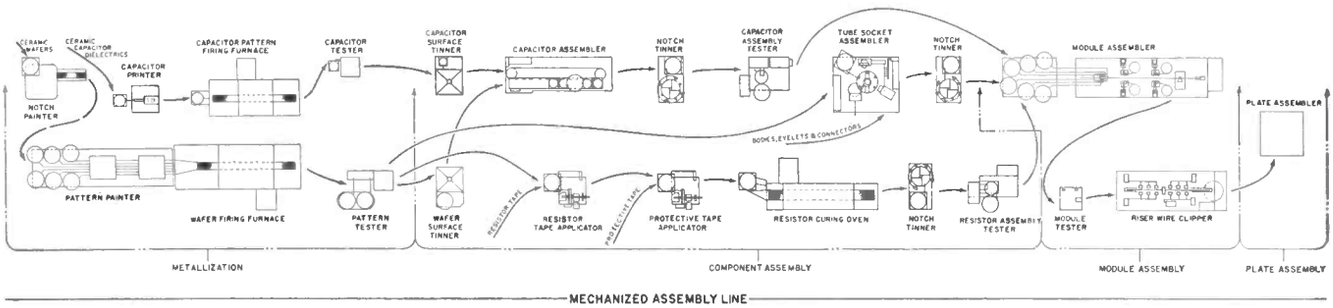


FIG. 4. DIAGRAM OF THE NBS-DEVELOPED COMPLETELY AUTOMATIC PRODUCTION LINE FOR MANUFACTURING AND TESTING CIRCUIT SUBASSEMBLIES

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.

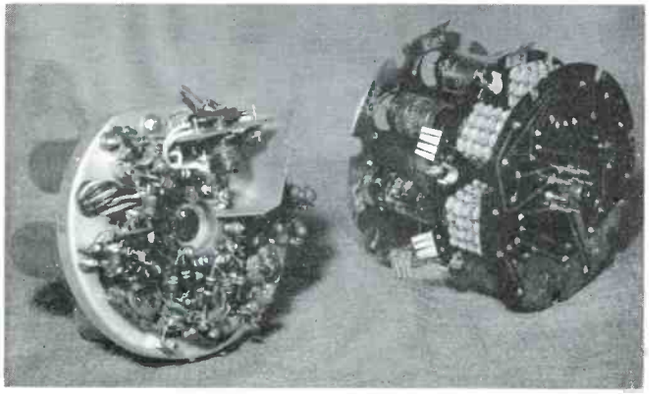
The system is based almost entirely on the use of bulk or semiprocessed materials, since the MPE line produces all the large-quantity parts except for the tubes. Joining modules together to form subassemblies can also be accomplished by machines. The pilot plant is designed for a production goal of 1,000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

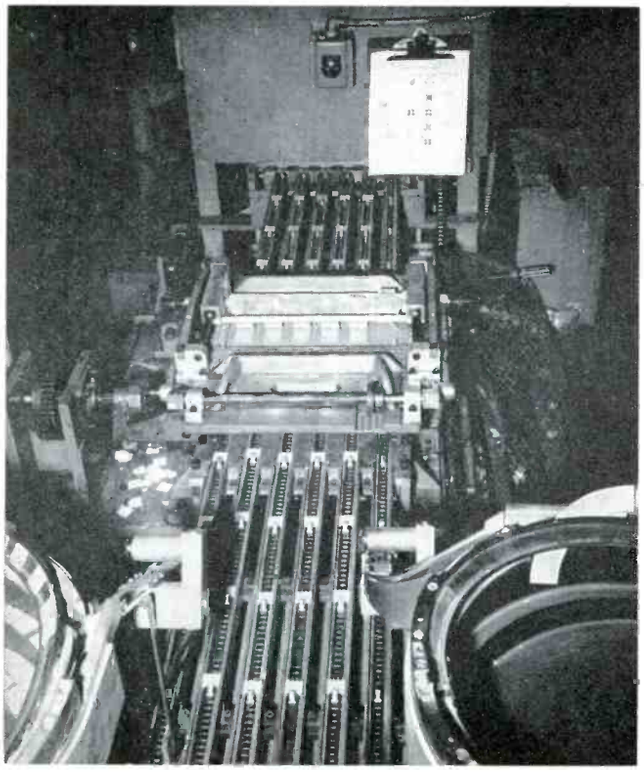
and drying, the pieces are stamped out at about 2,800 per hour by the machine shown in Fig. 5. They are cured at 2,300° F. in a tunnel kiln. Then, the pieces are mechanically gaged; all that do not conform to close tolerances are rejected.

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.



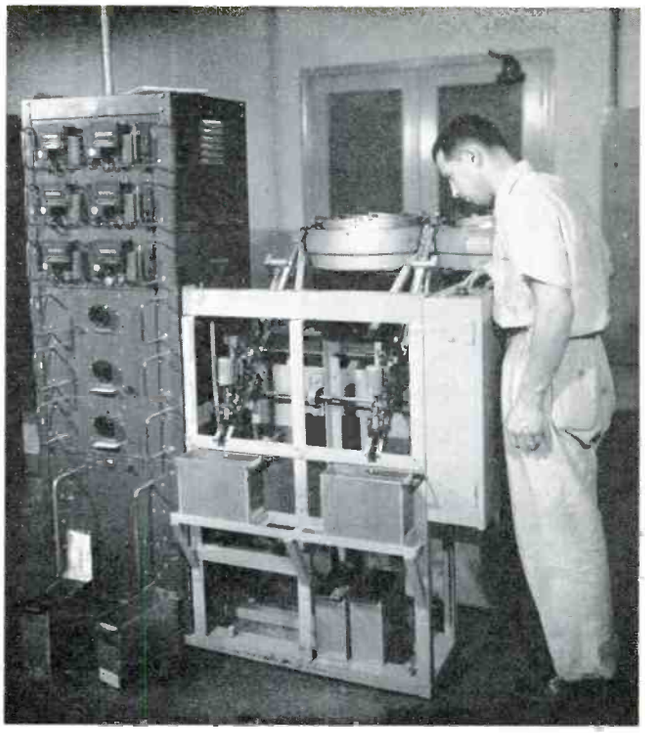


FIG. 8. WAFER INSPECTION CIRCUITS ARE SET UP BY PUNCHED CARD

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

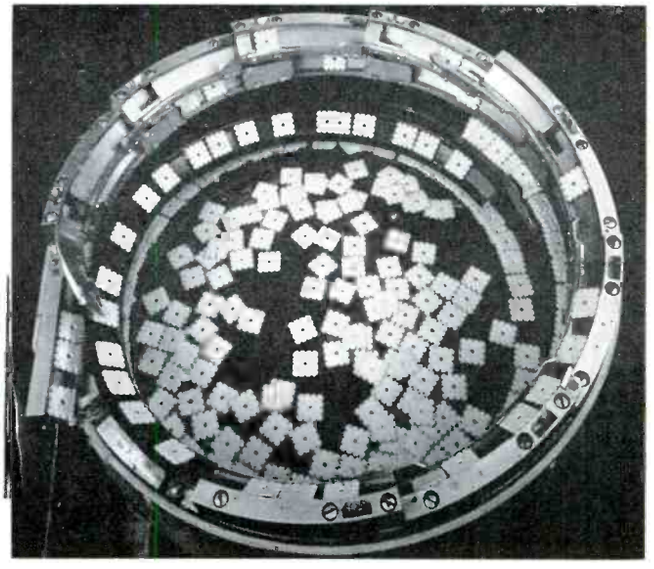


FIG. 10. ONE OF THE AUTOMATIC FACTORY'S SURFACE TINNING MACHINES

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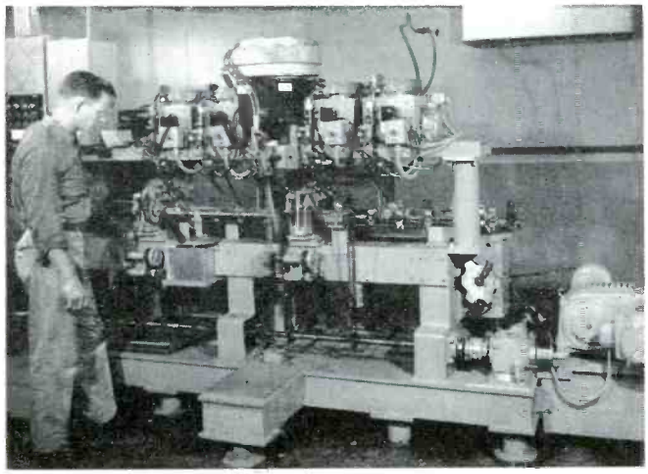
FIG. 9, BELOW: THIS MACHINE BONDS UP TO 4 CAPACITORS ON A WAFER
FIG. 11, RIGHT: PART OF THE MODULE ASSEMBLY SECTION OF MPE PLANT



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

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

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."

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

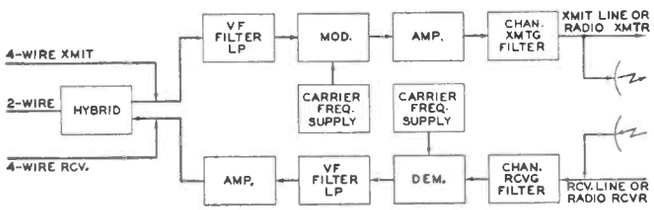


FIG. 1. DIAGRAM OF TYPICAL FREQUENCY DIVISION MULTIPLEX SYSTEM

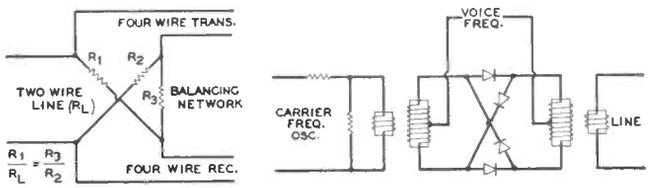
equipment. The best-known and oldest method is frequency division, wherein each voice-frequency band is superimposed on a selected carrier frequency above the audible range. By using a number of different frequencies and a system of filters, many voice channels are thereby obtained in the available frequency 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.

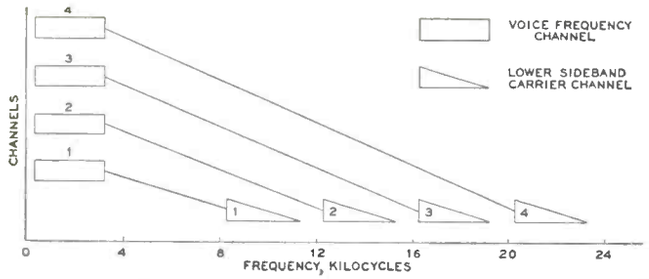


FIG. 4. FREQUENCY ALLOCATIONS FOR FOUR-CHANNEL CARRIER SYSTEM

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

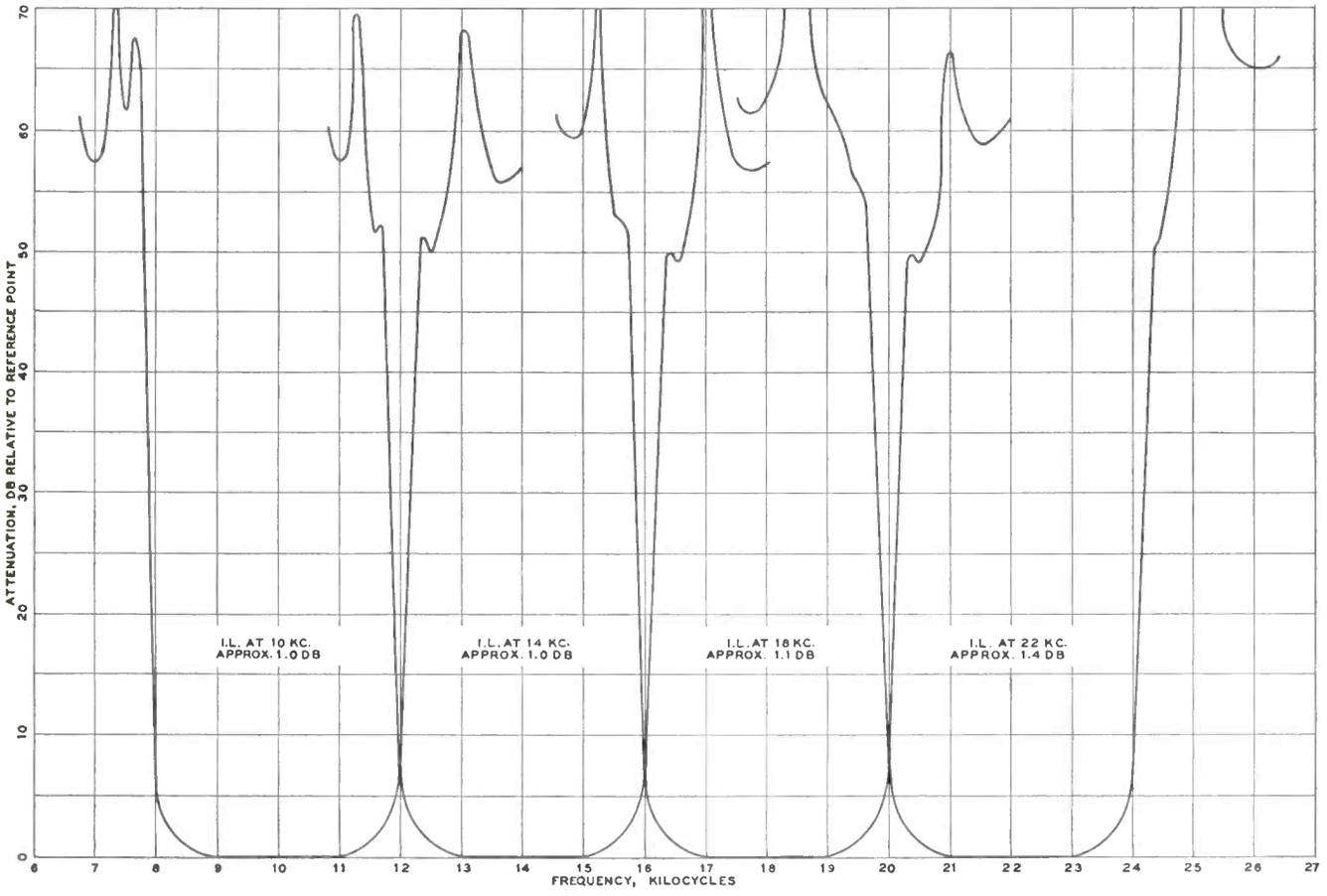
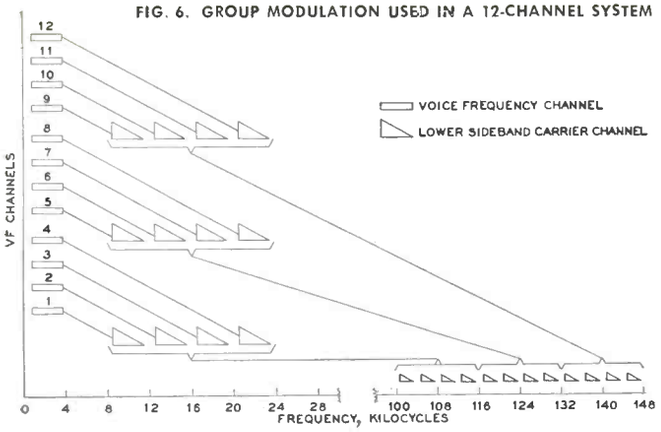


FIG. 6. GROUP MODULATION USED IN A 12-CHANNEL SYSTEM



(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.

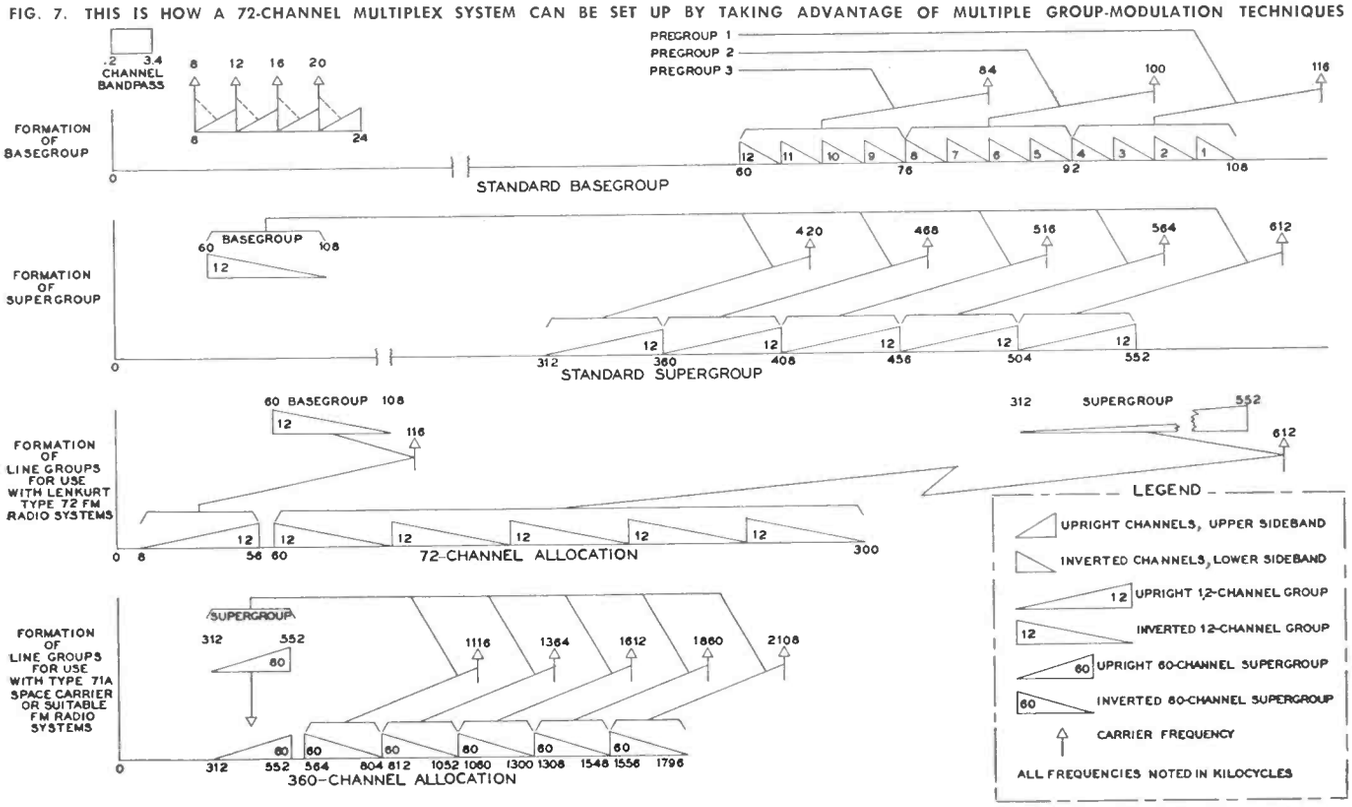
A typical balanced modulator used for a suppressed-carrier system is diagrammed in Fig. 3. Theoretically, the output of this modulator is only the upper and lower sidebands, the voice frequencies and the carrier frequency being balanced out. Practically, there is some carrier leak, but it is usually 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

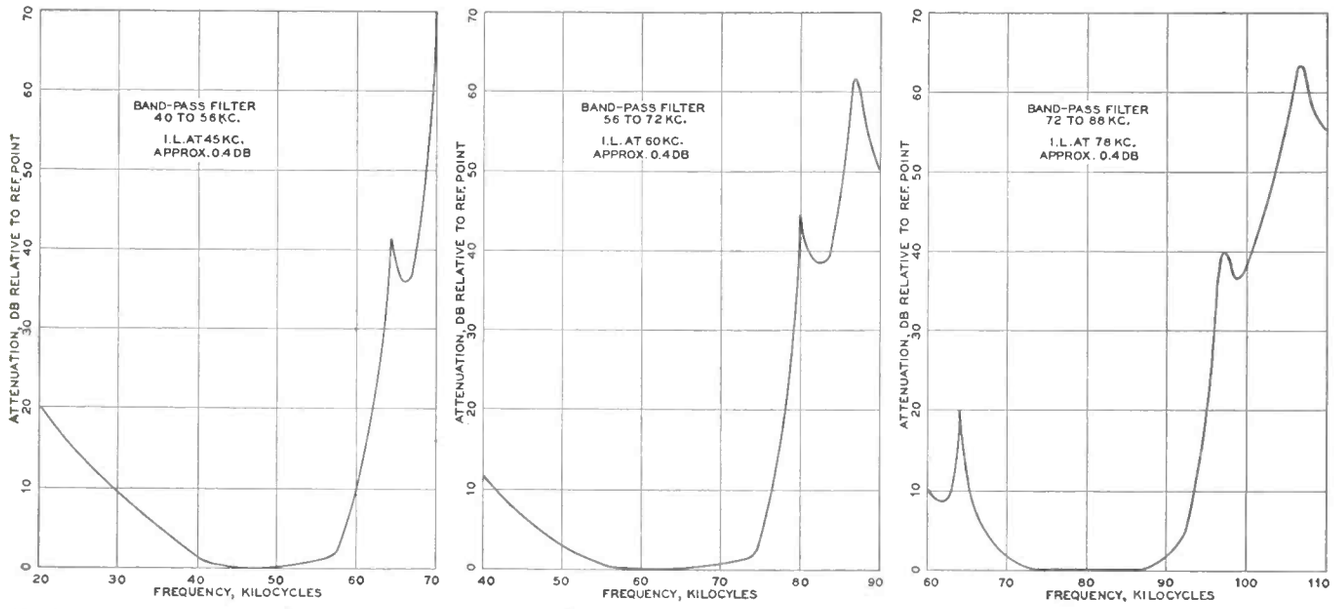


FIG. 8. BANDPASS FILTER CHARACTERISTICS FOR TYPE 45A PREGROUPS. SHAPE OF THE CURVE VARIES IN THE DIFFERENT FREQUENCY RANGES

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.

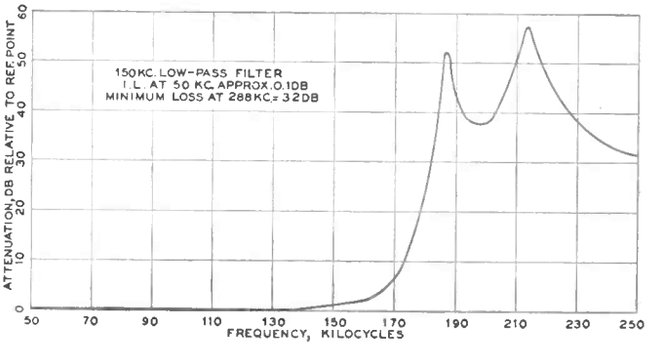
In group modulation a wide band of frequencies including the intelligence of a number of voice channels, formed by regular carrier methods, is used to modulate a new carrier. Any number of channels can be included in a group. The frequency allocation chart of Fig. 6 shows how group modulation can be 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.

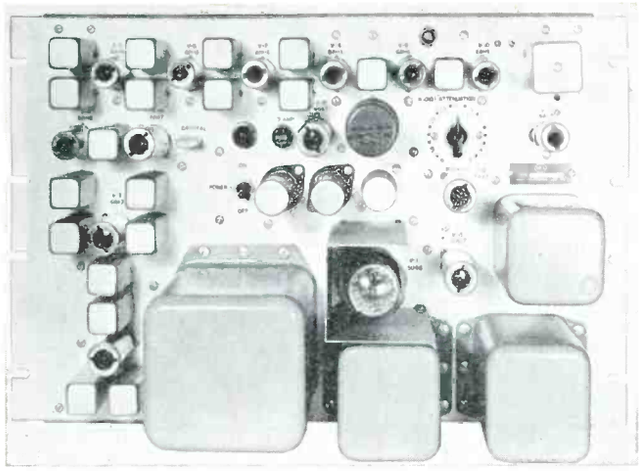
Each 12-channel basegroup is modulated with one of five carriers to create a supergroup with a total of 60 channels between 312 and 552 kc. In the last stage of the 72-channel allocation, the supergroup is translated to the band from 60 to 300 kc. and one basegroup is translated to the band from 8 to 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.

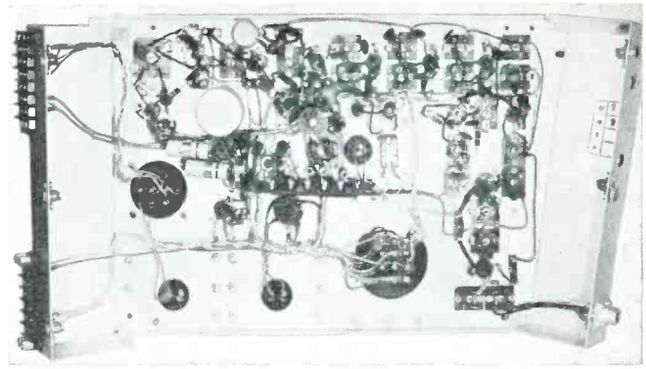
Lenkurt type 45D systems are designed especially for radio and operate on a true four-wire basis with identical frequencies used for both directions of transmission. Therefore, formation of the channels for the opposite path accompanying the 72 channels described above is identical.

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.

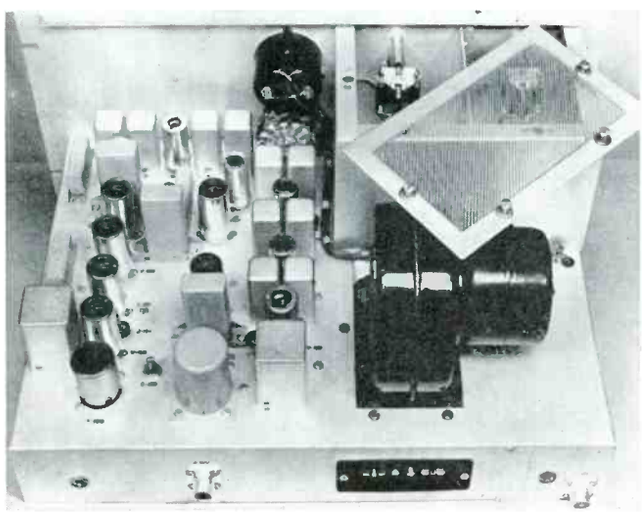
Operating frequency range of the equipment is 152 to 174 mc. System deviation is ± 50 kc. for 100% modulation; this is adjustable on special order. Modulation frequency response is ± 1 db from .2 to 20 kc., and amplitude distortion is 1% from .2 to 10 kc. Intermodulation is —46 dbm for A-B test tones 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.

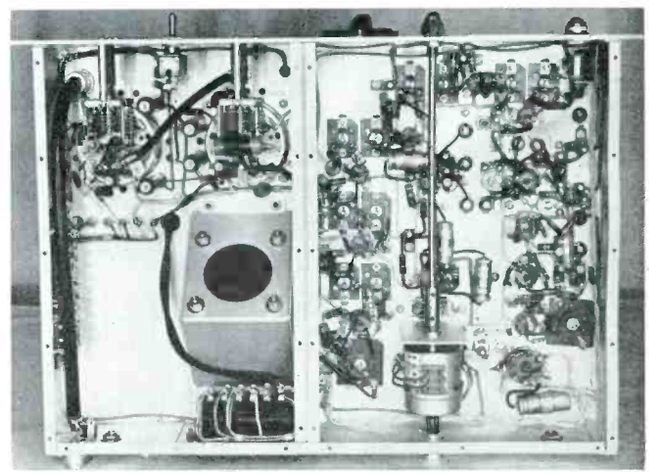
Primary power input is 115 volts, 50 to 60 cycles, single-phase AC at 415 watts. If the 747 amplifier is used the total power requirement is increased to 765 watts.

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



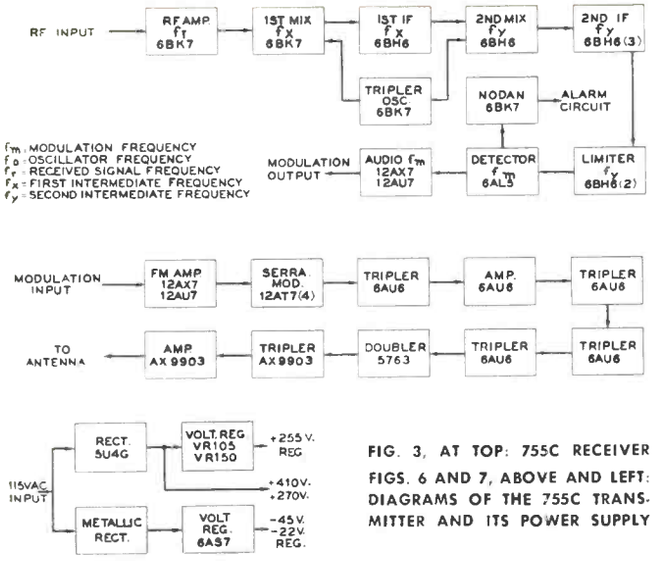
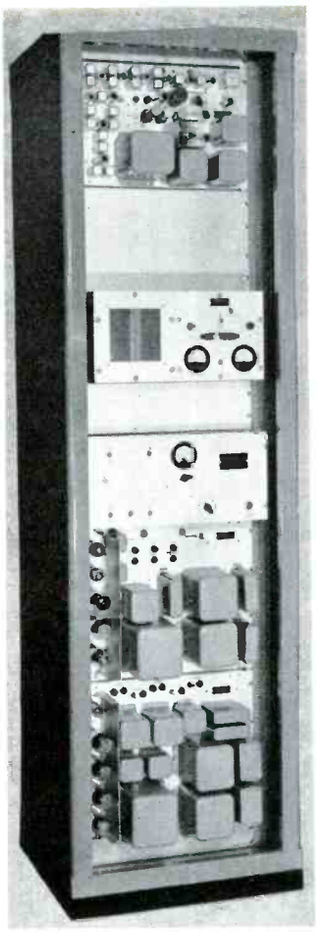
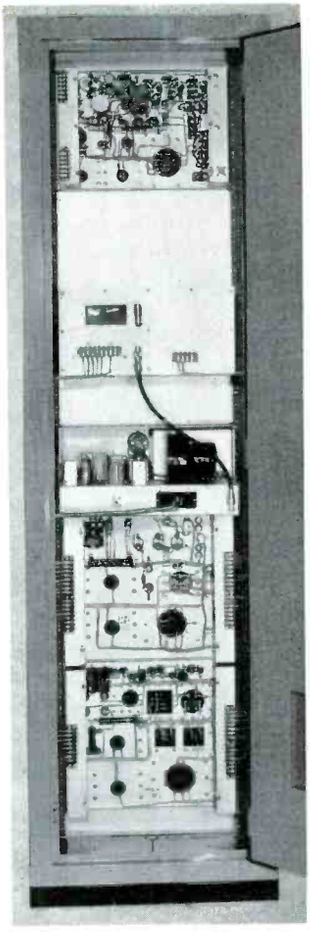


FIG. 3, AT TOP: 755C RECEIVER
FIGS. 6 AND 7, ABOVE AND LEFT: DIAGRAMS OF THE 755C TRANSMITTER AND ITS POWER SUPPLY





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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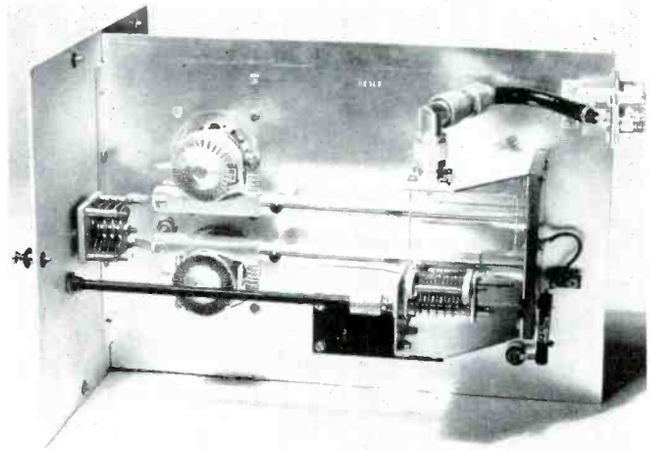
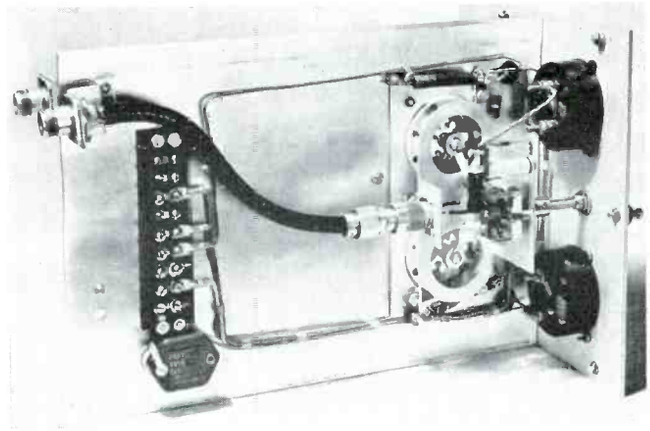


FIGS. 11 AND 12, TOP RIGHT: THE COMPLETE 150-MC. TERMINAL RACK
FIG. 9, RIGHT: TOP OF A 747 100-WATT AMPLIFIER, SHOWING AX9903'S
FIGS. 8 AND 10, BOTTOM ROW: FRONT AND BOTTOM VIEWS OF THE 747



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:

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

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
$C = 70\mu\mu F$

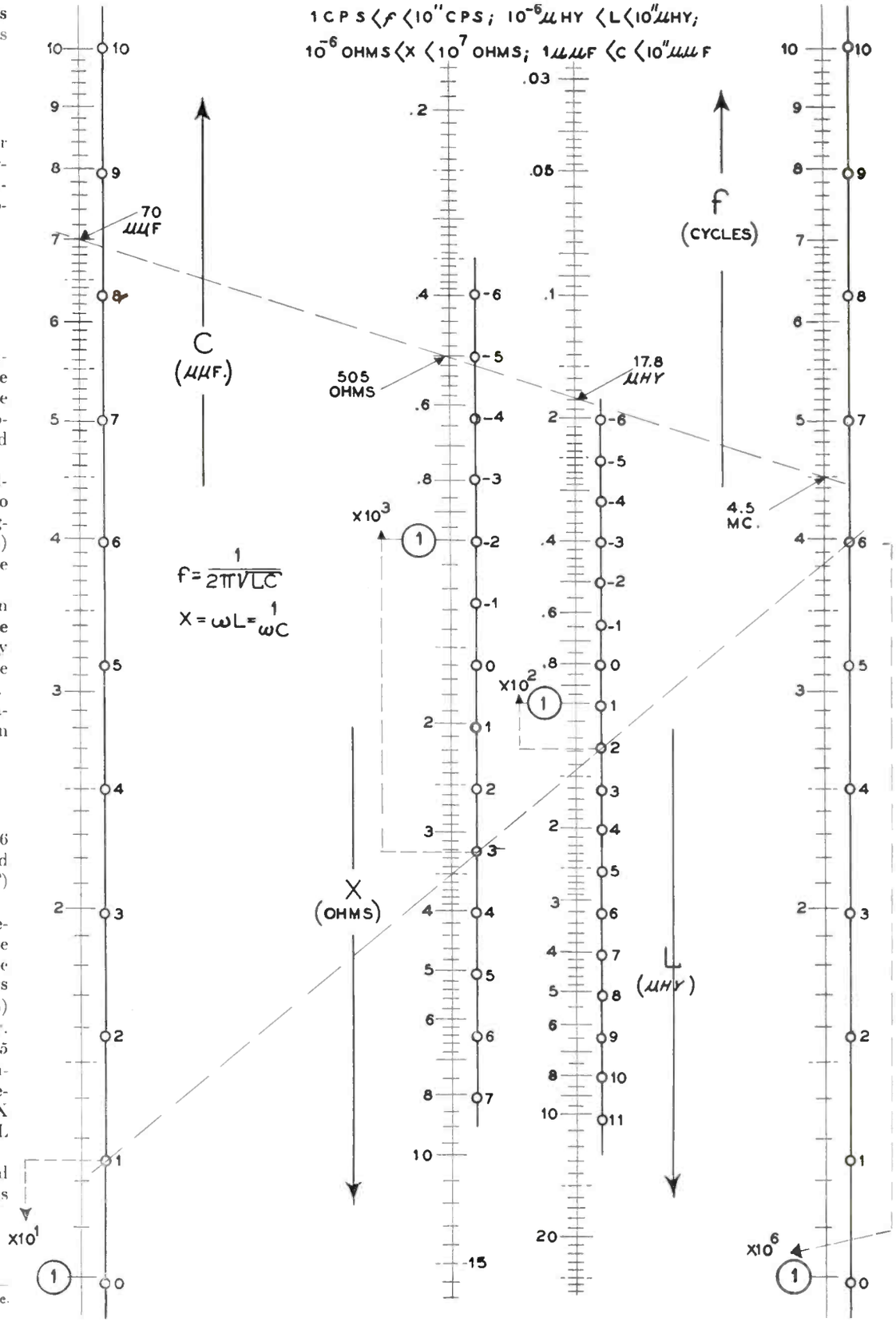
This requires a line through 6 (10^6 cycles = mc.) for f and through $1(10^1\ \mu\mu F. = 10\mu\mu F)$ in the dot system (a).

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.

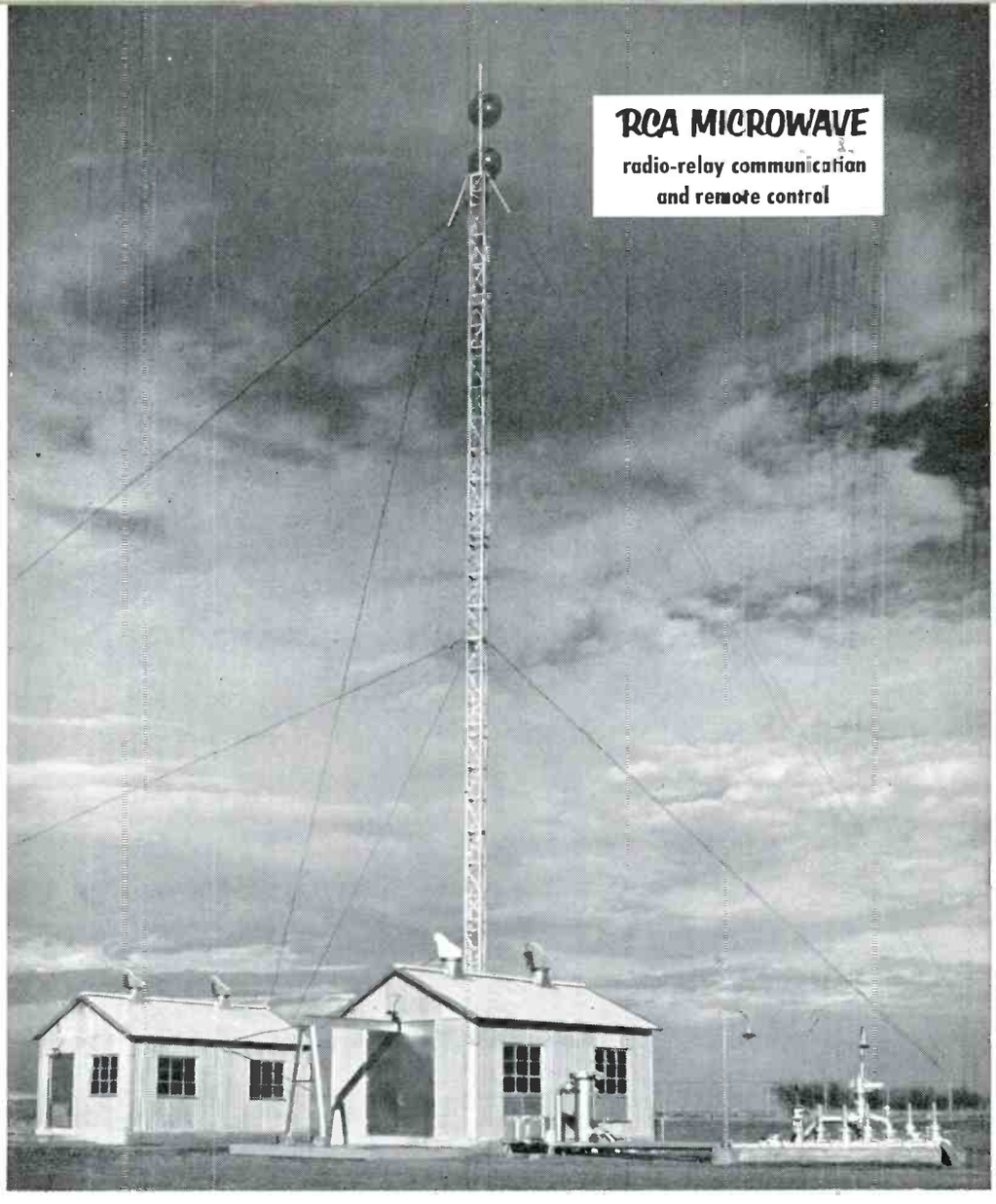
When the Sunray microwave-operated "*boosters*" were put in operation on January 31, 1952, *the pipe line's capacity immediately increased 25 per cent!*

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.

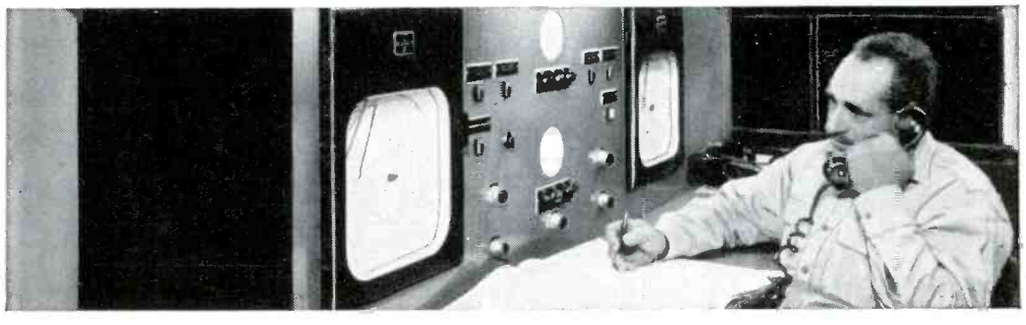
In addition to remote control and supervisory functions, RCA Microwave provides as many voice and teletype channels as you need—and does it with a minimum of frequency space. It employs readily available tubes and familiar circuits which are easy to service. It interconnects with your telephone lines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

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

Dept. 132W, Building 15-1

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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 490. 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

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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

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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 circuts, 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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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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