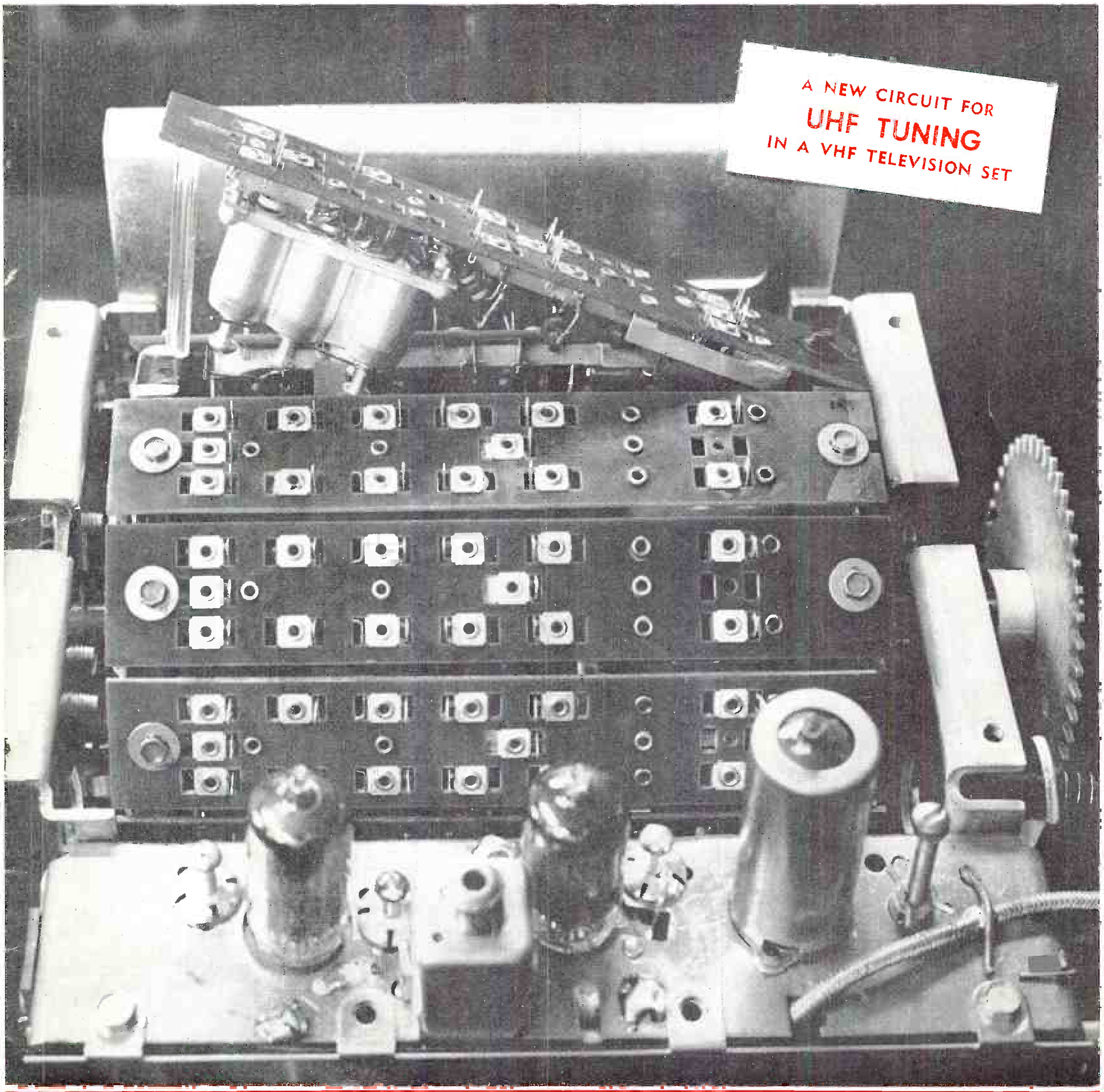
Price 35 Cents May '51

FM-TV RADIO COMMUNICATION

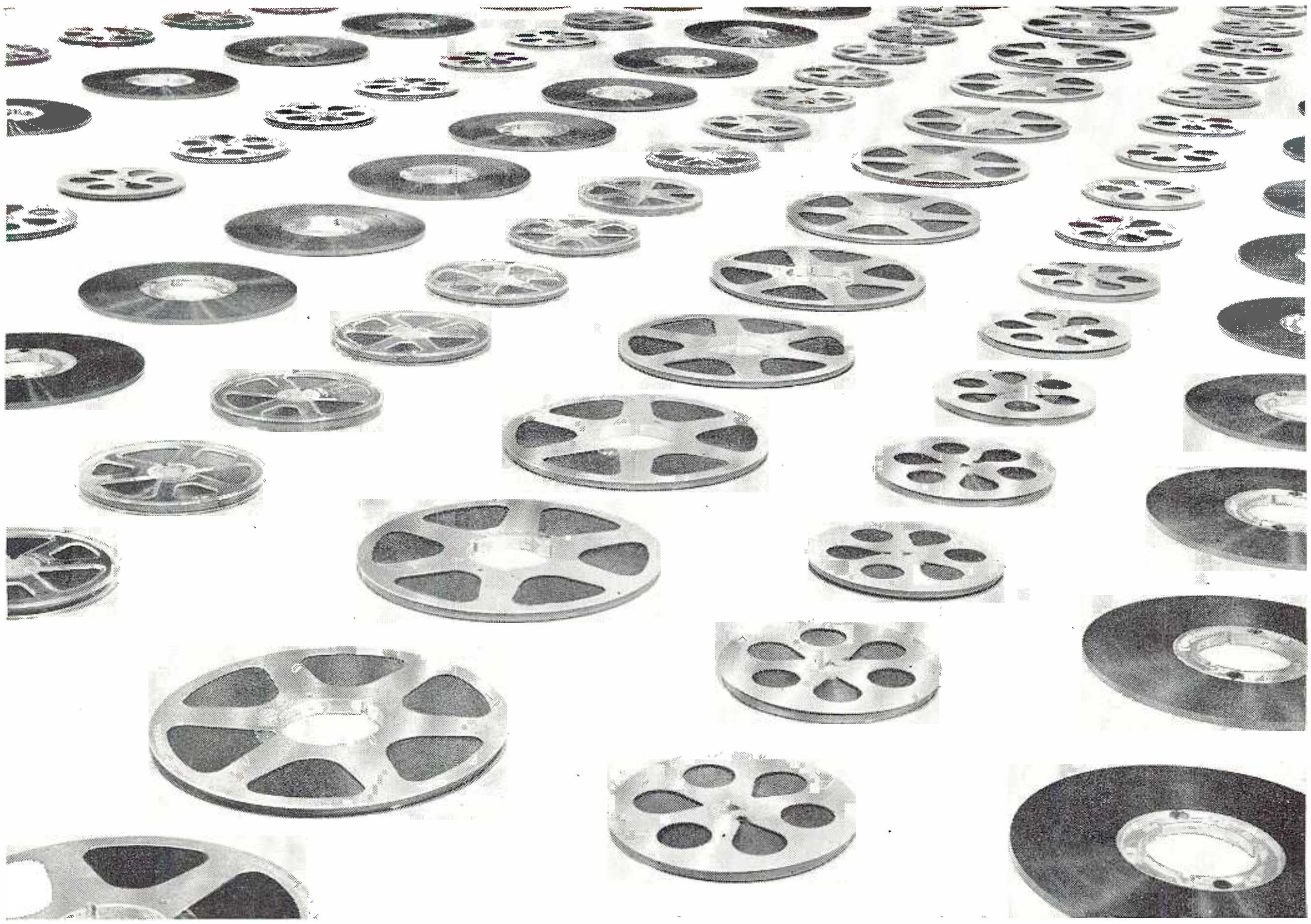
★ ★ Edited by ★ ★
Milton B. Sleeper



A NEW CIRCUIT FOR
UHF TUNING
IN A VHF TELEVISION SET

11th Year of Service to Management and Engineering

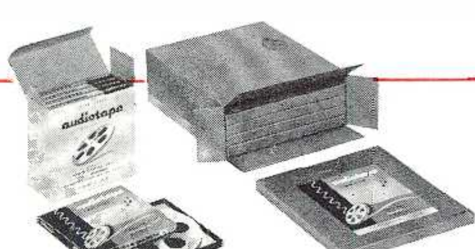
CONSISTENT UNIFORM QUALITY



. . . reel after reel after reel!

That's just one of the EXTRA VALUES that you get in **audiotape***

made by audio engineers, for audio engineers



NOW — output curves in every package!

Here's output uniformity that you can *see* for yourself. For every 5-reel package of plastic base Audiotape, in 1250 and 2500 ft sizes, now contains an Esterline-Angus output curve made from one of the reels in that package. And since all five reels are slit from the same roll after coating, it shows you the actual output characteristics of every reel — giving positive visual proof of unequalled uniformity.

● Yes — when you reach for a reel of Audiotape, you can be *sure* that you will have the finest recording that your equipment can produce. You *know* that the output volume will not vary more than ± ¼ db within every 1250 ft or 2500 ft reel of plastic base Audiotape. That is *guaranteed.* You *know* that these reels are entirely free from splices. That is guaranteed also. But, still more important, you know that you can depend on Audiotape for unequalled over-all performance — with maximum fidelity of reproduction and minimum surface noise and distortion.

In short, Audiotape *always* gives you the same consistent, uniform quality that has characterized Audiodiscs for more than a decade.

Have you heard about our new disc *recoating service?* We are now prepared to recoat your used discs for you — at a substantial saving over the cost of new discs. Your Audiodisc distributor will be glad to give you complete details.

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AUDIO DEVICES, Inc.

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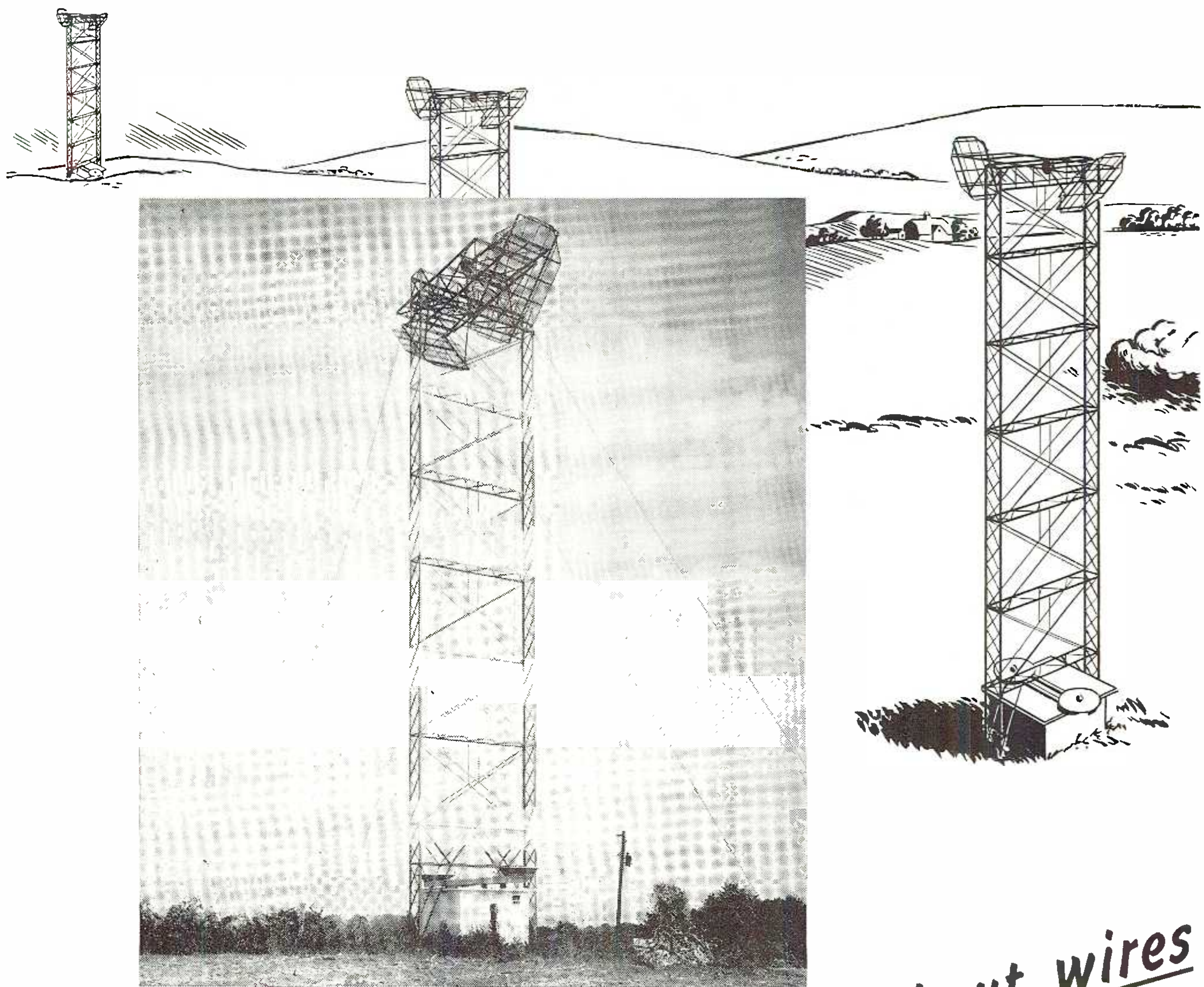
Export Dept.: 13 East 40th St., New York 16, N. Y., Cables: "ARLAB"

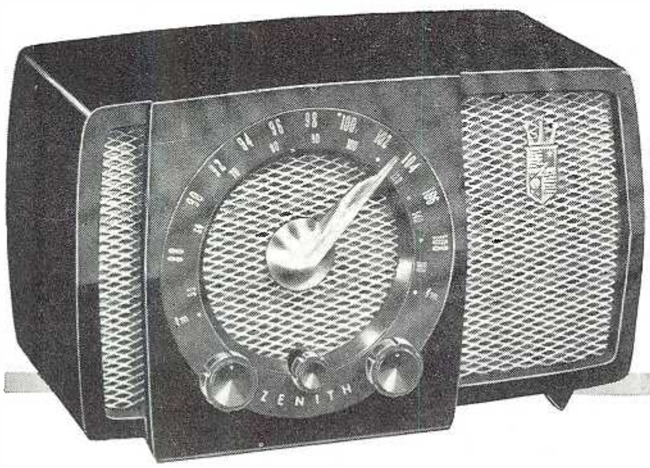


ZENITH ANNOUNCES

2 Super-Sensitive FM-AM Radios

with Performance Superiority that makes Sales!

Again Zenith lengthens its lead over the FM-AM field—with new and better versions of the Zeniths that were already the industry's two best sellers. With Zenith's unrivaled Super-Sensitive FM, they bring in a wealth of entertainment, static-free and real as only genuine FM can be. Their newly designed cabinets are the style highlights of the radio year. Of course, both have Zenith's famous Long Distance AM, big Zenith-built Alnico speakers and other Zenith advantages.



New Super-Medallion

Genuine Super-Sensitive Zenith FM plus Zenith Long Distance AM — automatic volume control — built-in Wavemagnet* and Light-Line Antenna — cabinet of beautiful maroon plastic with Roman Gold mesh grille and tuning indicator.

New Super-Triumph

The same Super-Sensitive FM and Long Distance AM as the Super-Medallion, plus new broad-range tone control—jewel-like on/off indicator—maroon plastic cabinet with "Flexo-Grip" carrying handle—Roman Gold embossed dial.

Zenith is No. 1 for '51!

ZENITH RADIO CORPORATION, CHICAGO 39, ILLINOIS

Over 30 Years of "Know-How" in Radionics Exclusively

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ZENITH® "LONG DISTANCE" RADIO and TELEVISION

THE ROYALTY OF RADIO AND TELEVISION®

FM-TV RADIO COMMUNICATION

Formerly *FM* MAGAZINE, and *FM* RADIO-ELECTRONICS

VOL. 11 MAY, 1951 NO. 5

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CPA AUDIT

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

IN February, TV set production, as estimated by RTMA, continued at a level considerably above public demand. Reasoning on the part of the larger companies is probably that they should make sets while they can, and keep their factory forces employed against the time when they will be needed for military production. Dealers, however, are accustomed to working on quick turnover, and to meet falling demand with cut prices. Result is that inventories of TV sets are a headache now, although it seems certain that there will be a severe shortage come fall. This situation is putting the squeeze on small manufacturers.

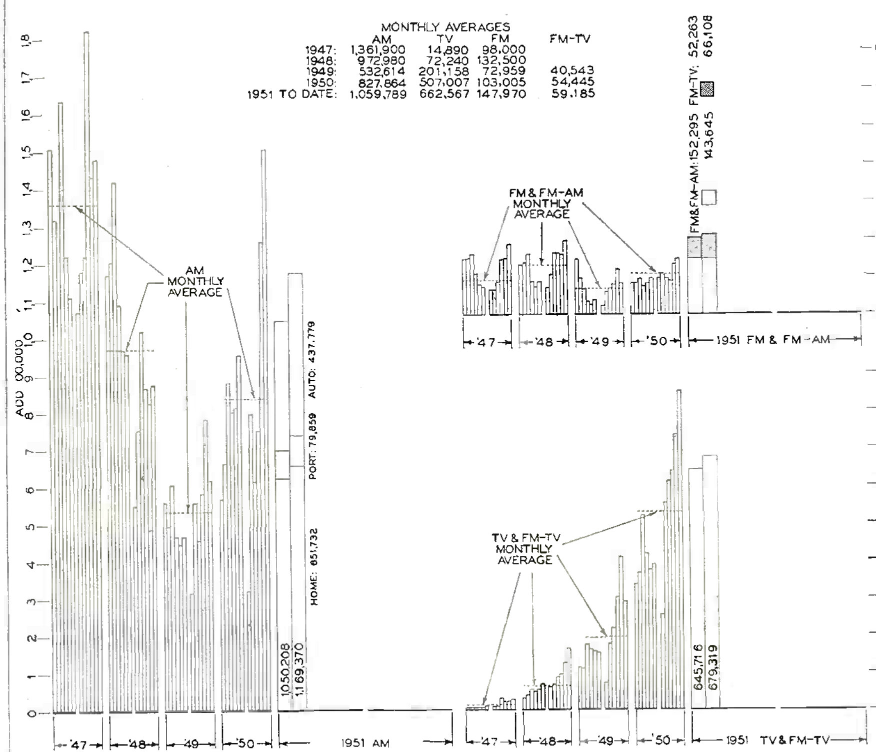
AM production continued at the highest rate since 1947, but only 65% of the sets were home models. Auto radios accounted for 38%, and portables for 7%. This is shown by the separate sections of the AM block in the Production Barometer.

FM dipped slightly below January, but that was offset by an increase in the number of TV sets equipped for FM tuning. The production rate is substantially above any preceding year, and the large percent of FM phono combinations has built this category up to an impressive dollar volume. In fact, cut prices on TV sets, and the low AM unit of sale have made FM models the most profitable and fastest selling in dealers' stores wherever there is broadcast service.

Incidentally, sales on high-fidelity audio equipment and FM-AM tuners for custom installations are proving to be the most stable, year-round segment of the radio business. There is practically no price-cutting trouble, comparatively little dip in summer volume, and better-than-average profit for dealers.

TV picture-tube sales in February amounted to 634,080 units, valued at $17,555,375. This was 9% above the number of tubes sold in January. Only 4% were smaller than 16 ins., and 82% were rectangular in shape.

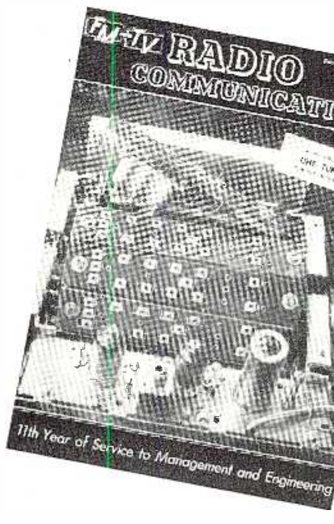
Receiving tube sales were just slightly below January, amounting to 36,821,794. This was 48% above February, 1950. RTMA reported 24,578,991 for audio and TV sets; 2,355,356 for other new equipment; 8,237,372 for replacements; 1,429,783 for export, and 220,292 for Government Agencies.



TV, FM, and AM Set production Barometer, prepared from RTMA figures

THIS MONTH'S COVER

There has been more discussion and less factual information about Zenith's claim to providing sensitive UHF reception in their VHF television sets than on any other subject that has come up in a long time. This month's cover shows one of the UHF tuning strips, partly removed from the turret. It does not disclose, however, the new circuit. For that detail, and the method of combining a VHF with a UHF antenna, turn to page 12 of this issue.



SPOT NEWS NOTES

ITEMS AND COMMENTS, PERSONAL AND OTHERWISE, ABOUT PEOPLE AND COMPANIES CONCERNED WITH RADIO COMMUNICATIONS

Government Contracts:

If you want *official* information on securing contracts or subcontracts for military equipment, send 15 cents in coin to the Chamber of Commerce of the U. S., Washington 6, D. C., and ask for a copy of "Six Steps in Selling the Armed Services." It contains all the details.

By Hook or Crook:

Production of FM tuners has been pushed up to the limit, but manufacturers report that back orders are piling higher than ever. Someone, though, got prompt delivery on an RJ-10A chassis by stealing it from the Browning exhibit at the recent IRE Show, despite the fact that four men were in attendance at the booth when it happened.

TV at the UN:

Equipment for the new United Nations building at New York City will be supplied by Marconi's Wireless Telegraph Company, Ltd., of London.

Washington Award for 1951:

Presented by the Western Society of Engineers to Edwin Howard Armstrong, for "outstanding inventions basic to radio transmission and reception, and notable service to his Country." Among the previous recipients are Herbert Hoover, Orville Wright, Michael Pupin, Charles Kettering, Frank Jewett, Henry Ford, and Vannevar Bush.

Parabolic Antenna Problems:

Can be solved readily with a slide rule designed by Workshop Associates, Inc., Needham Heights, Mass. There are scales for diameter, wavelength, gain, and half-power angles. Copies can be obtained without charge by letter-head request.

John S. Boyers:

Chief engineer and assistant treasurer of Magnecord, Inc., has been elected president of this company. Before joining Magnecord, Mr. Boyers was associate physicist at Armour Institute, where he was engaged in the development of magnetic recording.

C-D Communication:

An excellent booklet entitled "Guide to Communication for Civil Defense" has been published by Leece-Neville Company, Cleveland 14, Ohio. Very interesting information is also contained on the L-N alternator system for battery charging and as an emergency AC supply. Copies are available on request.

Industry Credit Problems:

Will be discussed at a joint meeting of RTMA eastern and western credit committees at Hotel Stevens, Chicago, on June 6, during the RTMA convention. Right now, there are some problems that require discussion.

George H. Phelps:

Appointed chief engineer of Hammarlund Manufacturing Company. Previously, he was sales application engineer for RCA microwave products.

Television IF Interference:

State police communication transmitters on 42 to 44 mc. are now authorized to use up to 10 kw. With TV sound IF on 41.25 mc., and picture IF on 45.75 mc., there may be interference trouble in some areas. Fortunately, most of the

(Continued on page 8)

NOW! TWO* FULL WATTS ANTENNA POWER

littlefone®

AC OPERATED
CENTRAL STATION

*PVFX-4	TWO FULL WATTS OUTPUT	25-50 MC
PVFX-14	ONE FULL WATT OUPUT	150-175 MC

SIZE: 11" x 7" x 8¾" — POWER CONSUMPTION 35 W.

Here's a portable central station that weighs only 15 lbs. and provides loudspeaker operation. The PVFX-4 is a complete self-contained 2-way radio with an output of two full watts! It is AC operated, using the reliable standard littlefone chassis, operating from AC power pack with audio amplifier providing one watt of audio for loudspeaker operation. Has crystal controlled 10 tube FM transmitter and ultra-sensitive 12 tube receiver in one compact unit, ready for instant operation. Complies with FCC regulations. Power consumption is 35 watts.

Just plug in the littlefone Central Station unit in any AC outlet (110 volts), and it is ready to give remarkable coverage as a fixed station for communicating with mobile equipment. Used with standard littlefones it is ideal for setting up complete 2-way systems for many industrial applications, and adds new scope to public safety and land transportation operations. Easy to carry, simple to operate. Thoroughly dependable.

Public Safety

Fire ● Police ● Forestry Conservation ● Highway Maintenance Special Emergency

Industrial Radio Services

Power ● Petroleum ● Forestry Products ● Motion Picture ● Relay Press ● Special Industrial ● Low Power Industrial

Land Transportation

Inter-City Bus ● Highway Truck Railroad ● Taxicab ● Urban Transit ● Automobile Emergency

Doolittle RADIO, INC.

7421 S. LOOMIS BLVD. CHICAGO 36, ILLINOIS

Builders of Precision Radio Communication Equipment

SPOT NEWS NOTES

(Continued from page 6)

transmitters are outside thickly populated sections, so that this situation should not be serious.

Don't Send Stamps:

On such programs as The Great Gildersleeve and the U. S. Steel Theatre, listeners have been urged to send "coin or stamps" to the Government Printing Office for copies of the Civil Defense booklet. However, instructions from the GPO state specifically: "Do not send stamps." The reason is that Government departments have no use for them.

1952 NARTB Convention:

It isn't settled entirely, but the next annual convention will probably be held at the Waldorf Astoria, New York City, from April 26 to May 2.

Transmitting Tube Data:

New bulletins from Eitel-McCullough explains this company's tube-type numbering system, and describe two new transmitting tubes and heat-dissipating connectors.

The Need for Networks:

While affiliates are smarting over the audio broadcast rate cuts initiated by CBS, a lot of people are beginning to ask: Are networks necessary? When broadcasting started, network operation provided the cheapest way of distributing live-talent shows. But today, the audio quality of the best disc and tape recording is superior to 5,000-cycle lines, and those media offer release from the time limitations of programs which must be scheduled on a nation-wide basis, and a means of eliminating line charges.

New Tube Plant:

Automatic tube machinery is now being built for a huge plant which Westinghouse will erect on a 70-acre site at Bath, N. Y., 40 miles northwest from Elmira. Initial tube production will be for the Armed Services, but it is expected that the plant will be converted to the manufacture of tubes for civilian consumption after the current emergency is over. About 2,000 people will be employed when construction is completed.

Bright Idea:

Ray Meyers, Superintendent of Communication at Vallejo, Calif., reports that, at a recent CPRA-APCO conference, a resolution was passed calling on the FCC to require the use of an identifying signal on diathermy and industrial heating equipment. Certainly would make it easier to locate that kind of increasingly troublesome interference.

(Concluded on page 9)

SPOT NEWS NOTES

(Continued from page 8)

Dr. Mervin J. Kelly:

Executive vice president of Bell Telephone Laboratories has been elected president, succeeding Dr. Oliver E. Buckley, whom President Truman appointed chairman for the newly-created Science Advisory Committee. Dr. Buckley was elected board chairman of Bell Laboratories.

Variable Loudness Control:

A continuously variable audio-compensated control has been brought out by International Resistance Company, 401 Broad Street, Philadelphia 8. It is described in a new booklet that gives complete data on specifications, installation, and performance.

High-Temperature Magnet Wire:

Sprague Electric has purchased a plant of 45,000 square feet at Bennington, Vt., for manufacturing Ceroc 200 and Ceroc T magnet wire. Operation on a 3-shift basis will supplement production at their North Adams plant.

Theodore Lindenberg:

Appointed chief design engineer for Pickering & Company. He was formerly in charge of Fairchild's instrument and disc recording division, and was president of the Audio Engineering Society in 1949.

Transcontinental Relay:

Last of the 107 repeater stations of the Bell System cross-country radio relay was completed this month. Telephone service will probably start in August, and it is expected that TV programs can be exchanged between New York and Hollywood by the end of this year.

Cloud-Scraper Towers:

The 1,057-ft. tower for WBEN Buffalo, and one of 1,017 ft. for WTMJ Milwaukee will be built by the Ideco division of Dresser Equipment Company, Dallas, Tex. The former will be for FM and TV, while the latter will be used only for TV, since *The Milwaukee Journal* dropped out of FM some time ago.

Wire and Cable:

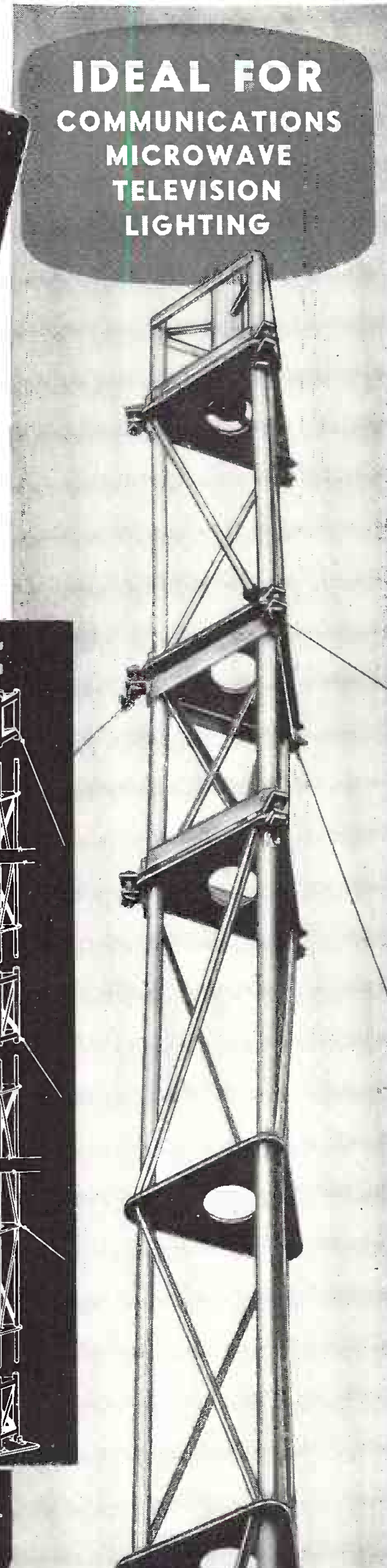
Reeves Soundcraft Corporation has purchased outright the Bergen Wire Rope Company of Lodi, N. J. This concern manufactures industrial and TV lead-in cable, and other types for transmission, construction, and marine use.

J. W. Dawson:

Appointed chief engineer of Sylvania's electronics division. Mr. Dawson was formerly in charge of equipment engineering at Stamford Research Institute.

HE OWER OF STRENGTH

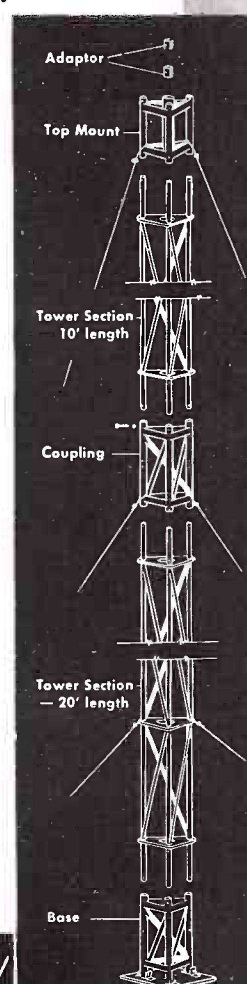
IDEAL FOR
COMMUNICATIONS
MICROWAVE
TELEVISION
LIGHTING



Superior construction features give LOW COST Vee-D-X sectional towers the highest safety factor of any tower in its price class.

If you have an elevated installation problem, absolute permanency of your installation is assured when you use a VEE-D-X sectional tower. Strength is a major factor. Don't take chances with structural failure. Be sure with VEE-D-X!

- *Rugged, all-welded construction diagonally laced with angle iron for maximum rigidity.*
- *Can be erected on ground or on flat or peaked roof.*
- *Patented plate spaced at two foot intervals prevents twisting and affords rigidity found in no other tower.*
- *Safe and easy to climb.*
- *Completely galvanized, light weight tubular steel . . . 20 ft. section 72 lbs.*

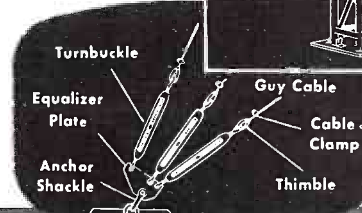


PRE-ASSEMBLED
for fast, inexpensive installation

VEE-D-X towers are designed for use at any height from 10 to 140 feet. They are self-supporting up to 20 feet and, where space is limited, *semi-guyed** type installations may be used at 30, 40, and 50 foot heights. Sketch at right shows the basic parts and necessary accessories for a complete installation. Three types of top mount are available. VEE-D-X towers may be ordered in separate units or as a complete package for a specific height. (Either guyed or semi-guyed.) Write the LaPointe-Plascomold Corporation of Windsor Locks, Conn. for complete information.

*Semi-guyed towers employ one set of guy cables attached at a height of 10 ft. up the tower and anchored at a 6 ft . radius from the base.

VEE-D-X



BUILDERS OF THE WORLD'S MOST POWERFUL ANTENNAS

WHAT'S NEW THIS MONTH

CURTIS PLUMMER TO HEAD FCC'S NEW BROADCAST BUREAU — SUPER-POWER AT WBEN-FM BUFFALO — NARTB CONVENTION DRAWS RECORD ATTENDANCE

THE choice of Curtis B. Plummer, presently Chief Engineer of the FCC, as head of the new Broadcast Bureau of the Commission, is welcome news. We extend our hearty congratulations to Mr. Plummer for earning this promotion, and to the Commissioners Walker, Hyde, Jones, Sterling, and Webster for their wisdom in choosing a man with practical broadcasting experience and an engineering background.

Formation of the Broadcast Bureau marks another step in the functional reorganization of the FCC, inaugurated during Chairman Coy's administration. This Bureau, under the Office of the Chief, will comprise five Divisions, devoted to Aural Facilities, Television Facilities, Renewal and Transfer, Hearing, and Rules and Standards. Thus a single Bureau, under its Chief, will be responsible to the Commission for legal, accounting, and engineering functions related to the broadcast services. The new Bureau will start operation officially on June 4.

Supplemental orders to be released redefine the functions of the Offices of the General Counsel, Chief Accountant, and Chief Engineer in the light of the transfer of their broadcast units to the new bureau. The General Counsel will retain the Legislative and Administration Division; the Accounting System Division and the Economics Division will remain under the Chief Accountant; while the Field Engineering and Monitoring Division, the Frequency Allocation and Treaty Division, the Technical Research Division, and the Laboratory Division will continue under the Chief Engineer. Broadcast licensing functions will remain under the Office of the Secretary.

Mr. Plummer was born at Boston, August 15, 1912. After receiving his B.S. degree from the University of Maine in 1935, he was associated with WHEB Portsmouth, N. H., and WGAN Portland, Maine, until he joined the FCC as radio inspector at Boston, in 1940. He moved to Washington, in 1941, as an associate radio engineer, and was advanced rapidly until, four years later, he was made Assistant Chief of the AM broadcast engineering section. In 1945 he became Acting Chief of the TV Broadcast Division, and Chief of that Division the following year, succeeding George Sterling as Chief Engineer of the FCC on April 3, 1950.

We have high expectations of our fellow Bostonian, and we look for wise and progressive administration of the new Bureau to which the broadcasters will be responsible, and which will inevitably exert great influence on a large segment of the radio equipment manufacturing industry.

A STATEMENT OF CONFIDENCE IN FM — FROM BUFFALO, N. Y.

EDWARD H. BUTLER, president of WBEN, Inc., has announced that construction has begun on one of the tallest radio towers in the world for WBEN-FM and that the radiated power of the FM station will be increased to 105,000 watts. Elevation of the transmitter site is 1,642 feet above sea level. This added to the height of the new tower will give WBEN-FM a range which will reach out to give radio service to listeners in New York and Pennsylvania who have heretofore experienced noisy reception, particularly in the evening hours.

WBEN-FM went on the air with six kilowatts of radiated power on Nov. 11, 1946. Since that time, FM has not experienced its anticipated growth due to factors which all in the industry recognize. WBEN has continued its interim operation without interruption and is convinced that the future of FM is bright, though more remote than was originally expected. We are backing this belief with a major investment to give the finest FM service which engineering resources can provide.

One of the impediments which slowed the acceptance of FM was the arrival of TV. Now the initial TV excitement is over in Western New York, and we believe that radio, both AM and FM, will continue to hold its place in the habits of the population. A second impediment was the fact that FM receivers were difficult to tune and had a strong inclination to drift. Some newer models have overcome these deficiencies and we believe that manufacturers whose product has been outstripped by those of their competitors will not be content until all FM receivers are easy to tune and resistant to drift.

WBEN is going ahead with this major FM investment, with the conviction that the acceptance of FM will accelerate in the months and the years ahead. We will back FM by a wholehearted promotional effort to show listeners, particularly those in AM fringe areas, that FM is a superior means of reception. Meanwhile, WBEN-FM, as in the past, is a bonus to those who use the FM facilities of WBEN, and will continue to be until the economic structure of radio indicates that some adjustment should be made.

A. H. KIRCHHOFER
Vice-President
WBEN, NBC Basic Station

THE NARTB convention at Chicago was a thorough going success from every point of view. Record attendance of more than 1,500 provided worthwhile discussion and exchange of ideas, and that is the principal justification for the time and expense involved in attending any convention. Biggest thrill was the large-screen reception of General MacArthur's address to the joint meeting of the House and Senate.

The CBS rate cut and FCC Chairman Coy's defense of the North American Regional Broadcasting Agreement furnished the management group with subjects for hot debate.

Neil McNaughton, NARTB director of engineering, did an admirable job of assembling speakers and papers on a wide range of technical subjects covering AM, FM, and TV broadcasting.

The exhibits were small in number and, except for RCA's, somewhat meager in the amount of equipment displayed. This was to be expected, for sales volume is at a lull-before-the-storm level right now. But next year, assuming the expected progress in authorizing new TV stations, the exhibits should be the outstanding feature of the convention — if materials are available to the manufacturers.

This was the first time that there was no word around about folding up FM. Last year, when the convention opened, we recall that Ed Sellers, who had just joined NARTB as head of the FM department, was ready to look for a new job! Since then, he has performed so many useful services for FM, and FM has made so much progress, that it seems certain that Ed Sellers and FM broadcasting are here to stay.

There was enthusiastic response to the proposal that FM stations undertake the promotion, at their own expense, of good receivers. This seems to be the most effective way to put pressure on manufacturers who are making FM sets of poor performance, or none at all.

At the business session, a resolution was passed calling on the NARTB board to participate in FCC proceedings involving special FM services, on the theory that they should be encouraged in behalf of overall industry growth.

Judge Justin Miller, who has so skillfully piloted the Association through the postwar years, now becomes chairman of the board. He will be succeeded by president-elect Harold Fellows.

UNDER an FCC order to be effective on June 13, facsimile transmission by FM broadcast stations will have an established position as a commercial service. The report and order No. 62424, issued May 3, climaxes an effort initiated by John V. L. Hogan on May 27, 1949, to have the Rules and Regulations amended to permit multiplexed aural and facsimile transmission on an unlimited time basis, and to have the provision deleted under which

(Concluded on page 30)

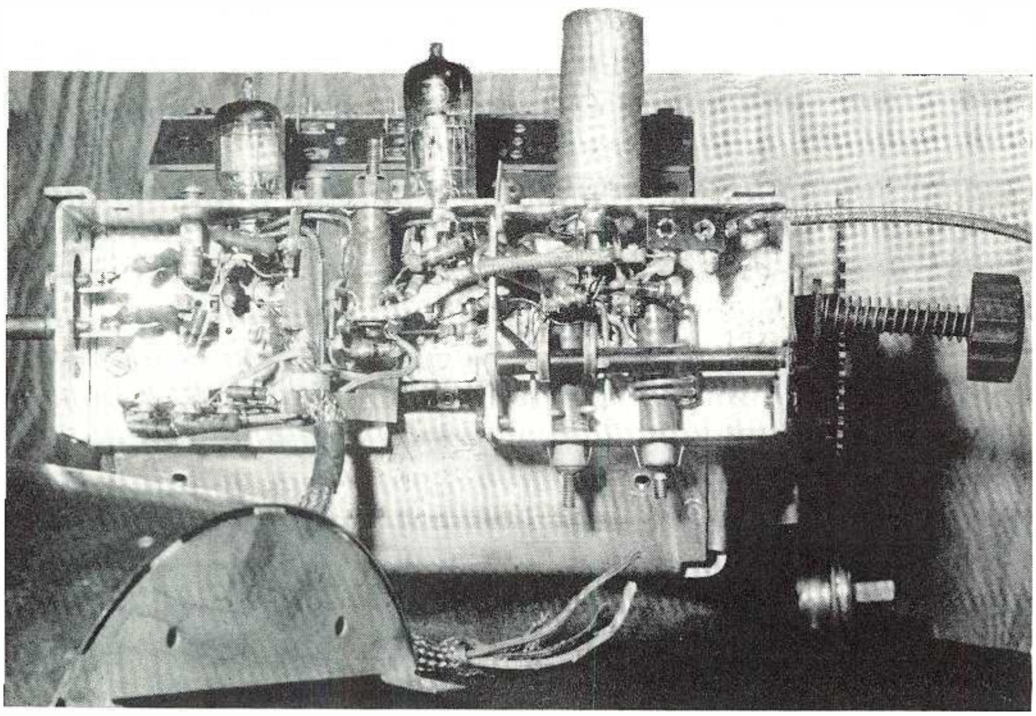


FIG. 1. STANDARD ZENITH VHF TELEVISION TUNER. THE TURRET CAN BE SEEN AT THE REAR

ZENITH VHF-UHF TUNER

A NEW CIRCUIT DEVELOPMENT FOR RECEPTION OF INTERMIXED TV CHANNELS — *By* JOHN BELL*

COMMERCIAL televison broadcasting on the UHF band is coming close to reality. One of the problems brought up by the establishment of this service will be the question of what to do with VHF receivers now in the hands of the public. Obviously, provision for adapting these sets to UHF reception would be very desirable. However, because of the very strong pressure to reduce the cost of television receivers, adequate provision for this conversion has not been included in most designs.

One obvious solution to this problem is the conventional UHF converter, but this involves an extra oscillator and mixer, a separate chassis, and perhaps a cabinet. This is at best a makeshift, and experience has indicated that there is limited demand for such an auxiliary unit. Also, the spurious responses and poor oscillator stability which naturally result from the use of two oscillators in the overall UHF receiver require elaborate corrective measures in the design of a converter.

Zenith receivers solve this problem through the use of replaceable, interchangeable VHF and UHF channel strips which are mounted on the turret tuner. The turret can be seen at the top of Fig. 1, and its circuit details are shown in Fig. 4. A special UHF channel strip has been designed which converts the tuner to a conventional superheterodyne. The local signal on which the mixer operates is derived from a harmonic of the VHF oscillator already in the receiver. Since all the changes necessary to accommodate UHF are made on the channel strips themselves, no alterations are involved in the receiver except the installation of the appropriate UHF strips.

*Engineering Department, Zenith Radio Corporation, 6001 Dickens Avenue, Chicago, Illinois.

VHF-UHF Antenna Problem:

Another problem which arises in the conversion to UHF is that of altering the antenna installation. Where UHF signals are strong enough, adequate reception is possible on a VHF antenna, in which case the insertion of UHF channel strips to replace unused VHF channels represents the only necessary change. In other locations, the owner will require a separate antenna for each band, and a manual switch to connect the appropriate antenna to the receiver.

Such a switch, however, can be eliminated by using the high-pass, low-pass filter shown in Figs. 2 and 3. This filter effectively isolates the low-band antenna from the transmission line at all UHF frequencies and, conversely, isolates the UHF antenna from the transmission line at all VHF frequencies. Each antenna performs on its respective band substantially as if the other antenna were absent. The filter makes it possible to bring signals from both antennas down to the receiver on a single transmission line. Thus, the installation inside the owner's home requires no extra connections and no external converter.

Experience to date indicates that it is desirable to use the tubular type of twin lead rather than the flat type, because rain and moisture increase the attenuation more on the flat type of transmission line. Where a long line is necessary out of doors, perhaps even the tubular type will have too much attenuation in wet weather, although for short runs of 20 to 30 ft. the attenuation is quite tolerable.

Turret and Shelf Assembly:

A photograph of the revolving turret and associated components mounted on the adjacent shelf is shown in Fig. 1. For VHF tuning, the circuitry is conventional in that a 6AK5 (or 6CB6 or 6AG5) RF stage, a 6AG5 mixer, and a 6C4 oscillator are used. The shelf assembly incorporating these components is a self-contained unit with the IF output connection provided by the short length of coaxial line at the right. This unit is screwed to the turret mounting. The turret is normally provided with positions for thirteen VHF channel strips of the type shown in Fig. 5. A heavy-duty, positive indexing spring is provided so that the channel strips are always positioned accurately.

Oscillator Alignment and Operation:

Although the exact oscillator alignment procedure varies somewhat with different models, the procedure on the Zenith model H will serve as an example. On this model, each channel strip, with the exception of channel 7, is provided with an oscillator trimmer, and the oscillator itself has a fine tuning control which is brought out behind a door on the front panel. In order to achieve precise tuning on the turret, the oscillator tank is first standardized on channel 7 by means of a small slug adjustment, shown second from the right at the bottom of the shelf in Fig. 1. When this adjustment is being made, the fine tuning control, which is the bakelite shaft shown coming out at the right end of the shelf, must be set near its midposition. Then all the remaining channel oscillator trimmers are set for the exact oscillator frequency required on each channel. Long term drift can be corrected by setting the fine tuning control.

Stability in this oscillator is achieved by mounting a high-*Q* oscillator tank circuit on the shelf itself, and making direct connections between this oscillator tank and the oscillator tube. When no channel strip or the strip for channel 7 is in position, the frequency of the oscillator is near the middle of its range of 100 to 168 mc. The oscillator is shifted to the specific frequencies for each channel by means of a small capacity or a large inductance on each channel strip. In this way, the smallest possible portion of the total oscillator tank current flows through the turret contacts, resulting in much smoother operation and more accurate positioning of the oscillator frequency. Contact troubles are further reduced by means of plastic guides on the shelf which make it impossible for the strip contacts to enter the shelf contacts improperly. This restricted oscillator range is made possible by operating the oscillator above the signal frequency on the 54 to 88-mc. band, and below the signal on the 174 to 216-mc band. This type of operation is in turn made possible by the use of intercarrier sound and the symmetrical IF pass band shown in Fig. 6. The sound and picture frequencies are shifted in the passband in going from the low band to the high band as indicated on the IF pass band curve.

UHF Channel Strips:

The difference between the two types of channel strips is apparent from Figs. 5 and 7, which show the VHF and UHF strips respectively, with the block diagrams in Fig. 8.

Incorporated on the UHF channel strip is the UHF preselector; the UHF crystal mixer which derives its local signal from a crystal multiplier between the mixer and the VHF oscillator; and coils for tuning the RF grid and plate, and the converter grid to the intermediate frequency. The 6AG5 converter output connection remains unchanged. These circuit changes are made entirely on the channel strip itself.

The entire high-frequency portion of the UHF channel strip is housed in a small metal die-casting, Fig. 7, having three separate cavities. The RF, mixer, and multiplier tuned circuits are mounted inside these cavities, and are thus completely shielded from each other and all external influences such as the effect of adjacent channel strips and hand capacity. The housing is mounted by means of four screws to a small metal bracket which also forms a positioning channel into which the multiplier crystal is mounted. This holder is in turn mounted to a bakelite strip, shown in Fig. 9, which carries all of the contacts. The bakelite strip, the contacts, and the oscillator coil are all very similar to the corresponding arrangement on the VHF channel strips. The housing can be removed by unsoldering two leads (multiplier crystal and IF output) and removing the four mounting screws.

Circuit diagrams of both UHF and VHF channel strips are given in Fig. 9. The inductance for the UHF tuned circuits is supplied by small solenoids wound with flat strip as shown in the exploded view of Fig. 10. The capacitance for these circuits is a combination of three capacities: 1) the capacity between the top end of the coil and the cavity, 2) the distributed capacity of the coil, and 3) the capacity of the adjustable tuning screw as it enters the top end of the coil.

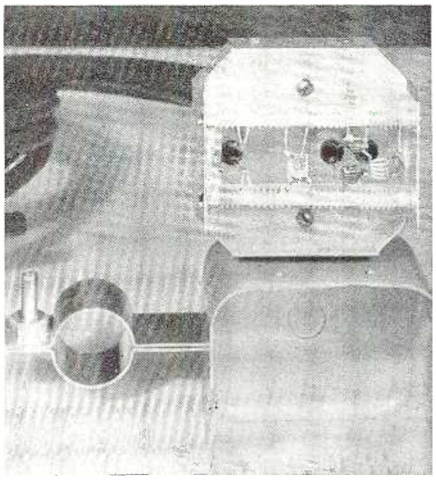


FIG. 2. FILTER FOR VHF AND UHF ANTENNAS

A tuned circuit made in this way has an extremely small tuning capacity, of the order of .5 to 1 mmf., and therefore a relatively large tuning inductance. For example, the coils which tune to the bottom third of the UHF band have 6½ turns wound on a mean diameter of .2 in. A coil of this shape and size has nearly optimum Q, which is approximately 500 at the bottom end of the UHF band, and increases with frequency.

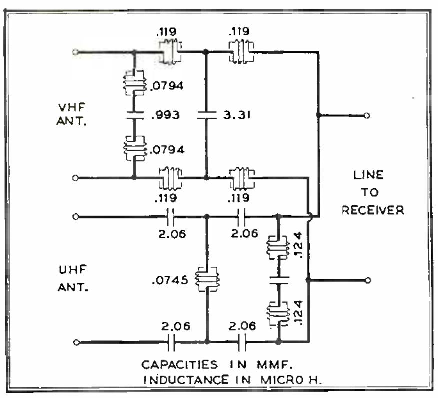


FIG. 3. CIRCUIT OF THE ANTENNA FILTER

Circuits having unloaded *Q's* of this order assure that the loss in the preselector will be small, since nearly all of the damping on the preselector circuits is provided by the antenna on the input and the crystal on the output. Tuned circuits formed in this way are extremely simple and rugged, especially in regard to the tuning adjustment described above. This provides extremely smooth and stable adjustment throughout the tuning range of the housing. Since the minimum capacity of the circuit is extremely small, useful tuning ranges are achieved with very small tuning capacities. With these tiny cavities (7/16 in. in diameter by ⅞ in. long), tuning ranges of 200 mc. in the UHF band are easily achieved.

Because of the shielding afforded by the cavities, it is possible to remove all coupling elements between the antenna and the mixer except the desired one which, in this case, is the common coupling inductance L2. This inductance is in the form of a cylindrical bushing which mounts a terminal lug for the low-potential end of the antenna and mixer coils. The bushing and terminal can be seen in the exploded view, Fig. 10. With a single purely inductive coupling element and variable capacity tuning, the bandwidth is proportional to frequency. Thus the variation in bandwidth over the 200-megacycle tuning range is extremely small and predictable. In an earlier, unshielded structure, several coupling mechanisms were involved, and resonances in the coupling impedances were a constant source of trouble. The totally shielded structure completely eliminates those problems.

The antenna is inductively coupled to the first tuned circuit by means of a small loop of enameled wire inserted at the bottom end of the antenna coil. The mixer coil is coupled to the crystal mixer by means of another small loop at the bottom end of the mixer coil. The IF load impedance is developed across a 20-mmf. ceramic disk capacitor which also serves as an RF bypass condenser in the mixer circuit. This condenser is soldered to a small, cold-rolled steel plate which is also a terminal lug for the low-poten-

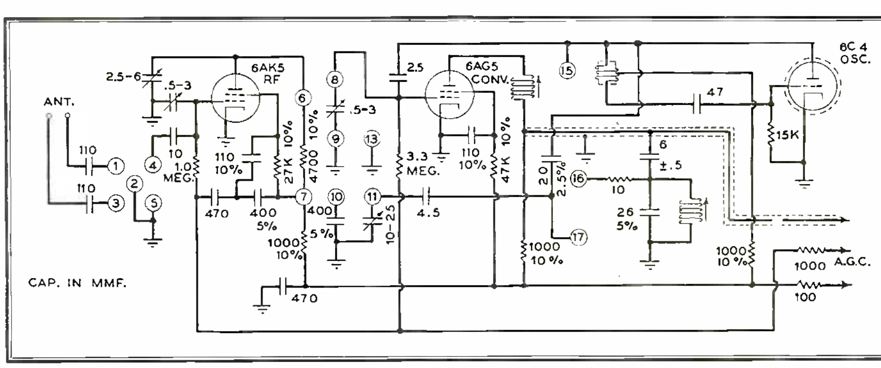


FIG. 4. TUNING CIRCUITS ARE COMPLETED THROUGH COMPONENTS ON THE TURRET STRIPS

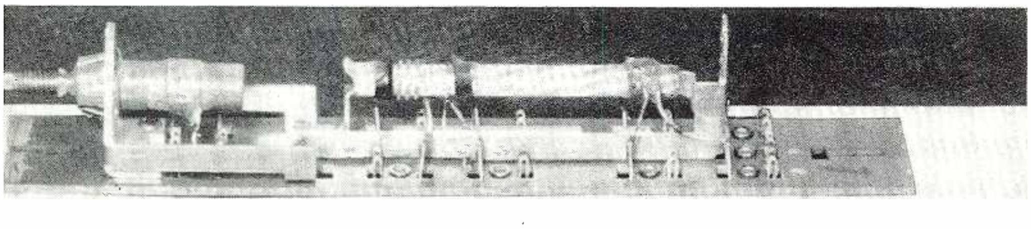


FIG. 5. THE VHF TUNING STRIP. FIG. 8 SHOWS THE BLOCK DIAGRAM, WITH THE CIRCUIT IN FIG. 9

tial end of the multiplier coil. The assembly is then riveted securely to the housing to provide an extremely low-inductance bypass. The mixer circuit includes a small portion of the multiplier coil, so that injection voltage appears in series with the mixer crystal and the signal induced in the mixer coupling loop, as may be noted in Fig. 9.

In the antenna and mixer circuits, the coupling between the circuits is adjusted for correct bandwith, and the damping is set by adjusting the coupling of the antenna and mixer coupling loops such that very nearly critical coupling and equal Q's are obtained. This is determined by the design of the loop, and is not a part of the alignment procedure. When both the conditions are met, correct bandwith and matching is obtained, through the preselector filter, between the antenna and the crystal mixer.

With the current bias applied, as will be explained later, it is possible to make this adjustment accurately with nto excitation to the mixer crystal from the multiplier circuit. The adjustment can be made simply and easily with a sweeping oscillator and oscilloscope.

At these frequencies, extremely small stray coupling elements become effective. So small are they, in fact, that they seem almost to float in the air. For this reason, careful shielding is necessary to take full advantage of the theoretical skirt characteristics of the preselector. If this is not done. portions of energy will bypass the preselector entirely at some frequencies, and the preselector therefore cannot be depended upon to attenuate spurious responses. Although the shielding on the channel strips is quite thorough, it is still not perfect, with the result that the expected skirt characteristics are available to somewhat in excess of 40 db.

The local signal for the mixer is provided by the multiplier crystal, shown in Fig. 5, mounted within the holder slightly to the left of the center of the channel strip. This diode is connected to the oscillator by a blocking condenser, using a 22,000-ohm diode load resistor, in order that the current through the multi-

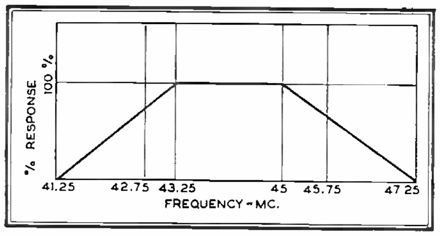


FIG. 6. INTERCARRIER SOUND AND IF PASSBAND

plier crystal will consist of pulses flowing at the peaks of the oscillator sine wave. The current, containing harmonics, flows through the crystal and into the multiplier output circuit where it develops a voltage at the desired harmonic frequency, thus supplying power to the mixer crystal at the proper frequency. The 22,000-ohm load resistor is not critical but is optimum for the following reasons: If the resistor were of a higher value, little power would be extracted from the oscillator circuit, and only a small amount would be available at the harmonics. On the other hand, if the resistor were smaller, the oscillator would be loaded more and, in the extreme, would cease to oscillate. Also, for very small load resistors, the diode current wave form would not contain the sharp corners necessary for effective harmonic generation. Because the multiplier output circuit is very selective, only the desired harmonic is applied to the mixer crystal. Thus conversion is achieved by injection of the fundamental rather than by harmonic injection with its larger conversion loss. The power required to achieve optimum conversion in the mixer is quite small, but the harmonic power output of the crystal multiplier is also small, and great care is required in order to achieve adequate injection. The multiplier crystal mounting provides a low-impedance return for both the low and high-frequency components of the crystal current.

FIG. 7. HOUSING AT RIGHT OF UHF STRIP CONTAINS RF, MIXER, AND MULTIPLIER CIRCUITS

Current Biasing of Crystal:

Even with these precautions, the power available to the mixer on some harmonics was found to be inadequate, and performance was therefore variable. This was corrected by the combination of the germanium crystal mixer and current biasing of this crystal.

The current bias is provided by a 270,000-ohm resistor, Fig. 11, to a B-plus terminal on the strip. This resistor provides the only path by which direct current can flow through the crystal and, therefore, the crystal current is determined only by the B plus supply voltage divided by the resistance, or approximately .5 milliampere. Because of the static characteristic of the crystal, such current bias automatically selects an operating point near the maximum curvature on the crystal characteristic, for a wide variety of crystals, thereby assuring that minimum excitation power will be required. It also has the advantage that the damping presented to both the RF and IF circuits by the crystal is largely independent of excitation.

Excitation can be measured by connecting across the crystal a voltmeter having a full-scale reading of a few tenths of a volt. With no excitation, the drop across the crystal will be approximately .2 or .3 volt. As excitation is increased, this voltage will drop back toward zero or beyond. The multiplier output circuit can be peaked to the desired harmonic by observing this dip in voltage.

Oscillator Tuning:

As on the VHF strips, the oscillator frequency is determined by the inductance or capacity across the oscillator contacts on the channel strip. However, it was desired to manufacture UHF strips capable of being tuned to as wide a range of frequency as possible, in order to minimize the different types of strips required. Also, it is desirable in every case to have at least some capacity

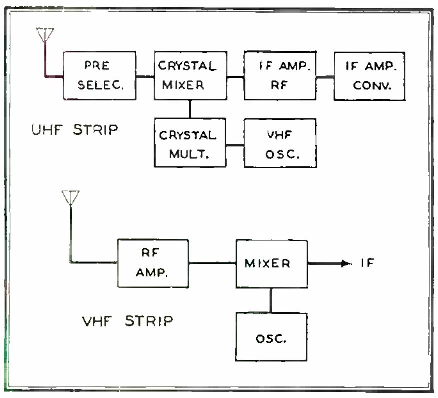


FIG. 8. BLOCK DIAGRAMS OF THE TUNING STRIPS

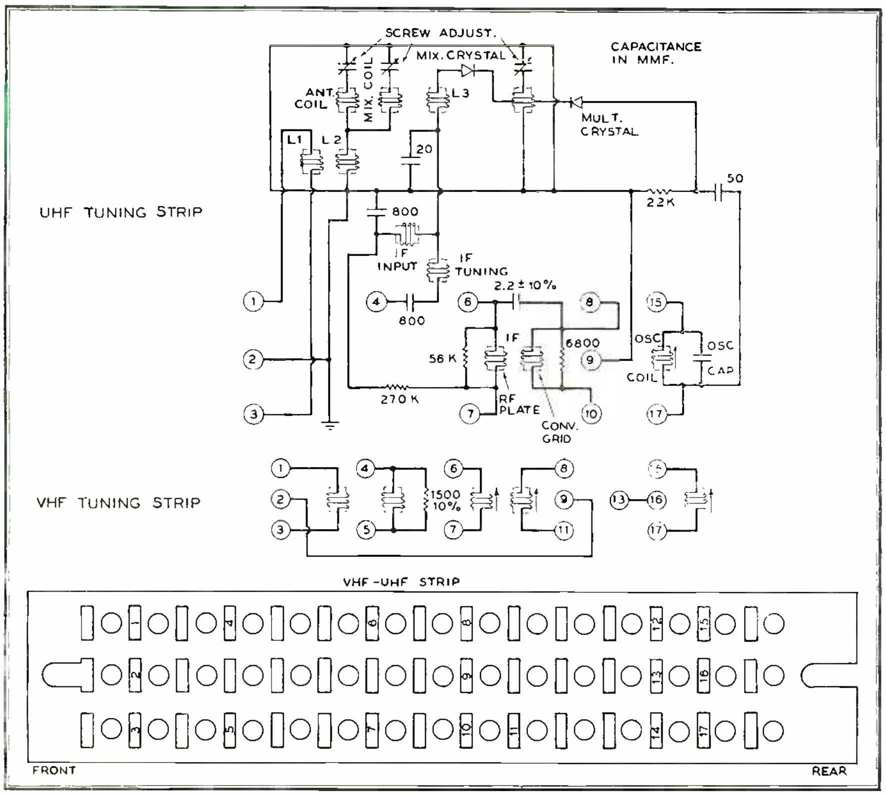


FIG. 9. CIRCUITS OF THE COMPONENTS ON THE TUNING STRIPS. NUMBERS ARE FOR TURRET CONTACTS

across the oscillator contacts to serve as a bypass for the harmonic frequency currents.

For these reasons, the oscillator frequency-determining elements on the strip consist of an inductance and capacity in parallel, whose net reactance determine the oscillator frequency. The oscillator is thus adjustable over a wider range of frequencies with a simple slug-tuned coil than would be possible with an inductance or capacity trimmer alone. In order to further increase the range of this coil, a double slug was used, consisting of adjacent iron and copper portions. This slug and the condenser were designed to minimize temperature drift in order to realize the best possible frequency stability. The trimmer inductance is mounted on the bracket proper, for greater rigidity and ease of adjustment, since the oscillator frequency in the UHF band must be held to closer limits than on VHF. Actual use of these units in the field has shown the oscillator stability to be entirely adequate for the UHF band and, in fact, with intercarrier sets, service personnel were unable to detect the existence of any oscillator drift.

Mixer Output Circuit:

The mixer output circuit is shown in simplified form in Fig. 11. The 20-mmf. RF bypass condenser is tuned to mid-band by means of the IF input inductance. The ungrounded side of the condenser forms the output terminal of the mixer, and between this terminal and ground is connected a series resonant circuit consisting of a tuning inductance and the grid-cathode capacitance of the 6AK5 (or 6CB6) IF amplifier. At resonance, then, the crystal output is effectively short-circuited by a series resonant circuit. There is, however, a voltage developed across C6 which is applied to the IF amplifier. Connected in this way, the crystal forms practically the entire damping on the first tuned circuit in the IF amplifier. There is no loss in noise factor due to matching in the output of the crystal. The crystal output resistance is approximately 180 ohms. The ratio of the open-circuit crystal output voltage to the 1st IF grid voltage is determined by the ratio of this resistance to the reactance of C6 since, at resonance, substantially the same current flows through both elements. Two blocking condensers, C4 and C5, are provided to permit the current bias to flow through the crystal and also to make possible the application of AGC voltage to the 6AK5 grid. This IF circuit and the interstage circuit following the 6AK5 are formed by small fixed-tuned coils mounted directly to the RF grid, RF plate, and converter grid terminals on the strip. Equal *Q's* in these circuits are used to minimize the effects of detuning due to tolerances. The resistor needed to achieve this required damping is used as the form for the tuning coils. In the case of the crystal output circuit, both coils L1 and L2 are mounted on the same dummy resistor form.

Non-Intercarrier Sets:

Early receivers used non-intercarrier sound and 21 to 27-mc. IF. When the UHF channel strips are adjusted for appropriate IF and oscillator frequencies, they operate equally well on such receivers. The effects of oscillator drift are, of course, more apparent than is the case with intercarrier sets, and the setting of

(Continued on page 26)

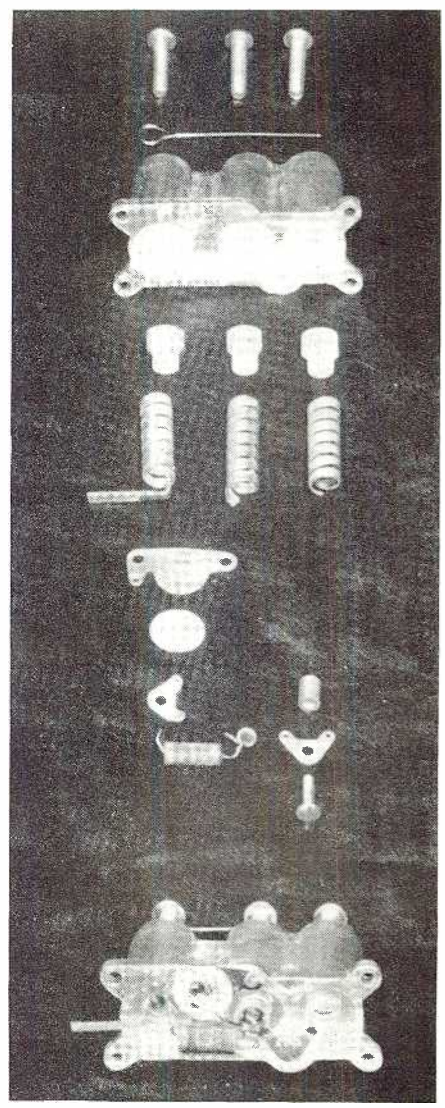


FIG. 10. COMPONENTS OF THE UHF HOUSING UNIT

THIS MAY BE ANOTHER PLOTSKY

FCC'S ATTACK ON SPECIAL FM SERVICES MAY INDICATE AN INTENT TO DESTROY "THE FINEST AURAL BROADCAST SYSTEM" — *By* MILTON B. SLEEPER

THE contention by the Federal Communications Commission that functional-music stations do not "achieve compliance with all lawful requirements" of the Communications Act of 1934, and the FCC Rules and Regulations brings into focus certain aspects of Government regulation, as exercised currently by the Commission and its Legal Department, that call for immediate, careful review, and ultimate revision.

As Chairman Coy pointed out in a recent address, the FCC enjoys very wide discretionary powers. Congress intended this, recognizing that the Commission would have to deal with new situations that would arise in the course of scientific progress. In fact, the Commission is charged specifically with encouraging the adoption and use of technical improvements to the end that public interest, convenience, and necessity shall be served to better advantage.

Nevertheless, against the dissenting opinions of Commissioners Sterling and Jones, Commissioners Coy, Walker, Hyde, and Webster were "constrained to conclude from our study of your replies to our inquiries that the 'beep' services[1] in which you [WRLD, WACE-FM, WMFM, and KDFC] are presently engaged are inconsistent with basic statutory and administrative duties incumbent upon licensees of broadcast facilities."

Bearing in mind the Commission's wide discretionary powers in administering the Communications Act, one is constrained to ask: Was that decision necessary?

Certainly the authors of the Act of 1934 did not intend to forbid broadcast licensees from providing functional music service, nor any of the other special, new services which can be provided only on FM transmission.

The Finest Aural System:

Five years ago, Charles R. Denny, then FCC Chairman, said: "The Commission has expressly authorized me to say to you again that it is our opinion that FM is the finest aural broadcast system obtainable in the present state of the radio art." Since then, that opinion has been confirmed by several million FM broadcast listeners.

The vicissitudes of FM broadcasting require no review here. That it has survived is ample evidence of widespread conviction that it will ultimately, however belatedly, replace AM. The ills from which it now suffers are only those which can be cured by added operating revenue.

Functional-music stations have met this problem by performing special services in the course of transmitting conventional programs of music, commercial spots, and station announcements. That is, for the benefit of those who choose to rent specially-equipped receivers, they transmit inaudible signals that operate relays in the sets to silence the speakers between musical selections.

This, it must be noted, does not affect reception on the part of the station's nominal radio audience. It is, however, a means of making musical entertainment available in restaurants, hotels, and factories where radio reception was never used before, and where it would not be tolerated now if it included voice announcements.

Yet on April 11, the Commission advised four of the stations currently furnishing this extra service that it is "of the view that your operations are not in accordance with the requirements of the Communications Act, and the Commission's Rules and Regulations." Further, the stations are called upon to "submit a statement showing how you intend to achieve compliance with all lawful requirements."

There was no intention, when the Communications Act of 1934 was written, to ban functional music as service in addition to that performed for home listeners, or as a source of station revenue. Why should the FCC now assert that the Act and the Rules "contemplate that the categories of information there defined will be transmitted to the station's entire audience; they admit of no discretion on the part of the licensees to introduce exceptions thereto for the benefit of subscribers to 'special services' or other selected listeners."

That may be the way the FCC chooses to interpret and apply the Act and the Rules, but they contain no specific or implied provision that indicates an intention to forbid a broadcaster, either voluntarily or for pay, to cooperate with those who, for reasons of their own, wish to substitute automatic control for manual operation in silencing certain parts of radio programs.

The FCC acknowledges, with admirable restraint, that: "Members of the public are free to tune in or out any material they desire." However, "Licensees are required to operate their stations in accordance with the requirements of the Communications Act and the Commission's Rules and Regulations. One of these requirements is that certain announcements be made to the audience."

Now, it should be noted that the required announcements *are* made by the functional-music stations. But here is the hook the Commission has dreamed up to catch these broadcasters: "You cannot prevent members of the audience from voluntarily tuning out such announcements. This does not, however, permit you to broadcast a [supersonic] tone which prevents a portion of the audience from hearing the announcements."

In other words, people can't, according to the Commission, extend their right to cut out portions of a broadcast to the extent of paying a station to do it for them. To some stations, that revenue represents the difference between operating at a profit or a loss. On this point the FCC shed a crocodile tear: ". . . it accordingly views with sympathy attempts on the part of pioneers in this meritorious and, as yet, in the main unprofitable, field of broadcasting, to ensure the solvency of their operations."

It should be noted that the Commission did not offer any objection to or criticism of functional-music programs. From listeners, there has been only the highest praise for the agreeable quality of the type of selections transmitted; the usefulness of interspersed time signals, weather reports, and news items; and the moderate, low-key style of the commercial announcements.

The Commission's action against the functional-music stations, therefore, can be regarded only as an example of Government control administered to express some private ideology, with complete disregard for public interest, convenience, and necessity.

Another Plotsky Plan:

The fact that the law seems to have been fitted to the requirements of a pur-

(Continued on page 30)

[1] EDITOR'S NOTE: This descriptive term is inaccurate and misleading. In its common and accepted use, "beep" indicates a short audio-frequency tone, such as is transmitted when a telephone conversation is benig recorded. "Beep service" has been used to describe and identify the special type of broadcast transmission proposed by Muzak, during which interfering audio tones are transmitted in order to discourage listening on the part of those who do not rent devices to remove the "beep" at the receiving end. Functional-music transmission does not employ interfering, audible signals, and listeners using standard receiving sets can hear nothing that differentiates a station providing functional-music service from one that does not.

FIG. 1. COMPLETE 450 MC. MOBILE TRANSMITTER AND RECEIVER ARE SHOWN WITH COVER REMOVED AT THE LEFT.

450-MC. MOBILE EQUIPMENT

INFORMATION ON THE 450-MC. EQUIPMENT GOING INTO SERVICE FOR THE YELLOW AND CHECKER CABS IN CHICAGO, THE FIRST TO USE THIS BAND

PERFORMANCE of the initial 450-mc. equipment installed for the Yellow and Checker Cab Companies in Chicago has definitely confirmed previous investigation reports, and has launched the use of the new band on a wide expansion in the 2-way communication services.

Results obtained in Chicago show that 450-mc. operation over areas of limited radius is equal or superior to that on 152 to 162 mc. Presumably, additional coverage on 450 mc. can be obtained by the use of higher power. To summarize the situation, it can be said that there is no question now about the practicability of using this band for mobile service. In fact, further study will probably show that, under certain conditions, systems can be planned to take advantage of the limited radius and sharp signal cutoff at the service perimeter, thereby obtaining operational and economic advantages.

As an example of this, the Link Radio system for Chicago Yellow and Checker cabs is planned to cover the city with eight transmitters with a checker-board distribution of two transmitting frequencies.

Fig. 1 shows the design of the mobile transmitter-receiver. At the left is a standard 162-mc. transmitter and re-

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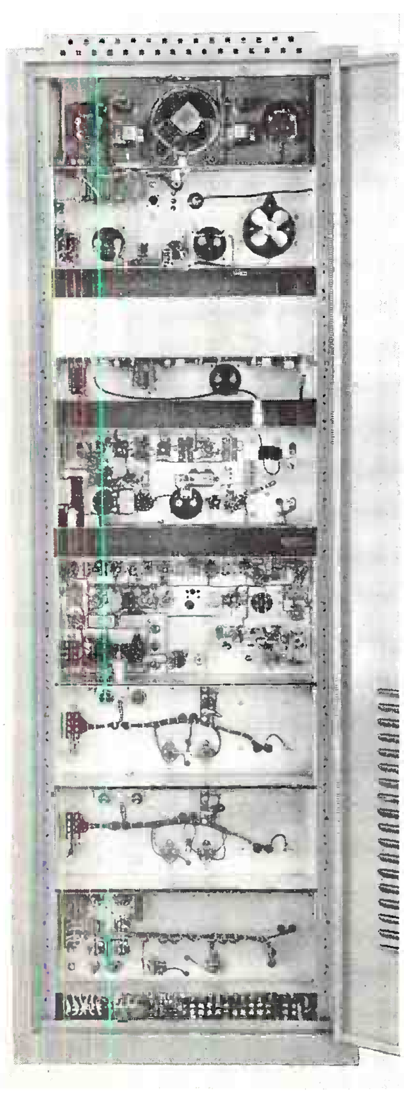
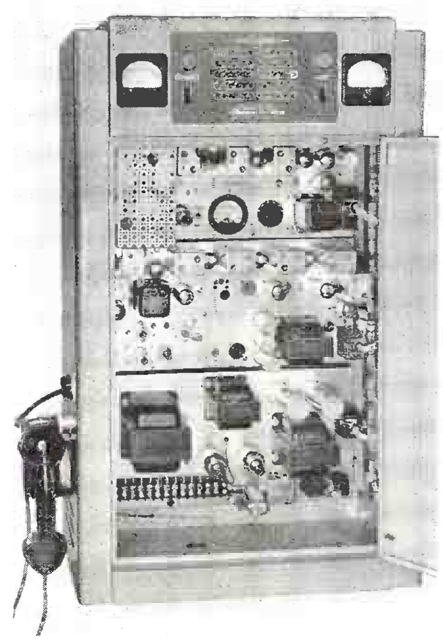




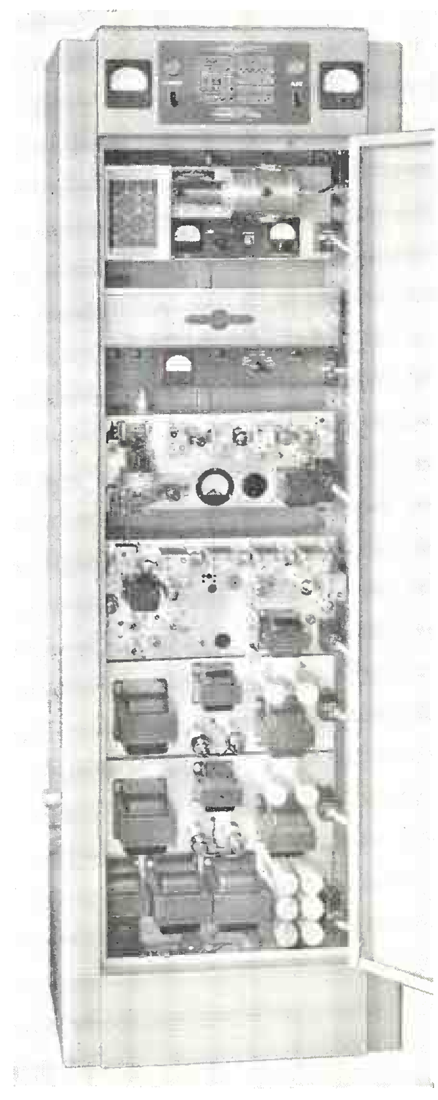
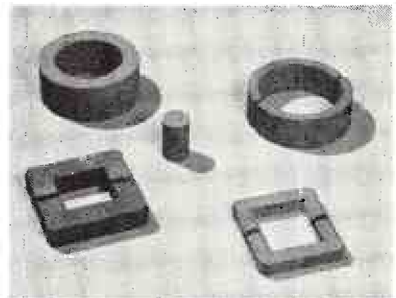


FIG. 2, ABOVE: THE 4-WATT STATION UNIT. FIGS. 3 AND 4: REAR AND FRONT VIEWS OF THE 100-WATT TRANSMITTER AND THE RECEIVER

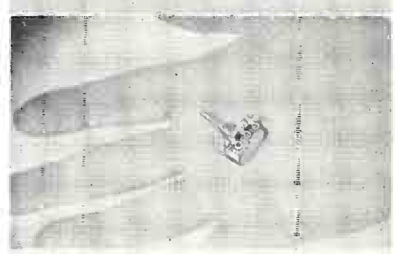
REVIEW OF NEW COMPO

INTERESTING DESIGN TRENDS, PARTICULARLY TOWARD SMALLER DI

LEFT: SMALLER MIKE
Shown in the photograph is a small-size uni-directional microphone employing a moving coil system having a high overall efficiency and smooth frequency response. Large air-gap clearance and rugged coil construction provide immunity to abnormal atmospheric conditions and severe mechanical shock. This ultra-cardioid microphone is approximately one-half the size of its companion in the line, and yet retains all the directional qualities. Shure Bros., 1 N. La Salle, Chicago 2.



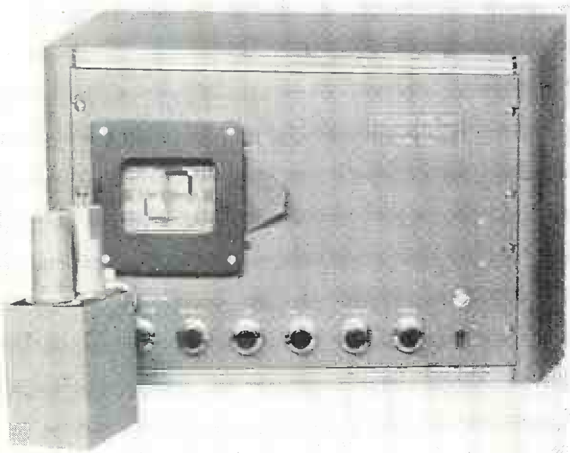
RIGHT: NON-CRITICAL FERRITES
High-permeability ferrite parts such as transformer cores and antenna cores for television and electronics are now available in non-critical, nickel-free materials. These materials are being manufactured at a new plant devoted solely to the production of ferrite parts. Complete technical information is contained in Engineering Bulletin FC-5101, available upon letterhead request. Ferroxcube Corp. of America, 50 E. 41 St., New York 17.



RIGHT: MINIATURE VARIABLE RESISTOR
A new, miniaturized variable resistor has been developed which is described as having unprecedented high-temperature and humidity stability. Manufactured from specially developed materials, it is designed for use in all types of military communications, such as in aircraft operating in tropical areas, where temperature and humidity vary tremendously from ground level to extreme altitudes. Chicago Telephone Supply Corp., Elkhart, Ind.

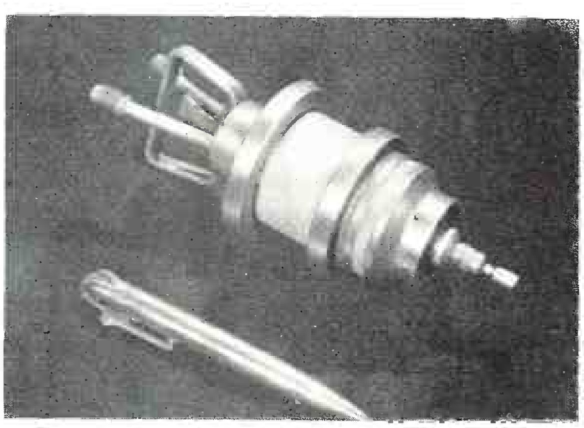
LEFT: TV FLYING SPOT SCANNER
The television flying spot scanner pictured is used to convert slide information to a video signal suitable for television broadcasting. It makes possible the effective and economical handling of commercials, test patterns, spot news, and other TV slide information. This unit can also be used to obtain flexible arrangements between two scanner units, or to achieve montage effects. Federal Telecommunication Laboratories, Inc., Nutley, N. J.

RIGHT: SKIRTED ONE-PIECE TUBE CAP
Shown is a new high-voltage, low-loss tube cap for miniature tube applications. The wire insulation and long skirted grid-cap insulation are molded in polyethylene as one homogeneous unit. The long skirt prevents danger of flash-over from cap to chassis at high voltages. The single-mold feature gives strain relief of leads and also provides 100% insulation. For use with 1X2 or similar tubes. Alden Products Co., 117 N. Main St., Brockton 64, Mass.



LEFT: VIDEO PICTURE GENERATOR
Pictured is a low-cost TV picture generator using 3 by 4-in. slide transparencies and negatives. Designed to supplement or replace monoscopes and camera chains, it is completely self-contained with regulated power supplies. The unit, designed to meet RTMA picture quality specifications, runs on standard driving pulses, off-the-air sync, or on self-contained sweep generators. Telechrome, Inc., 88 Merrick Rd., Amityville, L. I.

RIGHT: MINIATURE INDICATOR FUSEHOLDER
A new miniaturized indicating fuseholder that instantly spots a blown fuse, is now ready for commercial application after being developed under a government contract. The unique design has a neon bulb and double contacts molded as an integral part of the lens. The neon bulb, which glows when the fuse has blown, can be seen from any angle, giving an immediate indication of trouble. It has easily accessible solder tabs. Alden Products Co., Brockton, Mass.

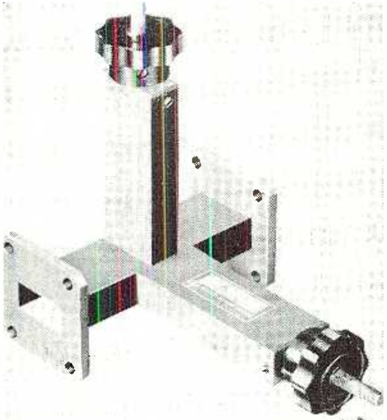


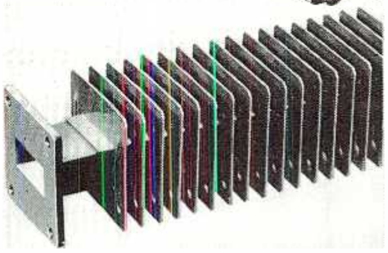
LEFT: UHF TELEVISION TRANSMITTER TUBE
The ceramic power tube illustrated is capable of operating up to and beyond the top frequency, 890 mc., of the proposed UHF television channels, and was designed primarily for such transmission. The use of ceramic minimizes high-frequency losses and makes envelope cooling problems less difficult than in glass tubes. Water pipes are so arranged that connections can be made outside the RF cavity. General Electric Tube Division, Syracuse, N. Y.

RIGHT: KT66 NOW AVAILABLE IN U. S.
Britain's famous KT66 power amplifying tube is now available in the United States. This tetrode is an especially fine tube for use in the output stage of quality audio amplifiers or as an oscillator in RF power amplifiers up to 30 mc. It is suitable for either single or push-pull audio operation and is interchangeable with a 6L6. This is the output tube specified in the original Williamson amplifier. British Industries Corp., 164 Duane St., New York 13.

NENTS AND EQUIPMENT

MENSIONS AND THE USE OF HIGHER FREQUENCIES, ARE INDICATED



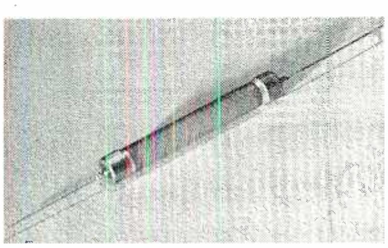


LEFT: MICROWAVE TUNER
The E-H tuner is designed to offer utmost convenience in matching sections for tuning out discontinuities in high power systems, or tuning systems where low leakage is essential. It consists of a hybrid waveguide tee, with movable contacting shorts placed in both shunt and series arms, and permits reduction of VSWR's as high as 20:1 to values of less than 1.02, and is intended for such use. Hewlett-Packard Co., 395 Page Mill Rd., Palo Alto, Calif.

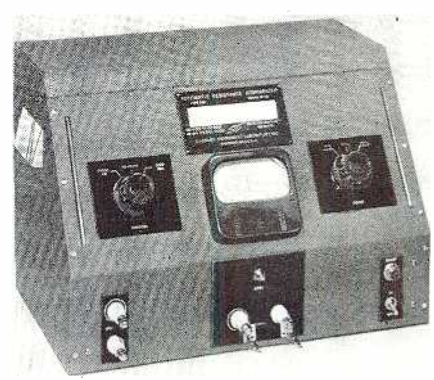
LEFT: MICROWAVE DUMMY LOAD
This power-dissipating termination is designed for use as a dummy load for high-power transmitters, and for testing tube characteristics and transmitter output. It consists of a rectangular waveguide section containing a high-loss material carefully tapered for low VSWR. Cooling fins on the waveguide exterior effectively dissipate power absorbed by the unit. Two models are offered in various sizes. Hewlett-Packard Co., Palo Alto, Calif.

RIGHT: HIGH-SENSITIVITY METER
This high-sensitivity volt-ohm-milliammeter is the thinnest instrument of its kind. Highly accurate, and compact in design, the large 5-in. lucite meter case gives increased readability. It is battery operated, making it a useful instrument for field engineers. The case is shock resistant and guaranteed unbreakable, thus protecting the sensitivity of the meter throughout long service. Hickok Electrical Instrument Co., 10530 Dupont Ave., Cleveland 8.

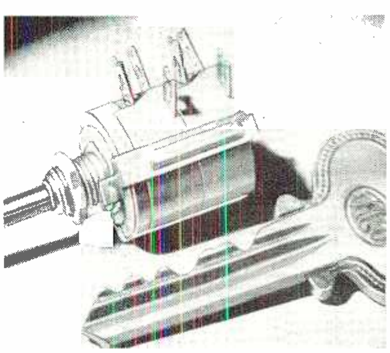
LEFT: STABLE PRECISION RESISTORS
Developed to fill the need for precision parts to meet the exacting requirements of instrument circuits, this line of resistors is highly stable under widely varying conditions. These ±1% precision resistors are made by coating a specially treated ceramic core with micro-crystalline carbon. This is protected by an insulating sleeve of thermoplastic material. Available in ½ watt, 1 and 2 watt sizes. Kay Electric Co., 14 Maple Ave., Pine Brook, N. J.



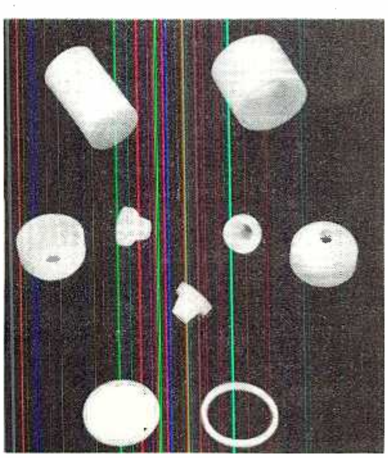
RIGHT: RESISTANCE COMPARATOR
A new high speed automatic resistance comparator has been developed which will enable unskilled labor to test as many as 17 resistors per minute, regardless of type. The new unit is specifically designed for checking incoming shipments, matching, grading to close tolerances, or checking factory output. It is completely self-contained and accurate to ±1% from 100 ohms to 100 megohms. Clippard Instrument Laboratory, Inc., 1125 Bank St., Cincinnati.



LEFT: SUB-MINIATURE VOLUME CONTROLS
Sub-miniature controls of the type shown are fit companions for sub-miniature tubes in ultra-compact electronic assemblies. Each unit, housed in a low-loss bakelite case, measures only ⅝ in. in diameter by ⅜ in. deep. Two units can be strapped together for dual-control purposes. The units are available in resistance values up to 3 megohms linear, and in tapers up to 1 megohm, round or slotted shafts. Clarostat Mfg. Co., Inc., Dover, N. H.

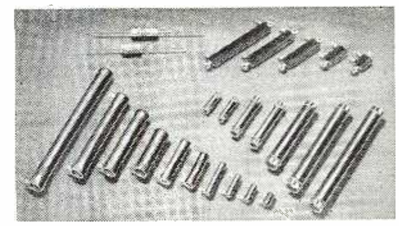


LEFT: LARGE EXTRUDED TEFLON RODS
Continuously extruded Teflon rod and tubing is now available in diameters up to 2 in. Until now, Teflon rod has been available in such large diameters, only in molded short lengths. Rods in diameters of 1/16 in. to 2 in. are now being commercially produced as is tubing of sizes from ⅜ in. through 5 in. inside diameter. Larger sizes are made to special order. Further information is available from the Polymer Corp. of Penna., Reading, Pa.

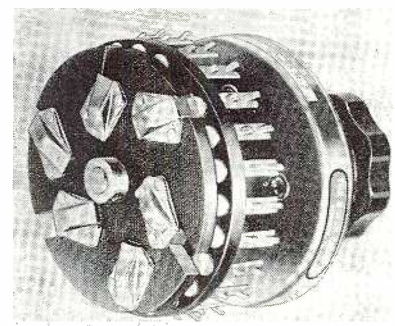


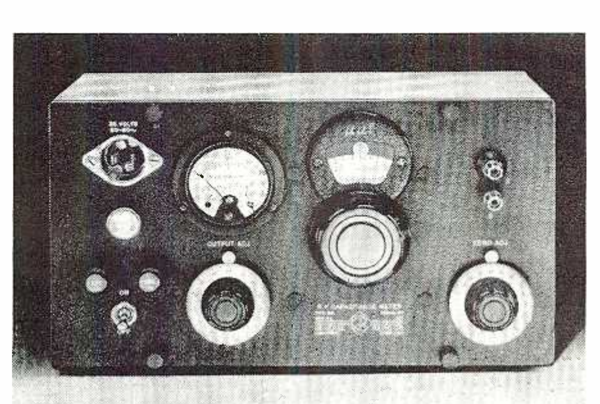
RIGHT: LOW-RANGE CAPACITANCE METER
Capacitances from a few hundredths of a micro-microfarad to 100 mmf are easily and quickly measured on this new RF capacitance meter. Two ranges, 0 to 10 mmf, and 0 to 100 mmf, are provided and are switched automatically by rotating the main capacitance dial. The instrument has a self-contained 1-mc. oscillator and resonance indicator. It can be used to measure tube-socket capacitances. General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

RIGHT: RESISTOR LINE
Now available is a complete line of JAN-type wire-wound resistors and rheostats. The rheostat line has eleven models, standard and enclosed, in sizes from 25 to 750 watts. The 33 resistor styles are of five types, each type available in a complete range of sizes, wattages, and resistance values. Ohmite Mfg. Co., Chicago.



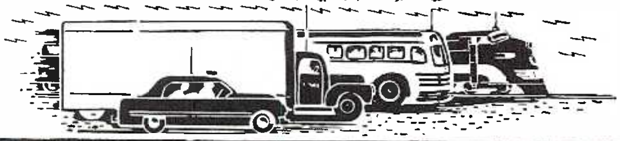
RIGHT: NEW SWITCHES
Rotary selector switches are now available with as many as 6 poles, 15 positions per pole, on each deck. This large number is made possible by a patented type of rotor arm which insures low contact resistance and uniform contact pressure over the life of the switches. Silver alloy contacts and rotor arms are used on all units. Daven Co., Newark, N. J.





JEREMIAH COURTNEY'S

MOBILE RADIO



NEWS AND FORECASTS

"My object is all sublime
I shall achieve in time
To let the punishment fit
the crime
To let the punishment fit
the crime"

GILBERT & Sullivan to the contrary notwithstanding, the sublime objective of letting the punishment fit the crime presents many problems in the mobile communications field.

Disproportionate Penalties:

The only punishment the Federal Communications Commission can mete out in dealing with a case of improper radio operation is to revoke the license of the offending operator or to designate his reinstatement or renewal application for public hearing. The Commission may also call upon the Department of Justice to invoke the criminal penalties of the Act: \$10,000 fine, two years imprisonment, or both. Any one of these actions can be a genuine catastrophe to the radio user, and if the infraction of the FCC rules is minor or unintentional, the punishment cannot possibly fit the "crime."

In the taxicab field, for example, once the company installs radio, its methods of doing business are so completely reorganized that it is practically impossible thereafter to handle or hold its business without radio. As soon as a taxicab company installs radio, its call box telephone company leased lines are promptly discontinued. Thereafter, the company relies entirely upon radio to reach and dispatch its cars in order to handle the company's prized call business.

That's not all. The number of taxis required to handle a particular number of calls at a stated service level (five-minute wait, for example) is much different when these cars are radio equipped than when they are not. It is no exaggeration to say that a company supplying satisfactory service to a large community with 100 radio-equipped cabs would have to add at least 50 cabs — in some places 200 more — to continue its service, without radio, at the former level.

Fleet car purchases, like leased lines from the telephone company, take time. Meanwhile, deprived of radio, the taxicab company may see the call business it developed over a long period of trying years destroyed over night through the unsatisfactory service resulting from being deprived of its radio system for even a short time. There are many companies to whom two months radio silence would be worse, economically, than the drastic maximum \$10,000 fine provided under the Communications Act. Yet the designation of a taxi renewal of reinstatement application for public hearing may mean a year or more without radio while the hearing procedures are exhausted: designation for hearing, appearances, setting of hearing date, trial, proposed findings, proposed decision, exceptions, oral argument and final decision. (Come, now, stop looking for your license dates.)

Taxi License History:

This problem is far from an academic one. Whether they recognize it or not, a substantial number of mobile operators, principally taxi companies, are faced with the possible loss of their licenses for the following reason. Back in 1948, the Commission extended for a year all the general mobile experimental licenses that were to expire on November 1, 1948. For the next year, every taxicab operator in the country *was required* to operate his radio system under a license which showed on its face that it had expired. This blanket extension of the taxicab experimental licenses and certain others was undoubtedly a very wise move on the part of the Commission at the time it was taken. It removed a tremendous administrative burden during a period when every bit of available staff time was necessary to put the newly reorganized mobile rules into effect. At the same time, the automatic renewal prevented any interruption to existing operations which would have been so costly for the industry.

Psychologically, however, the 1948 automatic extension has turned out very badly indeed for the taxi industry. There are probably some small taxicab companies *still operating on those old licenses.* There are, in addition probably many licenses calling for renewal at some past date which have escaped the attention of the operators because of the long period — normally four years — for which these licenses are issued. Thus, there are undoubtedly some taxicab stations operating on licenses which have expired now, and have not been renewed.

The question presented to the Commission is whether, for such an oversight, a radio user operating under an expired license should be placed in jail, fined up to \$10,000, or denied the use of radio for a long period while a hearing is held to test his qualifications to hold a station license. There are many variations to the problem but, without exception, there is never any criminal intent. Someone just failed to note an expiration date and to file the necessary forms — or the proper forms — to have the license renewed.

1934-1951 Differences:

Let's see how serious this "crime" is in terms of the results sought to be accomplished by the sanctions of the Communications Act. At the time the Act was written in 1934, operations of radio equipment were being handled much more loosely than they are now under the present, highly respected Commission and the efficient monitoring staff whose war-time achievements in policing the ether under Commissioner Sterling's direction are now so well known. Today, the Federal Government has complete knowledge of the location and nature of each radio transmitter. In 1934, many users of radio had failed intentionally to cooperate with the Government. Transmitters without crystal-controlled oscillators, operating at very high power and on frequencies which caused interference half way around the world, were not uncommon. The punitive measures of the Communications Act were designed to eliminate these conditions. And that has been done. Over the years, the FCC has built up in the minds of the public a deep and abiding respect for its overall control of radio operations of every character, even to industrial apparatus. No one in his right mind would today question the Commission's right or obligation to license and regulate all radio transmissions.

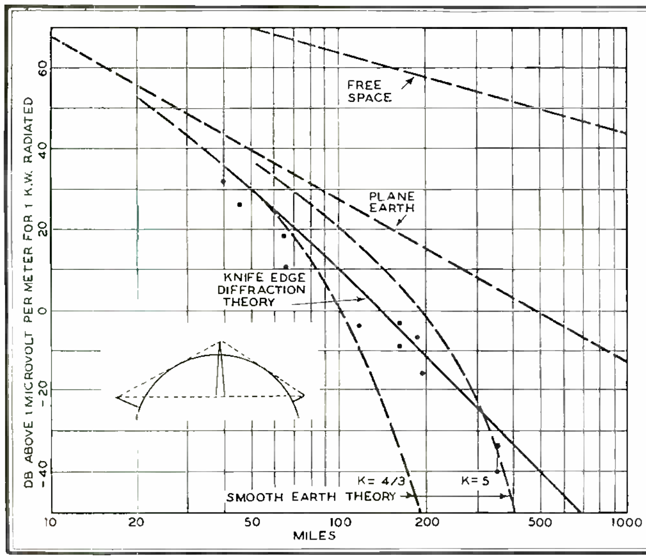
Not Bootleg Stations:

It is apparent, however, that any person in the mobile radio service who has failed to renew an expired license has not done so with any intention of operating an illicit or clandestine station. The power and frequency used are such that widespread interference is seldom possible. Crystal-controlled transmitters tuned to a single frequency also reduce the detection problem which previously confronted the FCC.

When someone operates a station previously licensed, but with respect to which the necessary paper work has not

(Concluded on page 32)

*1707 H Street, N. W., Washington, D. C.



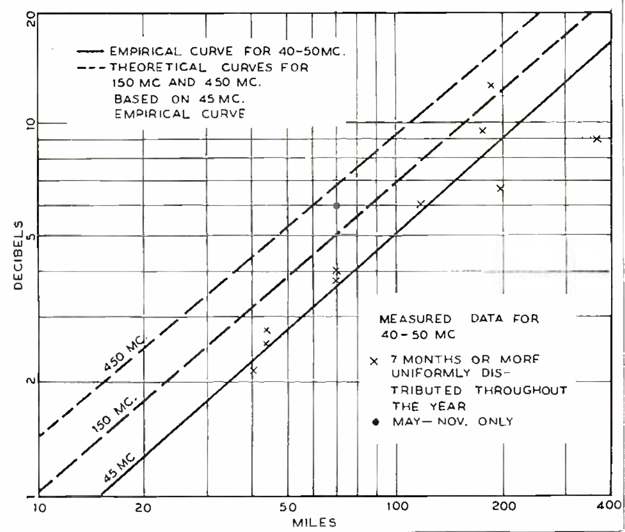


FIG. 1. MEASURED AND THEORETICAL FIELD INTENSITIES AT FREQUENCIES OF 40 TO 50 MC. FIG. 2. MEASURED AND THEORETICAL EFFECTS OF FADING

COVERAGE ON 45 TO 450 MC.

A PRACTICAL STUDY OF COVERAGE THAT CAN BE REASONABLY EXPECTED FROM MOBILE SYSTEMS IN URBAN AND RURAL AREAS — *By* K. BULLINGTON*

THE propagation of radio waves is subject to many variations that are not completely understood. Even over relatively smooth earth the median field intensity measured at distances of 200 miles or more may be 40 to 60 db greater than the values predicted by the smooth earth theory. In addition to this "discrepancy" in median values, the field intensity at any given location varies with time, and the resulting fading range tends to increase with both distance and frequency. Although these variations are relatively unimportant at distances within the reliable coverage area, they are of prime importance in estimating the geographical separation that is required between two transmitters assigned to the same frequency.

Other variations in field intensity result from the presence of hills, trees and buildings, and these are important in estimating reliable coverage areas as well as the interference area. In this case, the measured signals may be 40 db or more below the value indicated by the smooth earth theory. Thus it appears that the median field intensity is generally lower at short distances and higher at long distances than is predicted by the smooth earth theory. This situation is unfortunate, since it means that a given frequency assignment cannot be repeated as often geographically as the theory would indicate.

Since the range of the propagation variations may be many tens of decibels, it is obvious that an accurate prediction of the field intensity at a particular location is not possible. The best that can be done is to state the median value to be expected and the probable deviation from the median. It also follows that individual spot measurements may vary over a very wide range, and are of little value in establishing a general trend. In order to determine a general rule for fading, it is desirable to have measurements over a relatively smooth path for many months, preferably a year. Similarly, in order to determine the effects of terrain irregularities, it is necessary to have measurements at a sufficiently large number of locations within 20 or 30 miles from the transmitter where atmospheric fading can usually be neglected.

Some of the general trends in the available data on VHF and UHF that seem suitable for statistical analysis is summarized in the following sections. The results are applied to the problem of estimating the required separation between two co-channel transmitters in the 40 to 50-mc. range. This paper does not consider sky wave propagation, although ionospheric reflections can occur at frequencies above 30 mc.

Measurements Vs. Smooth Earth Theory:

The theory of radio propagation over plane earth is well established. It reduces to the familiar concept of a direct and reflected ray for antenna heights greater than about 1 wavelength above ground. The smooth earth theory which provides the correction for the curvature of the earth has not been checked as completely as the plane earth theory. [1,2,3] It agrees reasonably well with experimental results as long as the correction for earth's curvature is less than 20 or 30 db, but it seems to fail when the indicated curvature loss is greater than 30 to 40 db. This means that theoretical curves based on the smooth earth theory may be in serious error at distances beyond 100 miles for 30 to 40 mc., beyond 60 miles for 300 mc. and beyond 30 miles for 3,000 mc. unless the antenna heights are sufficiently high to approximate plane earth conditions.

Most of the data on long-range ground-wave transmission is at frequencies in the 40 to 50-mc. range. [4,5,6] The field intensities for the 10 paths listed in the following table are the median values that were recorded for periods of at least six months to a year. The measured values have been adjusted to an effective radiated power of 1 kw.

The right-hand column in the table above shows the approximate median field intensities that would be expected if the antenna heights were 500 and 30

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*Bell Telephone Laboratories, 463 West Street, New York City. This paper was presented at the IRE National Convention, New York City.

[1] "The Effect of the Earth's Curvature on Ground Wave Propagation" *Proc. IRE* January 1941, C. R. Burrows and M. C. Gray.

[2] "The Calculation of Ground Wave Field Intensity Over a Finitely Conducting Spherical Earth" *Proc. IRE* December 1941, K. A. Norton.

[3] "Radio Propagation at Frequencies Above 30 Mc." *Proc. IRE* October 1947, pp 1122-1136, K. Bullington.

[4] *T.I.D. Report* 2. 4. 5. Federal Communications Commission (27989) Oct. 20, 1948

[5] "Propagation Studies at 45.1, 474 and 2800 Mc." *Proc. IRE* July 1947, G. S. Wickizer and A. M. Braaten.

[6] "Trophospheric Reception at 428 Mc. and Meteorological Conditions" *Proc. IRE* Dec. 1947, G. N. Pickard and H. T. Stetson.

Path No. Used in T.I.D. 2.4.5	Miles	Megacycles	Measured Median Field db above 1 u V/m	Period of months	Trans. Antenna Height, Ft.	Rec. Antenna Height, Ft.	Median Field, Adjusted for Antenna Heights of 500 & 30 ft. db above 1 u V/m
	42.5	45.1	49.	12	1300	80	.32
34	45.	47.1	30.6	12	570	50	25.5
35	68.	47.1	18.	6	570	30	17.
	70.	45.1	31.	12	1300	132	10.
3	104.	45.7	7.6	7	380	30	10.
4	122.	45.5	3.	10	690	50	-4.
31	167.	42.8	4.1	11	700-900	50	-4.
36	186.	47.1	-6.2	12	570	30	-7.2
1	198.	42.8	-11.7	11	700-900	30	-15.7
2	337.	44.3	-31.	11	1600-680	30	-41 -33.5

ft. instead of the heights shown. The corrections are based on the plane earth theory which indicates that the field intensity is increased 6 db when the antenna height is doubled.[7] The corrected values are plotted on Fig. 1.

The theoretical curve based on the smooth earth theory, including the average refraction in the earth's atmosphere, is indicated by the dashed line for k = 4/3, where k is the ratio of the effective earth's radius to the true earth's radius. It will be noted that the experimental values of field intensity decrease much more gradually with increasing distance than is indicated by the smooth earth theory. Any assumed change in the value of k moves the theoretical curve horizontally (and slightly downward) without changing its general shape. This is indicated by the dashed line for k = 5. The assumption of another value of k would not provide a better fit with the experimental data and, in addition, a long term average value of k that is appreciably greater than 4/3 would be difficult to justify from a meteorological standpoint. In a similar manner, a change in the conductivity of the ground over the extreme range from perfectly insulating to perfectly conducting affects the theoretical values in approximately the same manner as a change from k = 4/3 to k = 2. There is no apparent method of adjusting the smooth earth theory by changes in the values of k or of the ground constants to fit the available experimental data at 45 mc.

The solid line on Fig. 1 is a theoretical curve obtained by assuming that the field intensity is below the plane earth value by the diffraction loss over a knife edge whose height is determined by the intersection of two straight lines drawn tangent to the earth's surface from the two antennas. This is illustrated by the insert in Fig. 1. It assumes the average refraction represented by k = 4/3. The best empirical curve drawn through these experimental points has the same general shape as the solid theoretical curve, but is lower by about 6 db. Thus the knife edge theory, which should not be applicable, seems to give a better correlation with the experimental data than the smooth spherical earth theory. In addition, the apparent failure of the smooth earth theory is most noticeable in the region where it should be most accurate, since the fundamental assumption of a smooth sphere is more closely approached as the distance is increased.

The long term experimental data at higher frequencies is too meager for firm conclusions, but the present results indicate that the median field intensity at points beyond the line of sight is also higher than predicted by the smooth earth theory, but is less than indicated by the knife edge diffraction theory. Determination as to whether the smooth earth theory holds for microwaves must await long term recordings at several points far beyond the optical horizon.

Effects of Atmospheric Fading:

The variations in field intensity around the median value are presumably the result of changes in the atmospheric conditions. The field intensity tends to be higher in summer than in winter and higher at night than during the day for overland paths that are beyond the optical line of sight. The fading range ordinarily increases with an increase in either distance or frequency. As a first approximation, the distribution of field intensities follows a normal probability law in decibels, except that the signal seldom exceeds the value expected over plane earth.

The difference in decibels between the values exceeded 10% of the time, and the median values are shown on Fig. 2 for the 40 to 50-mc. paths for which data is available for more than 6 months. It will be noted that consider-

[7] According to the smooth earth theory, this method is in error at 45 mc. for points beyond the horizon by about 0.7 db at 500 ft., 3 db at 1000 ft., and 5 db at 1,500 ft., but these differences are small compared with the discrepancy between the experimental and theoretical results.

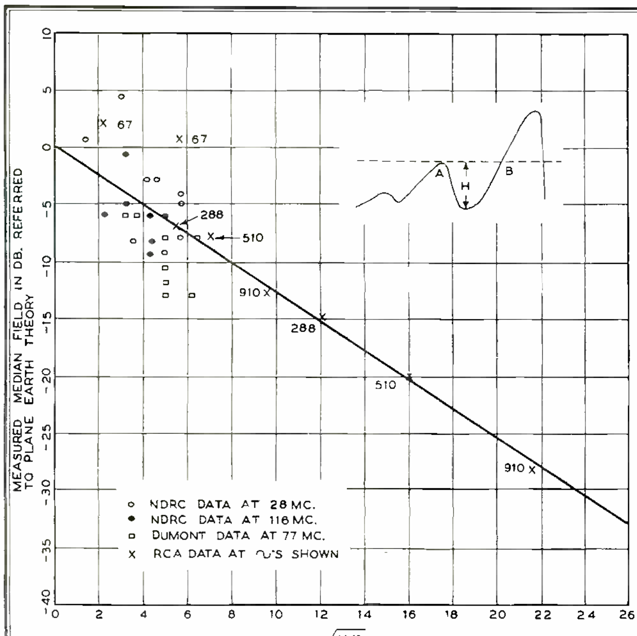


FIG. 3. EFFECTS OF TERRAIN IRREGULARITIES ON RADIO PROPAGATION

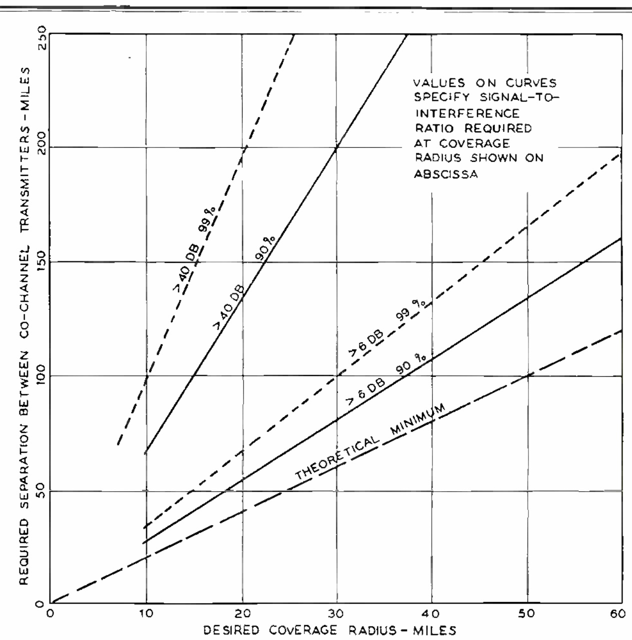


FIG 5. ESTIMATED SEPARATION REQUIRED, ASSUMING 200-FT. IRREGULARITIES

able spread exists between the measured values and any single line drawn to represent the data. Most of this spread probably results from factors other than distance, such as antenna height, type of terrain, and different climatic conditions.

At frequencies higher than 40 to 50 mc., the long term data on atmospheric fading is meager, and an empirical relationship drawn from a small number of points may be misleading. However, the available data at frequencies below 500 mc. is not inconsistent with the dashed lines on Fig. 2 for 150 and 450 mc.

These curves are derived from the 40 to 50-mc. data by assuming that the fading range varies with frequency in the same manner as the diffraction loss introduced by the earth's curvature. The diffraction theory for either a smooth sphere or the knife edge shown on Fig. 1 indicates that the diffraction loss varies as the product of the frequency times the cube of the distance. This extension of the 40 to 50-mc. data by theoretical considerations cannot be carried too far. For example, if this theory were assumed to hold at 4,000 mc. the resulting estimated fading range would be greater than the measured values on good optical paths, and would be less than the measured values on paths where the receiver is far below the optical horizon.

Some atmospheric fading also occurs over good optical paths.[6, 8]. For 1% of the time at 45 mc., the field intensity is about 2 or 3 db less than the median value, while at 4,000 mc. it may be 15 to 20 db below the median value.

Effect of Hills:

The available data on the effect of hills indicates that the shadow losses increase with frequency and with the roughness of the terrain.[9] The variations in shadow losses around the median value usually follow a normal probability law in db.

The principal experimental data on the effect of hills is shown on Fig. 3. The roughness of the terrain is assumed to be represented by height H shown on the profile at the top of the drawing. This height is the difference in elevation between the bottom of the valley and the elevation necessary to obtain line of sight with the transmitting antenna. The difference between the measured values of field intensity and the values to be expected over plane earth is computed for each point of measurement between A and B. The median value for each general location is plotted on Fig. 3 as a function of

$$\sqrt{\frac{H}{\lambda}}.$$

The choice of this parameter is based on knife edge diffraction theory which indicates that the parameter should be

$$\sqrt{\frac{H}{\lambda}\tan\Theta}.$$

where Θ is the angle of bend around the obstruction, and it is assumed that the variation in Θ is much less than the variation in H/λ.

The open circles indicate data taken at 28 mc. and the solid circles are data at 116 mc. The crosses indicate data at 67, 288, 510 and 910 mc. It will be noted that there is considerable spread, especially in the region where the shadow loss is less than 10 db. The solid line is an empirical approximation for the median shadow losses. In a similar manner an estimate of the shadow losses exceeded in 10% of the possible locations can be obtained.

These empirical relationships are summarized in the nomogram shown in Fig. 4. The scales on the right hand line indicate both the median value of shadow loss and the difference in shadow loss to be expected between the median and the 10% values. For example, with variations in terrain of 500 ft., the estimated median shadow loss at 500 mc. is about 20 db, and the shadow loss exceeded in only 10% of the possible locations is about 20 + 15 = 35 db. It will be recognized that this analysis is based on large-scale variations in field intensity, and does not include the standing wave effects which sometimes cause the field intensity to vary considerably in the matter of a few feet.

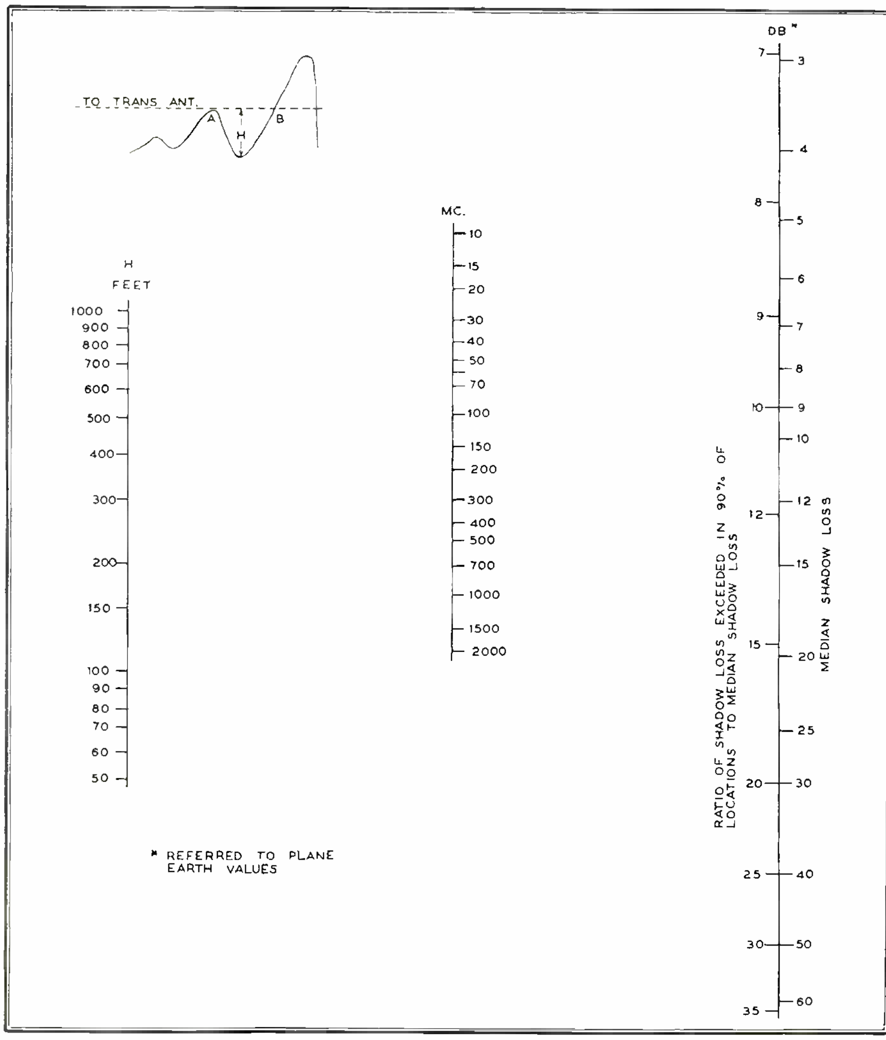


FIG. 4. ESTIMATED DISTRIBUTION OF SHADOW LOSSES FOR RANDOM LOCATIONS BETWEEN A AND B

Effects of Buildings and Trees:

The shadow losses resulting from buildings and trees follow different laws than those caused by hills. Buildings are more transparent to radio waves than the solid earth, and there is ordinarily much more back-scatter in the city than in the open country. Both of these factors tend to reduce the shadow losses caused by the buildings but, on the other hand, the angles of diffraction over or around the buildings are usually greater than for natural terrain. In other words, the artificial canyons caused by buildings are considerably narrower than natural val-

[8] "Results of Microwave Propagation Tests on a 40-mile Overland Path," A. L. Durkee, *Proc. IRE* Feb. 1948.

[9] "Comparative Propagation Measurements; Television Transmitters at 67.25, 288, 510 and 910 Megacycles," G. G. Brown, J. Epstein and D. W. Peterson, *RCA Review*, June 1948.

leys, and this factor tends to increase the loss resulting from the presence of buildings. The quantitative data on the effects of buildings is confined almost entirely to New York City. This data seems to indicate that in the range of 40 to 450 mc. there is no significant change with frequency, or at least the variation with frequency is somewhat less than the square root relationship noted in the case of hills. The median field intensity at street level for random locations in Manhattan (New York City) is about 20 db below the corresponding plane earth value. The corresponding values for the 10% and 90% points are about 10 and 30 db respectively.

Trees and other objects whose dimensions are of the same order of magnitude as the wavelength at VHF tend to act as parasitic radiators. The average shadow loss is small at 30 to 50 mc., but increases with increasing frequency. The distribution of losses in the immediate vicinity of trees does not follow a normal probability law, but is more accurately represented by Rayleigh's law which is the distribution of the sum of a large number of equal vectors having random phases. In this type of distribution the 10% and 1% points are about 8 and 18 db respectively below the median value.

Co-Channel Interference:

In order to make the most efficient use of a radio frequency spectrum, it is necessary to repeat frequency assignments as closely as possible without producing unreasonable co-channel interference. The amount of co-channel interference that can be tolerated depends on the type of receiver and on the quality and reliability of the service required. For example, with FM receivers having a 5:1 deviation ratio, a signal-to-interference ratio of 4 to 10 db or more is required, depending on the quality desired, while for television broadcasting. the FCC standards specify a signal-to-interference ratio of 40 db.

If the variations in radio transmission could be ignored, it would be possible to determine an optimum geographical layout from the required signal-to-interference ratio, and a curve of median field intensity versus distance, such as Fig. 1. However, the magnitude of the transmission variations may be comparable to or greater than the signal-to-interference ratio required by the receiver. Hence, these variations cannot be ignored. It is still possible to use the transmission curve of median field intensities vs. distance providing the required signal-to-interference ratio is taken as the above value plus an allowance for the magnitude of variations to be expected and the reliability desired. The principal variations seem to follow the normal probability law, and probability theory indicates that if these variations were independent, the required signal-to-interference ratio $\frac{S'}{I'}$ would be given by

$$20 \log \frac{S'}{I'} = 20 \log \frac{S}{I} + K \sqrt{X_S^2 + Y_F^2 + Y_S^2 + X_F^2}$$

where

$\frac{S}{I}$ = signal-to-interference ratio required by the receiver for the quality of service desired.

X_S = difference in db between the 10% and 50% values of shadow losses for the desired signal.

X_F = same for atmosphericfading.

Y_F = difference in db between the 10% and 50% values of atmospheric fading for the undesired signal.

Y_S = same for shadow losses.

K = 0 for 50% reliability (based on normal probability law)

= 1 for 90% reliability

= 1.8 for 99% reliability

Since the variations are not entirely independent, some judgment is needed in the use of the formula above. The two principal variations are the shadow loss distribution for the desired signal X_S shown in Fig. 4, and the atmospheric fading distribution for the undesired signal Y_F shown in Fig. 2. The shadow loss distribution for the undesired signal, Y_S, cannot be taken at full value, since the local terrain at the receiver may affect both signals alike, but it cannot be neglected since the two signals are usually coming from nearly opposite directions. The most probable value of Y_S is assumed in the following example to be one-half the value shown in Fig. 4. In a similar manner, the atmospheric fading of the desired signal is not independent of the fading of the undesired signal. That is, there is some tendency for the two signals to fade up and down together. Fortunately in this case, the value of X_F is always small compared with Y_F and also usually small compared with X_S, so that it can be neglected without an appreciable effect on the final results.

As an example, consider a mobile radiotelephone system operating at 40 mc. over terrain having variations of 200 ft. It is assumed that the interfering transmitter has the same effective radiated power and antenna height as the desired transmitter, and that a signal-to-interference ratio of at least 6 db is desired for more than 90% of the locations, and time, at the edge of the coverage area.[10] The value of X_S is shown on Fig. 4 to be about 7.5 db and the value of Y_F is shown on Fig. 2 to be about 3 db at 50 miles, 5 decibels at 100 miles and 9 decibels at 200 miles. It follows that the value of $20 \log S'/I'$ for a distance of 100 miles from the receiver to the undesired transmitter is given by

$$20 \log \frac{S'}{I'} = 6 + \sqrt{(7.5) + (5)^2 + \left(\frac{7.5}{2}\right)^2 + 0}$$

$= 15.8$ db.

This means that when the distance from the receiver to the undesired transmitter is 100 miles, the reliable coverage radius of the desired transmitter is limited to that distance at which the median field intensity from the desired transmitter is 15.8 db higher than the median field intensity at a distance of 100 miles. The required separation between the two transmitters is then 100 miles plus the coverage radius.

The principal remaining choice is the proper relationship of the median field intensity vs. distance. Although the absolute values of field intensity depend on the antenna heights and radiated power, these factors are equal for both the desired and undesired signals, so only the slope of the curve is important in this example. For distances between 20 and 250 miles, it is assumed that the signal intensities are given by the solid line on Fig. 1. In the example above, the median signal intensity at 60 miles is about 16 db stronger than at 100 miles. Thus the coverage radius is 60 miles and the required separation between co-channel stations is 100 + 60 = 160 miles.

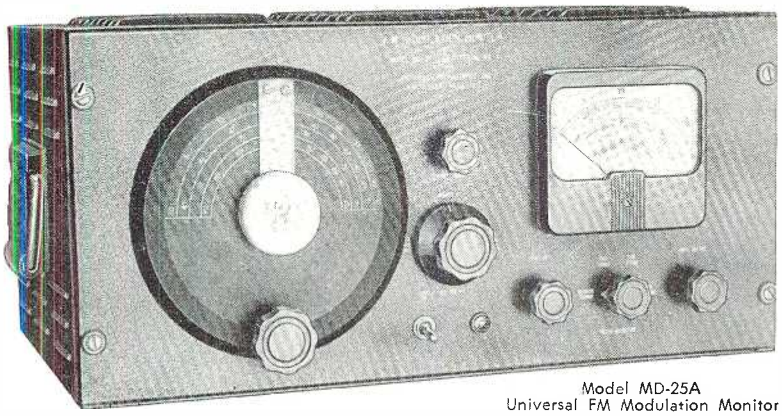
In a similar manner, additional points can be obtained for other distances between the receiver and the unwanted transmitter. The resulting separation required between co-channel transmitters is shown in Fig. 5 by the solid line marked ">6 db, 90%." Thus, for a coverage radius of 20 miles, the separation required at 45 mc. is about 55 miles. The corresponding value for 99% reliability is about 67 miles. Similar values for a required signal-to-interference ratio of 40 db at the receiver are also shown.

When higher frequencies are used or when more rugged terrain is considered, the required separation between co-channel stations will be greater than shown on Fig. 5. When the radiated powers or antenna heights are not the same for the two transmitters, the first-order effect is for the stronger station to gain coverage area at the expense of the weaker station, assuming equal receiving antenna heights, without any substantial change in the required separation between stations.

It will be realized that the coverage

(Concluded on page 36)

[10] This example is based on two-frequency operation, and considers the interference into a mobile receiver from an unwanted fixed transmitter. For single frequency operation, the principal co-channel interference occurs from a fixed transmitter into a fixed receiver, and the required separation between co-channel systems is considerably greater than is shown in this example.



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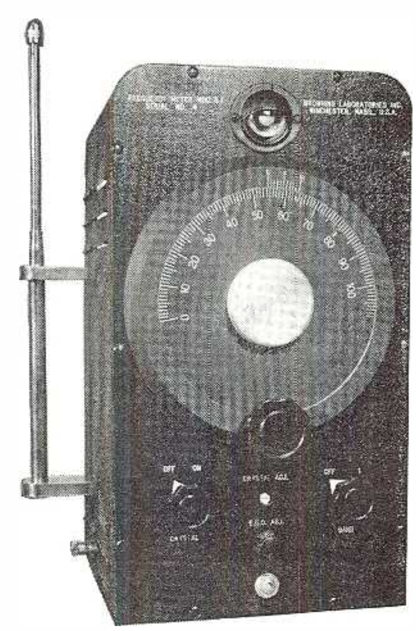

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ZENITH VHF-UHF TUNER

(Continued from page 15)

the oscillator trimmer is noticeably sharper than on the VHF band. However, even in these sets, stability is adequate for precision tuning.

The non-intercarrier sets use two oscillators, one for the 54 to 88-mc. band, and one for 174 to 216-mc. This oscillator is also capable of being tuned to frequencies which will produce appropriate harmonics throughout the UHF band. It appears that the availability of suitable harmonics of the oscillator is the factor which determines the highest frequency at which the channel strips can be built. Strips for 900 mc. have been built, and appear to be quite practical.

Noise and Rejection:

One of the most important characteristics in UHF receivers is the noise factor.

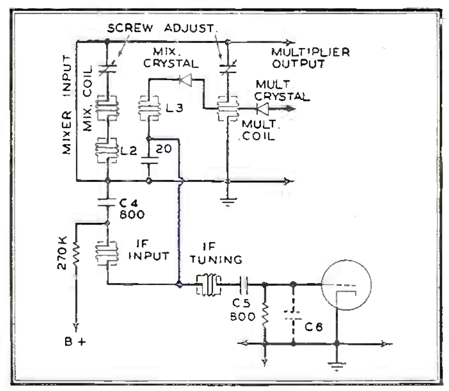


FIG. 11. SIMPLIFIED DIAGRAM OF MIXER OUTPUT

Experience has shown that the minimum acceptable signal is not determined by external noise, but rather by receiver input noise. This must be minimized to utilize all of the potential transmitter coverage. There are no practical RF amplifier tubes available for use in the UHF band which can exceed the performance of a good crystal mixer. Well-designed circuits employing such mixers make it possible to achieve a noise factor as low as 10 db.

This figure will be exceeded on the channel strips, however, as a result of the added grid capacity in the IF amplifier, caused by the contact switching on the turret. The additional capacity, which reduces the grid impedance, increases the noise factor, since the shot noise in the first tube is the dominant noise source. A reduction of this input capacity or the use of a well-designed cascade circuit would somewhat improve the 15 to 20-db figure which is now obtained on the channel strips.

Rejection to the various responses is also important. The most important of these is the image, which on the channel

(Continued on page 29)

ZENITH VHF-UHF TUNER

(Continued from page 26)

strip is approximately 40 db, as shown in Fig. 12. This amount of rejection is deemed adequate in view of the allocations currently proposed.

The curves show typical examples of the preselector only. The two curves were taken near the extremities of the tuning range of the housing. Tuning ranges of the other two housings are shown on the frequency scale.

The IF rejection varies somewhat, but it is of the order of 45 db. This is adequate for present purposes, but as utilization of the frequencies within the IF passband increases, IF rejection will become increasingly important. On UHF tuners of future design, the IF rejection can be easily increased to 70 db or more.

Oscillator Radiation and Stability:

Because the excitation on the crystal is so small, oscillator radiation on the channel strips in the UHF band is negligible.

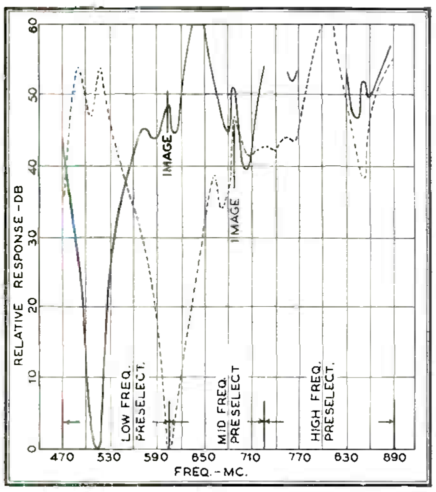


FIG. 12. CHARACTERISTICS OF TUNING STRIP

Although exact measurements are difficult to make, it can be said that approximately 100 microwatts of power is fed to the crystal, and this power is attenuated by the preselector by somewhat more than 20 db. Thus the radiation in the UHF band would appear to be considerably less than 1 microwatt. The oscillator radiates in the UHF band just as it does when a VHF channel strip is being used. This radiation, however, is small and does not interfere with the television channels.

The UHF channel strips are pretuned at the factory and it is not anticipated that they will be retuned in the field. The UHF tuned circuits are complete within themselves and, therefore, are not required to match any component in the receiver. For this reason, and also because of their ruggedness, the RF and multiplier tuned circuits can be expected to stay in tune to a high degree of pre-

ZENITH VHF-UHF TUNER

(Continued from page 29)

cision. The critical item is the stability of the VHF oscillator, which determines the actual frequency in the output of the multiplier. Inherent stability of the VHF oscillator is such that the reset accuracy and drift characteristics on the UHF channel strips are superior to most VHF receivers sold today. That the stability is adequate has been proven by reports from users and servicemen on approximately fifty installations in the Bridgeport, Conn., area. The 40-mc. IF circuits are wider than the remainder of the IF amplifier, and drift in these circuits is negligible. The coils are wound to 2½% tolerance and no provision is made for adjusting these circuits.

WHAT'S NEW THIS MONTH

(Continued from page 11)

degradation of aural FM programs was permitted to 10,000 cycles.

Section 8 (h) of the Standards of Good Engineering Practice concerning FM broadcast stations was amended:

7. Amplitude or frequency (frequency-shift) modulation of the subcarrier shall be used.

9. Negative modulation shall be used, *i.e.,* for amplitude modulation of subcarrier, maximum subcarrier amplitude and maximum radio frequency swing on black; for frequency modulation of subcarrier, highest instantaneous frequency of subcarrier on black.

1. The facsimile subcarrier transmission shall be conducted in the frequency range between 22 and 28 kc. Should amplitude modulation of the subcarrier be employed the subcarrier frequency shall be 25 kc. with side-bands extending not more than 3 kc. in either direction from the subcarrier frequency. Should frequency modulation of the sub-carrier be employed the total swing of the subcarrier shall be within the range from 22 to 28 kc., with 22 kc. corresponding to white and 28 kc. corresponding to black on the transmitted copy. In multiplex operation the modulation of the FM carrier by the modulated subcarrier shall not exceed 5%. In simplex operation, modulation of FM carrier by the modulated subcarrier shall not exceed 30%.

12. During periods of multiplex facsimile transmission, frequency modulation of the FM carrier caused by the aural signals shall, in the frequency range from 20 to 30 kc., be at least 60 db below 100% modulation. Frequency modulation of the FM carrier caused by the facsimile signals shall, in the range from 50 to 15,000 cycles, be at least 60 db below 100% modulation.

MOBILE RADIO NEWS

(Continued from page 32)

formation is available as would be the case had the necessary renewal forms been submitted on time.

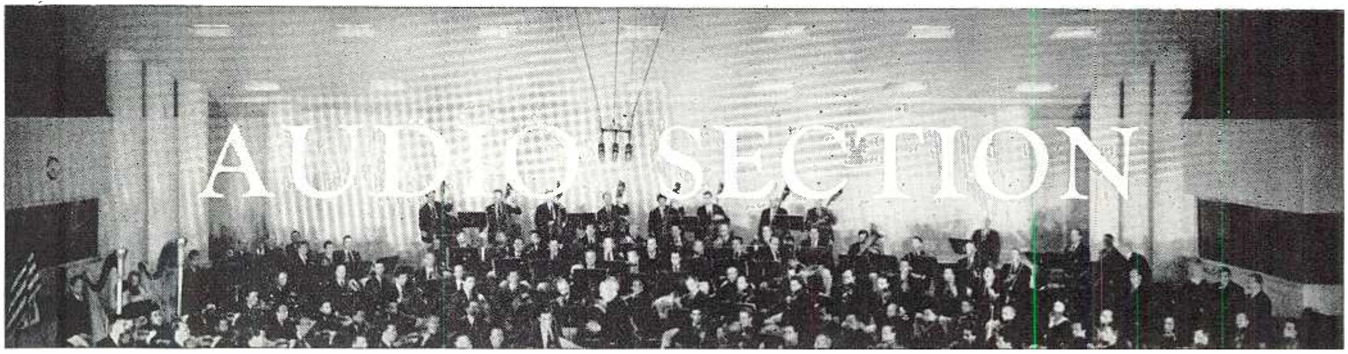
Under such circumstances, to invoke the criminal sanctions of the Communications Act as if the operator had been trying to bootleg communications and evade the regulations of the Commission would clearly constitute an undue hardship. Alternatively, to keep the operator off the air while a hearing is held to determine whether his license should be renewed or reinstated would be tantamount to a fine of hundreds or thousands of dollars in depriving the company meanwhile of its radio system. This, too, appears to be an unnecessarily harsh punishment to inflict upon the taxi operator and the community he serves with radio.

Amendment Is in Order:

A procedural lapse from license grace in the mobile field should call for the imposition at most of a small monetary fine to be increased if the lapse continues or is repeated. Unfortunately, however, the Communications Act does not permit the imposition by the Commission of small fines for small crimes. Until the Communications Act is so amended, however, it would seem that the Commission should draw some sort of distinction, for enforcement purposes, between the totally unauthorized type of radio operation and that which conforms in all respects to the requirements of a license previously issued.

The problem is an acute one, and by no means confined to the taxicab field. However, the present Commission, in the past few years, has simplified construction permit applications, reorganized its mobile rules, simplified third class radiotelephone licensing, and has done many other things to relieve the administrative load and to reduce the cost of Government and industry operations in the mobile field. Certainly it can be counted upon to effect a proper distinction in the treatment of totally unauthorized radio operations seeking to evade Commission regulation and those operating in conformance with the Commission's Rules and a license previously effective but now expired.

The first step in that direction would appear to be the issuance by the Commission of a definitive statement of what is required by the operator when he becomes aware of the expiration of his license, or is advised of that fact. The procedure established should also be such as not to deprive the operator of the use of his radio system after the license expiration is discovered and a proper license application filed.



DESIGN FOR A REFLEX AIR-COUPLER

STILL LOWER BASS RESPONSE, EVEN AT LOW VOLUME, CAN BE OBTAINED BY ADDING AN ENCLOSURE TO THE AIR-COUPLER — *By* CHARLES FOWLER

ONE of the outstanding features of the FAS system is its ability to convert relatively small amounts of speaker input energy into large amounts of sound power output. This is accomplished by employing a carefully designed amplifier and constructing an unusual but very effective speaker enclosure which makes possible low frequency response down to 30 cycles, even at low volume levels.

Since the whole purpose of the system is to utilize every bit of speaker energy, at low frequencies, to produce sound, many people have written in to ask, "Isn't there some way in which we can use the energy radiated by the back of the speaker? When the Air-coupler is in the room, some of this energy becomes sound, but when it is mounted in the floor, it is lost in the cellar."

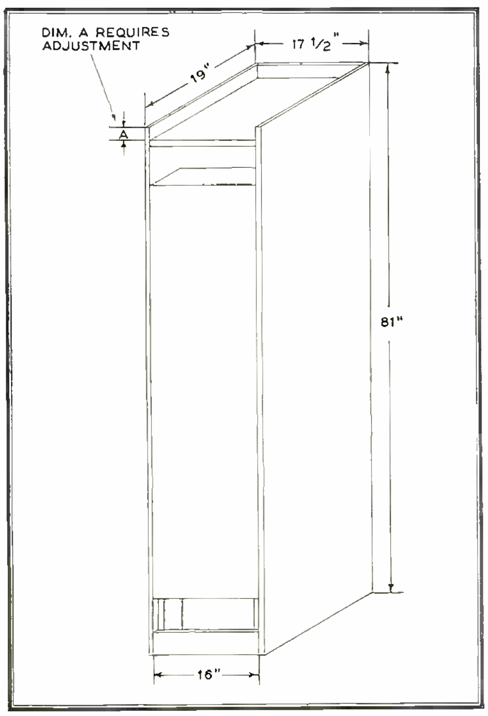


FIG. 2. DIMENSIONS OF THE REFLEX CABINET

This was certainly a reasonable question. It did seem as if there ought to be some way in which the radiation from the back of the speaker could be used to reinforce sound power output at the front. So we drew some sketches of a design for a reflex Air-coupler, all following the basic idea of closing in the back and bringing the sound out to a port on the front. We spent a good many hours trying to be scientific, and worked out innumerable formulas. The number of variables and unknowns was so great that, in the end, we just went ahead on the basis of well-informed estimates of optimum dimensions.

The result is shown in Figs. 1 and 2. As can be seen from the illustrations, we simply built an envelope around the basic Air-coupler. The front panel is the front of a standard 6-ft. Air-coupler, with its port at the bottom. A 12-in. speaker is mounted in the correct position for the 6-ft. unit, facing the port. We screwed two side pieces, 19 by 81 ins., to each of the 6-in. sides of the standard Air-coupler, and screwed another small piece, 16 by 12¼ ins., on the bottom. A back panel, 16 by 81 ins. finished the enclosure, except for the top. No braces were used anywhere.

First tests were made with the top open, so that the sound from the back of the speaker played against the ceiling. Frequency test records made it apparent that there were some bad peaks and valleys, so we clamped the top piece in position. It was then found that tuning the port was a critical operation. A very great difference in evenness of sound power output resulted from moving the top piece to change the size of the reflex port opening.

All tests were made by the final judge of any sound system: the ear. We had an assistant play the 30 to 300 cycle portion of a frequency test record over and over again, and changed the size of the port back and forth until what sounded like smooth sound power output was

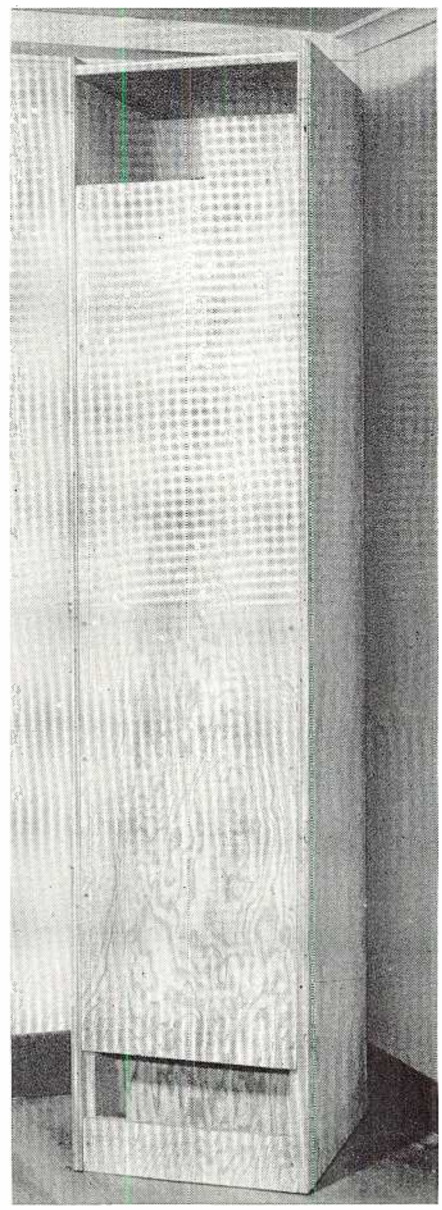


FIG. 1. AIR-COUPLER WITH A REFLEX CABINET

achieved throughout the range being tested. In our installation, with an Altec 600-B speaker on the Air-coupler, a port opening of 8 ins. gave the desired result. Since our unit was built of heavy ¾-in. plywood, almost all sound came from the ports, and virtually none from the enclosure itself.

There is no reason why — other than convenience — the reflex Air-coupler should stand on end. It can be laid flat so that the ports face the ceiling. However, unlike the original Air-coupler, there is no loss of performance when it is stood on end, as in Fig. 1, without being braced or anchored. The reflex unit can be built into the floor, of course, but two openings will be required.

The result of these experiments is all that we hoped for. Sound power output from this reflex Air-coupler is better than from a standard unit. Even lower frequencies can be reproduced; test playings of our standard record, St. Saens *Symphony No. 3,* showed up bass notes which he had not heard before! Further, the volume level can be cut to almost bare audibility without having the bass drop out.

But there were problems. As has been pointed out, tuning of the reflex port was critical, although the port on the standard Air-coupler was not disturbed or adjusted in any way. More important was an effect which can best be described as "taking hold" suddenly. On music such as piano, where volume level might be expected to be the same, relatively, at low and middle frequencies, the reflex unit came into action very noticeably, giving a bass-rise effect below certain frequencies, just as if the level control had been turned up suddenly. Tympani would dominate an orchestral piece. A deep bass voice would roll along smoothly, suddenly swelling in volume when a note below 250 cycles was sung.

In an effort to smooth out response throughout the middle and low frequency range, the crossover point was shifted from 350 to 150 cycles, but this made matters worse. The reflex Air-coupler didn't come into action except on exceptionally low notes, and then dominated the sound output. Adjusting the level controls did no good. Finally an entirely different cross-over network was tried. Instead of a sharp cut-off, such as had been found best for the standard Air-coupler, a slow-droop design was used. The rate of droop was changed from 12 db per octave to about 5 or 6 db. Finally, the cross-over point was moved to 250 cycles. With this arrangement, the shift from the middle range speaker to the reflex Air-coupler was imperceptible.

The new network has a major advantage: it is much simpler to build and

(Concluded on page 36)

REFLEX AIR-COUPLER

(Continued from page 35)

wire together. Only one inductance and one capacitance are necessary, and, in our setup, where matched middle and low-frequency speakers are used, no level controls are necessary. The schematic for this simplified network is shown in Fig. 3, with values of components for 4, 8, and 16-ohm systems given in Table 1.

TABLE I: COMPONENTS FOR SLOW DROOP NETWORKS

	System Impedance 16 ohms	8 ohms	4 ohms
L1, Mh:	10.2	5.1	2.6
C1, Mfd:	40.0	80.0	160.0*
C2, Mfd:	Try values from 0.5 to 4.0, depending on tweeter used		

* This is correct "formula" value. Results may be improved by lowering it to 100 to 130 mfd.

To carry the simplification process a step further, the tweeter network was revised radically, as shown in Fig. 4. However, this tweeter arrangement should be used with caution. As is apparent from this schematic, the middle range speaker carries everything from

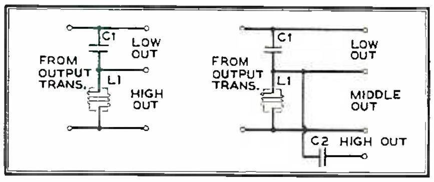


FIG. 3, LEFT: SIMPLIFIED NETWORK. FIG. 4, RIGHT: MODIFIED ARRANGEMENT FOR TWEETER

250 cycles on up. The highs are *not* filtered out. If the high-frequency response of the middle range speaker is poor, a conventional network should be used.

It must be borne in mind that the reflex design at this point is a first experiment. No doubt improvements can be made. Therefore, this article should be considered a starting point for the experimentally inclined. Since the design shown utilizes the basic Air-coupler without modification or damage, the experimenter can work with the reflex enclosure with a minimum of trouble.

Reports from readers on their experiences with this reflex design will be welcomed, together with suggestions for other mechanical arrangements.

COVERAGE ON 45-450 MC.

(Continued from page 26)

radii shown in Fig. 5 are the maximum values to be expected for a given separation, since they are based on co-channel interference only. The actual coverage radius may be less than shown if the signal level is insufficient to over-ride the noise at this distance. For optimum results, it is obvious that a proper balance is required between the limitations set by noise and those imposed by co-channel interference.

DESIGN DATA for AF AMPLIFIERS — No. 10 Cathode Followers

LOW INPUT AND OUTPUT IMPEDANCE OF A CATHODE FOLLOWER MAKES IT PARTICULARLY USEFUL WHEN FEEDING LONG TRANSMISSION LINES

TRANSMISSION lines at audio frequencies are almost always electrically short; that is, they are not appreciably long in comparison to the wavelengths involved. Thus, except in the case of long telephone lines, it is not necessary to consider characteristic impedance when determining line terminating impedances.

A practical short line can be considered as two closely-spaced wires, having low values of resistance and inductance but considerable shunt capacity. This shunt capacity can be seriously deleterious to high audio frequencies under two conditions:

1. Where the line is fed from a source of unusually high impedance, such as a photocell, or
2. Where the line is fed from a source of medium impedance but is long physically. Practical instances are found in recording studios, or in home audio installations where widely-separated units are connected to a common amplifier and speaker system.

If a line cannot conveniently be made shorter, the effect of the shunt capacity can be decreased only by decreasing the source impedance. Matching pads can be employed for this purpose. Unfortunately, a pad reduces the signal level as well as the source impedance, thus effectively reducing the signal-to-noise ratio at the output end of the line. Line-matching transformers have the same disadvantage.

In view of the serious limitations of these impedance-reducing devices, it is not surprising that the cathode-follower amplifier is becoming increasingly popular as a preamplifier output circuit. Many high-quality FM and TV tuners are now equipped with cathode-follower output stages.

The name of this unconventional amplifier is derived from the fact that the load is in the cathode circuit, as Fig. 1 shows. A positive swing of grid voltage causes an increase in cathode current, driving the cathode positive also. Thus, the cathode potential tends to follow that of the grid, reducing the effective grid-to-cathode signal.

Because of the heavy degeneration, the amplifier has extremely low shunt capacity across both input and output terminals. Consequently, it can be fed from a source of very high impedance with no high-frequency loss. Since the output impedance is low also, the circuit is suitable for feeding a transmission line many feet long.

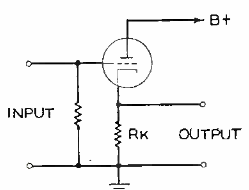


FIG. 1. SIMPLE CATHODE FOLLOWER CIRCUIT

Provision must be made for obtaining proper bias. The circuit of Fig. 2 is used extensively where a high value of cathode resistance must be employed.

Resistor R_1 should be as recommended in tube manuals for the tube employed. Triodes are generally used in cathode-follower circuits, since pentodes have greater shunt capacities and their higher gain capabilities cannot be utilized in any case.

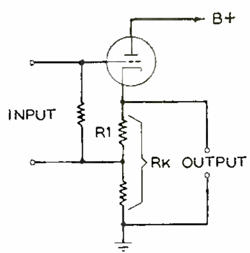


FIG. 2. PROVISION FOR PROPER BIAS

The voltage gain of a cathode follower is always less than one, although it can be made close to unity by proper choice of components. The formula for computing gain is given below:

$$A = \frac{M_U R_K}{R_P + R_K(M_U + 1)}$$

where A = voltage gain at cathode
Mu = amplification factor of tube
Rk = cathode load resistor
Rp = plate resistance

It is obvious that the gain is less than unity, and that it increases with higher values of load resistance and tube transconductance.

Output impedance, Zo, is computed as follows:

$$Z = \frac{R_K R_P}{R_P + R_K(M_U + 1)}$$

where symbols have the same meanings as above.

The effective output impedance is the parallel combination of the cathode resistor and the output impedance of the tube itself. Thus, the total can be varied, readily for low values of Zo by changing the size of the load resistor.

Recommended value for Zo is the range from 500 to 1,000 ohms. This represents a compromise between several factors. It requires a cathode resistor large enough so that reasonably good gain is obtained. It is low enough so that the shunt capacity of any but an unusually long line will not cause high-frequency losses. On the other hand, it is not so low that magnetic induction will become troublesome, nor the resistance of the line consume excessive power.

450-MC-MOBILE UNITS

(Continued from page 17)

ceiver, with a 450-mc. transmitter-receiver converter at the right. For transmission, the converter acts as a frequency tripler, while on reception it converts the incoming 450-mc. signals to 162 mc.

The output is rated at 15 watts. An automatic peak-modulation limiting circuit is employed to prevent excessive modulation swings.

An overall picture of the circuits is given by the tube types and their functions. In the transmitter, these are:

6AQ6	AF amplifier (peak modulation control)
7F7	Oscillator, phase modulator.
6AK5	Quadrupler
6AK5	First tripler
2E30	First doubler
2E30	Second doubler
2E24	Amplifier
AX9903	Second Tripler
AX9903	Output amplifier

As indicated by the receiver tube list, three IF frequencies are employed:

6J4	RF amplifier
1N21B	Mixer
6AH6	Harmonic oscillator-multiplier
6AK5	Tripler
6AK5	First IF, 150 mc.
6AK5	Mixer
6AH6	Harmonic oscillator-multiplier
7C7	Second IF, 5 mc.
7A8	Converter
7C7	Third IF, 456 mc.
7C7	First limiter
7C7	Second limiter
7A6	Discriminator
7F7	Noise amplifier, rectifier
7F7	AF amplifier, squelch
7B5	AF output

Operating on 6 volts, the battery drain of the mobile equipment is rated at 13 amperes standby, and 52 amperes during transmission. Fig. 1 shows the standard type of mobile roof-top antenna. This assembly has a standing-wave ratio of about 1.1 to 1.

A 4-watt fixed station transmitter and receiver assembly is illustrated in Fig. 2. The tube compliment is the same as for the mobile transmitter except that a single AX9903 is used as a tripler and output amplifier, and two 816 rectifiers are added for AC operation.

The 100-watt model, Figs. 3 and 4. uses one AX9903 as a tripler and another as an amplifier, followed by a 4X150A for the output.

For transmission, beacon-type antennas of conventional appearance offer the advantages of high gain and ease of mounting. Using 4 vertical half-wave dipoles, a gain of about 5 can be obtained over a single half-wave radiator. With 6 sections, the gain is increased to 8. Both types are matched to 50 ohms.

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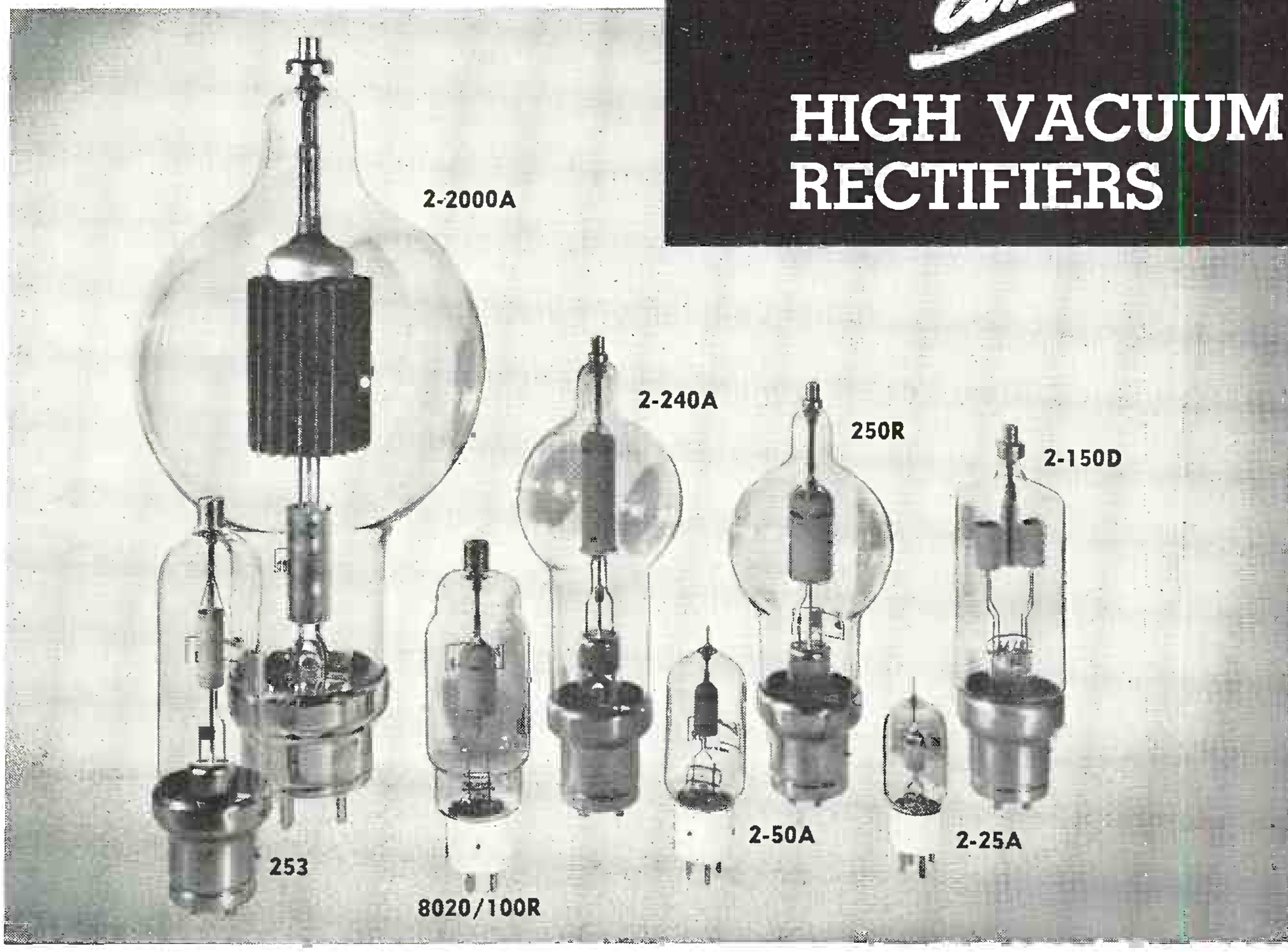
Eimac

HIGH VACUUM RECTIFIERS



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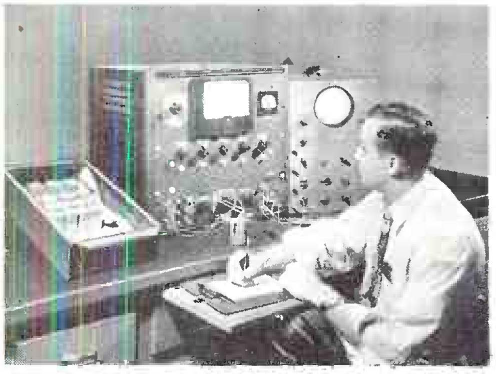
Export Agents: Frazar & Hansen, 301 Clay St., San Francisco, California

284

TYPE	DESCRIPTION	MAXIMUM DIMENSIONS Length inches	Diameter inches	AVERAGE PLATE CUR. Ma.	PLATE DISSIPATION Watts	PEAK INVERSE VOLTAGE Volts	FILAMENT Volts	Amps.
2-25A	High vacuum rectifier. High voltage, medium current. Instant heating, thoriated tungsten filament. Radiation cooled pyrovac plate.	4.5	1.5	50	15	25,000	6.3	3.0
2-50A	High vacuum rectifier. High voltage, medium current. Instant heating, thoriated tungsten filament. Radiation cooled pyrovac plate.	5.75	2	75	30	30,000	5.0	4.0
2-150D	High vacuum rectifier. High voltage medium current. Instant heating, thoriated tungsten filament. Radiation cooled pyrovac plate.	8.88	2.75	150	90	30,000	5.0	13.0
2-240A	High vacuum rectifier. High voltage, high current. Instant heating, thoriated tungsten filament. Radiation cooled pyrovac plate.	11.25	4	500	150	40,000	7.5	12.0
2-2000A	High vacuum rectifier. High voltage, high current. Instant heating, thoriated tungsten filament. Radiation cooled pyrovac plate.	18	8.25	750	1,200	75,000	10.0	25.0
250R	High vacuum rectifier. High voltage, medium current. Instant heating, thoriated tungsten filament. Radiation cooled pyrovac plate.	10.25	4	250	150	60,000	5.0	10.5
253	High vacuum rectifier. High current. Instant heating, thoriated tungsten filament. Radiation cooled pyrovac plate.	9	2.75	350	100	15,000	5.0	10.0
8020/100R	High vacuum rectifier. High voltage, medium current. Instant heating, thoriated tungsten filament. Radiation cooled pyrovac plate.	8	2.38	100	60	40,000	5.0	6.5

PRECISION IN PRODUCTION

Many people realize and take advantage of the fact that "the tough ones go to UTC." Many of these "tough ones," while requiring laboratory precision, are actually production in quantity. To take care of such special requirements, the UTC Laboratories have a special section which develops and produces production test equipment of laboratory accuracy. The few illustrations below indicate some of these tests as applied to a group of units used by one of our customers in one production item of equipment:



The component being checked here is a dual saturable reactor where the test and adjusting conditions necessitate uniformity of the complete *slope* of the saturation curve. The precision of this equipment permits measuring five widely separated points on the saturation curve with saturating DC controllable to .5% and inductance to .5%.

Servomechanisms and similar apparatus depend, to a considerable degree, on phase angle operation. The transformer adjusted in this operation requires an accuracy of .05 degrees phase angle calibration under the resonant condition of application. With wide change in voltage and temperature range from —40 to +85 degrees C., the phase angle deviation cannot exceed .2 degree. To effect this type of stability, specific temperature cycling and aging methods have been developed so that permanent stability is effected.

This test position involves two practical problems in a precision inductor. The unit shown is adjusted to an inductance accuracy of .3%, with precise (high) Q limits. It is then oriented in its case, using a test setup which simulates the actual final equipment so that minimum inductive coupling will result when installed in the final equipment.

The hermetic sealing of transformers involves considerable precision in manufacturing processes and materials. To assure consistent performance, continuous sampling of production is run through fully automatic temperature and humidity cycling apparatus. It is this type of continual production check that brings the bulk of hermetic sealed transformers to UTC.

United Transformer Co.

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