PRICE—TWENTY-FIVE CENTS

# FM AND TELEVISION

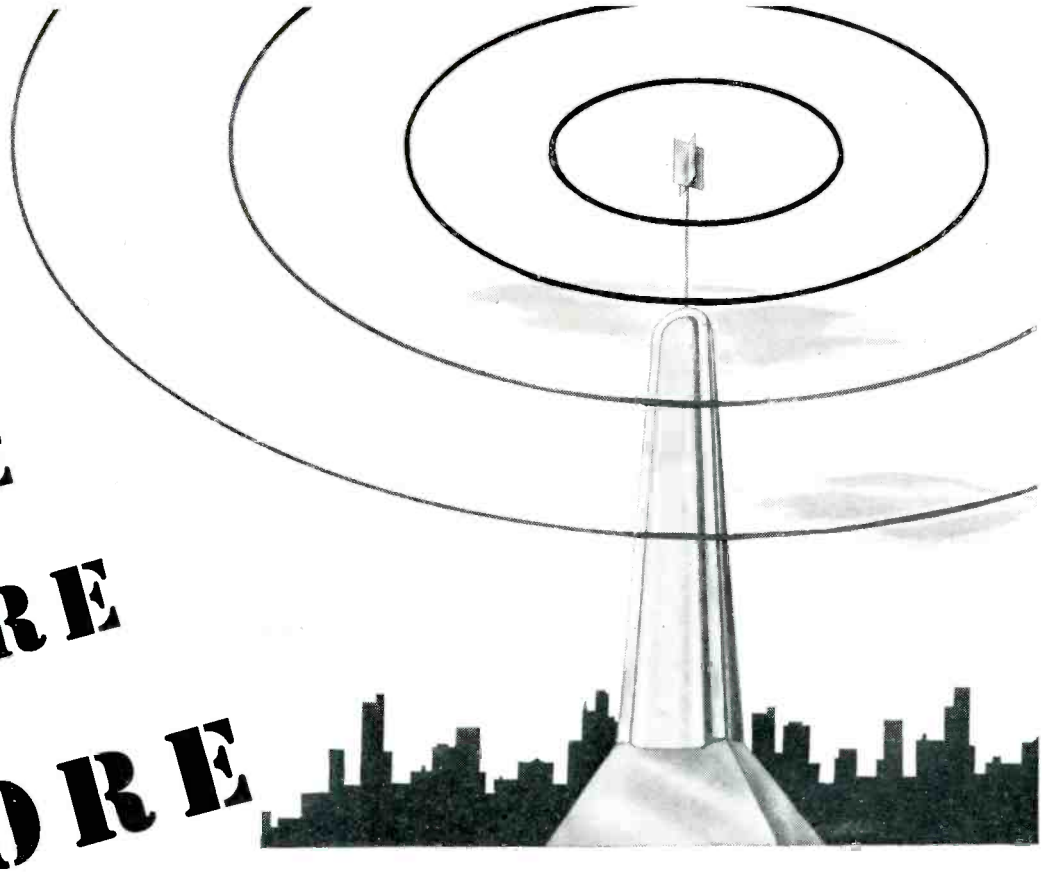
NOV. 1945

FINAL FM ENGINEERING MODEL GETS LAST CHECK

SEE PAGE 3

Directory of Manufacturers

★ ★ Edited by Milton B. Sleeper ★ ★



# MORE MORE MORE

## TELEVISION "Know How" THAN ANY OTHER COMPANY!

DuMont engineers have designed and built more television stations than any other organization...are now completing the world's first "Television City" in New York.

During more than four years of operational trail-blazing, DuMont equipment design has been steadily improved to keep pace with increasingly elaborate programming experimentation. Today, DuMont design boasts incomparably simplified precision controls...provides high efficiency, extreme flexibility and rugged dependability at *low operating cost.*

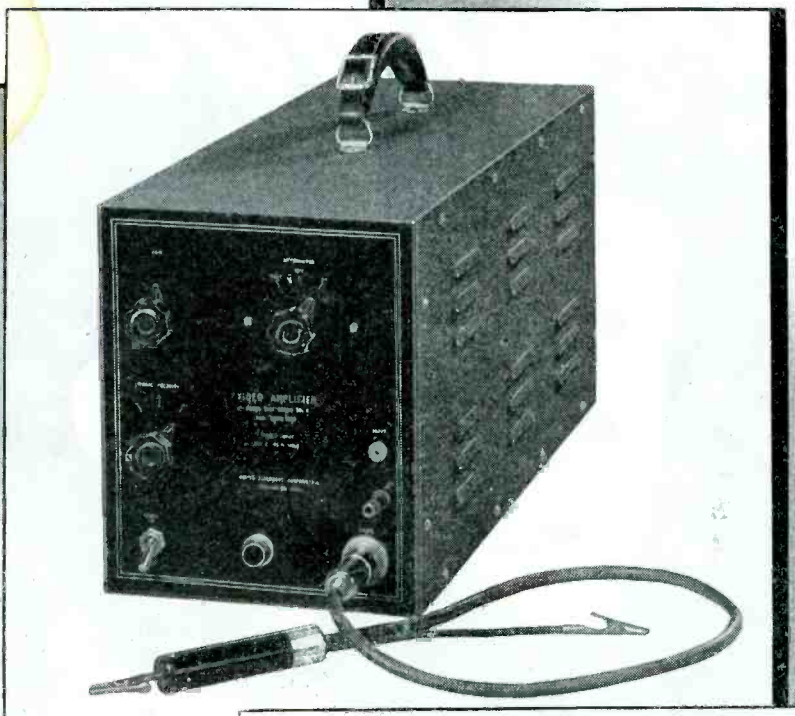
DuMont experience assures the finest craftsmanship for the least outlay...offers a pattern of station operation for your study and a plan for training your personnel...starts you off in television on the right foot!



DUMONT *Precision Electronics and Television*

ALLEN B. DuMONT LABORATORIES, INC., GENERAL OFFICES AND PLANT, 2 MAIN AVENUE, PASSAIC, N. J.
TELEVISION STUDIOS AND STATION WABD, 515 MADISON AVENUE, NEW YORK 22, NEW YORK

# . . . it's New!



## FOR TELEVISION RADAR AND FAC-SIMILE

# Wide Band VIDEO AMPLIFIER

Designed primarily for use in amplifying complex waves to be viewed on an oscilloscope, this instrument is also extremely useful in laboratory work as an audio amplifier for tracing and measuring small R. F. Voltages, (as in the early stages of radio receivers,) and many similar applications.

## Specifications

BAND WIDTH: Frequency response is flat within 1.5 DB of the 10 KC response from 15 cycles, to 4 megacycles and 3 DB from 10 cycles to 4.5 megacycles. Phase shift is controlled to provide satisfactory reproduction of pulses on the order of one micro-second, and square waves at repetition rates as low as 100 per second.

GAIN: The gain is approximately 1000 when direct input is used. Use of probe input introduces an attenuation of approximately 10:1.

INPUT is normally through a probe (furnished with the equipment), which has an input circuit consisting of a 1.1 megohm resistance in parallel with approximately 18 mmfd. The amplifier direct input (without probe) is approximately 2.2. megohms of resistance in parallel with 40 mmfd.

OUTPUT voltage can be adjusted from zero to 50 volts R.M.S. with a sine wave signal.

LOAD IMPEDANCE: Designed to work into a load of not more than 22 mmfd.

RIPPLE OUTPUT is less than 0.5 volt for all operating conditions and all positions of gain control.

CIRCUIT FEATURES: A cathode follower input stage provides circuit isolation and is equipped with a 3-position attenuator.

Attenuator ratios are 1:1, 10:1 and 100:1 (This is in addition to probe attenuation). A gain control conveniently varies the video output. A "Signal Polarity" switch is provided which carries the cathode bias on the output stage in such a manner that the amplifier may be adjusted for optimum performance, regardless of the polarity of the input signal.

OPERATING VOLTAGE: 110 to 120 volts, 60 cycles.

POWER CONSUMPTION: 100 watts.

WEIGHT: 35 pounds (Complete with tubes and probe).

WIDTH: 7¾" HEIGHT: 9" LENGTH: 20¾"

*INQUIRE EARLY TO INSURE PROMPT DELIVERY*

# UNITED CINEPHONE CORPORATION

***Designers, Engineers and Manufacturers of Electronic Products***

34 NEW LITCHFIELD STREET TORRINGTON, CONNECTICUT

# FM AND TELEVISION

FORMERLY: FM RADIO-ELECTRONICS

VOL. 5 NOVEMBER, 1945 NO. 11

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### THIS MONTH'S COVER

NEITHER the OPA nor the AFM is delaying the completion of final designs for new FM-AM broadcast receivers. Despite reports of plans to put only one FM band in these sets, latest information is that all sets, when they reach dealers' stores, will tune both the old and new FM frequencies. Such plans have received encouragement from FCC's announcement that the final decision on old-band transmission will be postponed, pending further propagation tests. This month's cover shows William F. Cotter, chief radio engineer of Stromberg-Carlson, giving a final FM-AM engineering model its last check before releasing it to the factory for production.



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# WHAT'S NEW THIS MONTH

1. Economics of FM
2. CIO-PAC Petition

1 There are good reasons to believe that the Zenith report on the superiority of old-band FM broadcasting over new-band service portrays propagation characteristics accurately over the test range of 76 miles. FCC engineering prestige is at too low an ebb for its unsupported contradiction of the Zenith report to carry much weight.

The quantitative examination of performance in the two bands is an important contribution to a subject too long neglected. However, its principal value lies not in determining which band should be used for FM broadcasting, but rather in deciding upon the best distribution of FM broadcasting services in both bands!

For the truth is that FM broadcasting needs both bands to deliver the nation-wide service which, as the Commission has stated, it is under statutory obligation to provide.

Here the FCC is confronted with not merely an engineering problem, but very practical questions of public interest, convenience, and necessity which involve both the economics of FM broadcasting and a conflict with existing competitive conditions in the business of broadcasting. In its actions so far, the FCC has considered the engineering aspects, and on that basis has undertaken to apply its findings in such a way as to appease the very apprehensive networks officials.

However, when present plans are applied to nation-wide service for radio listeners, they are found to be impractical because they are not sound economically. Efforts to correct this situation seem to involve the use of both the old and the new FM bands. This should have been determined long ago by RTPB, and by the FMBI before the allocations hearings ever started. Unfortunately, the RTPB FM panel included so many definitely anti-FM members that it was a tribute to C. M. Jansky, Jr., that the Panel ever arrived at the point of submitting a final report. As for the FMBI, their preparations for the hearings were totally inadequate, as subsequent circumstances have indicated.

A re-examination of these circumstances, in the light of the economics of nation-wide FM service, discloses some very interesting facts.

It has been established that the primary day-and-night coverage of a 50-kw. FM

(CONTINUED ON PAGE 93)

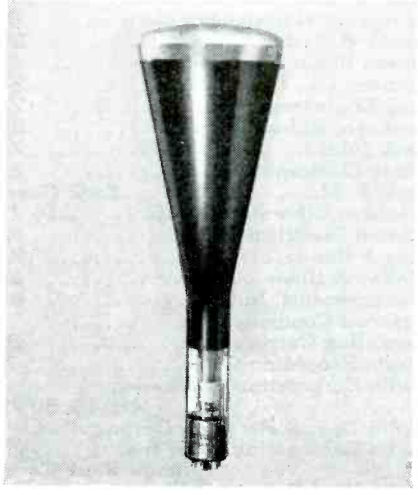
# SYLVANIA NEWS

ELECTRONIC EQUIPMENT EDITION

NOV. *Published by* SYLVANIA ELECTRIC PRODUCTS INC., Emporium, Pa. 1945


# RADIO AND ELECTRONIC EQUIPMENT MAKERS GETTING SET FOR FULL-SCALE PRODUCTION

## *Will Receive Highest Quality Tubes From Sylvania Electric To Meet Pent-Up Demand*



### CATHODE RAY TUBES

With the period of reconversion taking active form and spreading over the nation, the radio industry is looking forward to what promises to be one of the most expansive developments in its history. Millions wait for radio sets of improved design and, consequently, of more complex construction. Industries will turn to greater use of electronic equipment.

Manufacturers are rapidly getting set for full-scale production to meet this pent-up demand. Of course, in radio there's the problem of obtaining an adequate supply of component parts.

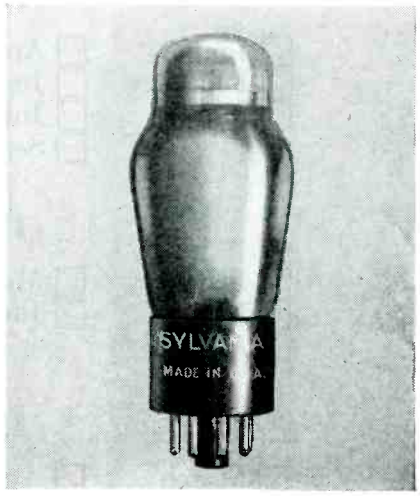
However, as far as dependable, pre-


### LOCK-IN RADIO TUBES

cision-built radio tubes are concerned, set makers are assured of receiving the benefits of Sylvania's more than 40 years' research experience and wide-scale production facilities. Note this list:

Television—experience in design and the production of untold thousands of Sylvania Cathode Ray Tubes for war requirements has contributed greatly to peace-time applications.

High frequency sets (FM, Television)—the Sylvania Lock-In Tube is so electrically and mechanically perfect in construction that it can handle




### "GLASS" RADIO TUBES

ultra-high frequencies with ease. Besides, it is more than perfectly suitable for *all* types of radio sets.

Radio—manufacture and distribution of the famous high quality Sylvania lock-in "Glass" and miniature tubes will continue to satisfy the exacting circuit requirements of modern radio receivers.

Electronic devices—the same laboratory and manufacturing resources that served our government so well, are now available to the manufacturer of electronic devices of every description.

# SYLVANIA ELECTRIC

*Emporium, Pa.*

MAKERS OF RADIO TUBES; CATHODE RAY TUBES; ELECTRONIC DEVICES; FLUORESCENT LAMPS, FIXTURES, WIRING DEVICES; ELECTRIC LIGHT BULBS

# Valuable Reference Data

*in these back issues of*

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*FM* AND TELEVISION

Great Barrington, Massachusetts

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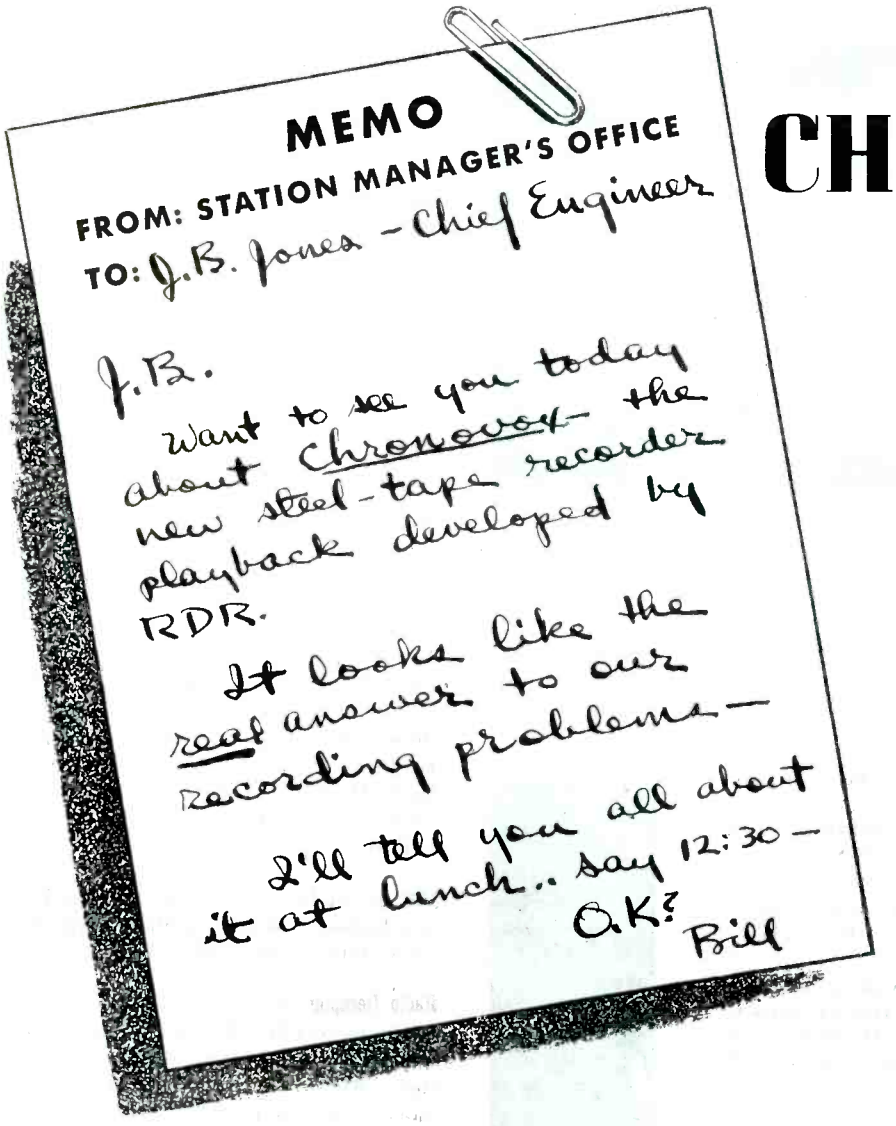
# Making Steel Talk with CHRONOVOX




## Know these Facts about Chronovox!

- The cost of discs is eliminated!
- The steel tape is permanent . . . indestructible!
- Recordings are erased at will!
- Surface noise lower than any other method of recording!
- Recordings reproduce indefinitely with less than 3DB attenuation!
- It's a complete, self-contained unit!
- Plugs in any 110 volt AC source!
- For a permanent record, "dub" from the final—perfect —Chronovox impression to your disc recorder!

Yes, memos like this one are being written daily. Radio executives KNOW that Chronovox will solve many of their recording problems. The RDR Chronovox is a precision instrument employing an improved method of recording sound on an indestructible steel tape. Recordings are made magnetically not physically—and the Chronovox will repeat the last recording indefinitely or until a new one is made.


FOR MORE INFORMATION — CONTACT:

## RADIO DEVELOPMENT & RESEARCH CORP.

233 WEST 54TH STREET NEW YORK 19, N. Y.

AFFILIATE: TRANSFORMER PRODUCTS, INC.
143 W. 51st Street, N. Y. C.

MIAMI: SALES—SERVICE
1415 N. E. 2nd Ave., Miami, Fla.

# ENGINEERING SALES

**Electronic Laboratories:** After a two-year absence, Herbert Jenkins is back at Electronic Laboratories in charge of sales to manufacturers.

**Westinghouse:** Has set up a new retail finance division under the management of Chester F. Gilbert, to implement dealers' installment sales.

**Hollywood:** Robert Browning has joined Norman B. Neely Enterprises as special field engineer. Formerly radar field engineer for Western Electric, he was previously audio equipment design engineer for RCA.

**Scott:** Has abandoned prewar mail-order sales and will distribute through exclusive franchised dealers. Already appointed are May's Music Co., Albuquerque; Grinnell Brothers, Battle Creek; Len Walter's Music Store, Butte; Wells Music Co., Casper; Woodrum's Home Outfitting Co., Charleston, W. Va.; Andrews Music Co., Charlotte; Fowler Brothers Furniture Co., Chattanooga; Wells Music Co., Cheyenne; Heims, Danbury, Conn.; Brander's Music Shop, Duluth.

**Lear:** Radio line will be distributed in Utah and Idaho by Mountain States Distributing Company, Salt Lake City.

**Radio Receptor:** Sales manager of their new selenium rectifier division is Julian Loebenstein, recently shifted from the factory, where he has been production manager for the past four years.

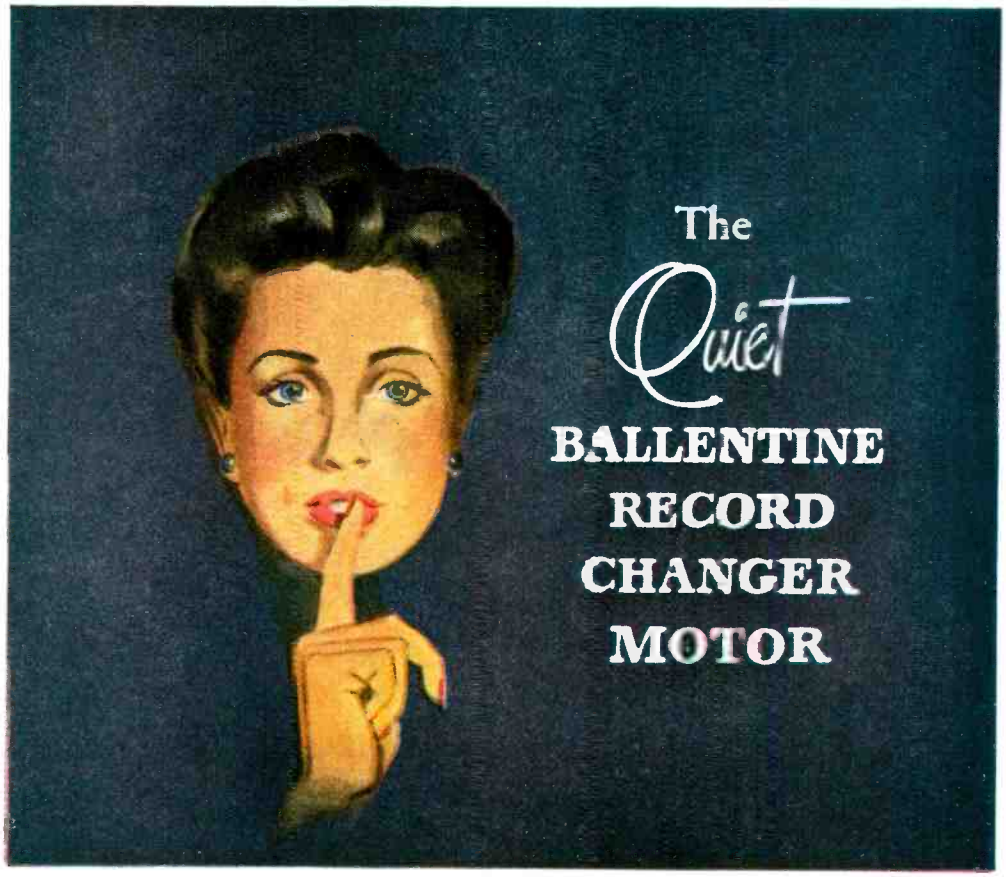
**RCA:** General sales manager of the home instrument division (home radio and television receivers and phonographs) is now Henry G. Baker, previously general purchasing director for RCA Victor. He will have complete charge of sales, advertising, and promotional activities.

**Philco:** L. Robert Evans, former manager of Utah's international division, has been appointed Philco International regional manager for Brazil.

**Westinghouse:** New manager of Southern California district home radio sales is E. W. Isenhower, for the past 11 years with Westinghouse Electric Supply Co.

**Meissner:** Has appointed Herbert G. Arcadius as district manager of radio-phono-

(CONCLUDED ON PAGE 64)




# The *Quiet Ballentine* Changer Motor

has these four characteristics achieved by advanced design, skilled engineering and precision manufacturing

- Lowest Rumble
- Highest Efficiency
- Most Compact Design
- Longest Life

The *Quiet Ballentine* Changer Motor is recommended to record changer manufacturers seeking to provide the ultimate in performance.

**RUSSELL ELECTRIC COMPANY**

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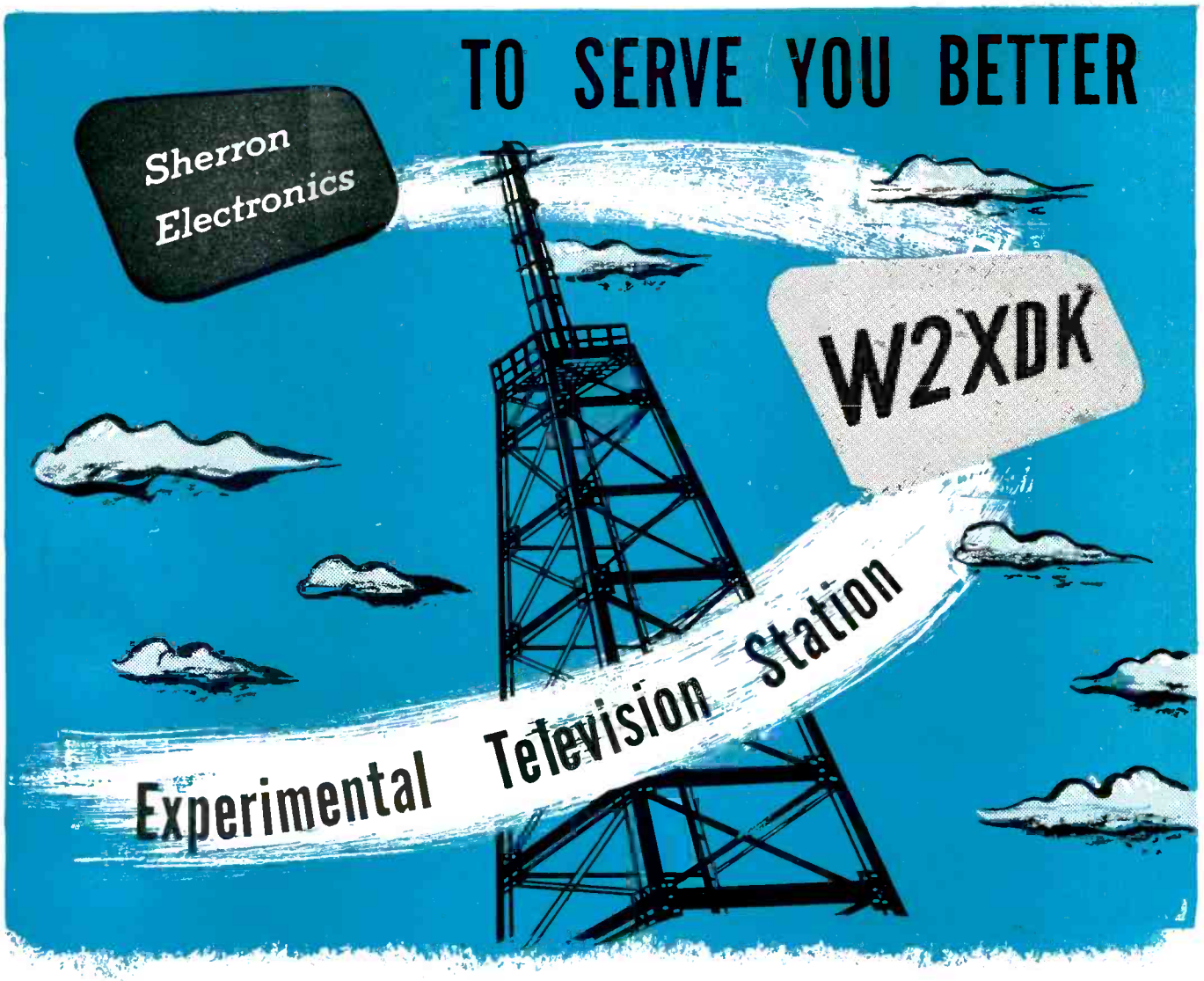
*Manufacturers of* **BALLENTINE RECORD CHANGER MOTOR**




A big step forward in our program of service to the television industry is the construction permit recently granted us by the Federal Communications Commission for an experimental television station. . . . We view this latest project of ours as an opportunity to study television's thorny problems first-hand, and to pass on the benefits of our findings to the manufacturers with whom we do business. It is our aim to demonstrate in the field of television the same "know-how" that distinguishes our engineering and manufacturing of custom-built electronic equipment. . . . As an engineering service and manufacturing organization, we are prepared to work with you in the development and design of the following to your specifications:

- TELEVISION TRANSMITTING . . . Video and Audio
- STUDIO CONTROL DESK . . . Exclusive Control for Technical Direction
- MASTER CONTROL BOARD . . . 5 Available Video Channels
- TRANSMITTER CONTROL DESK . . . Featuring Operation Controls for Both Video and Audio

Sherron Electronics

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*Division of Sherron Metallic Corporation*

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**"Where The Ideal Is The Standard, Sherron Units Are Standard Equipment"**

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To do your job and do it right, you need cable with certain characteristics. Three or four or more factors—heat resistance, dielectric strength, flexibility and durability, for instance—must be satisfied in the *one* cable. You *can* settle for less—but when a cable fails, it's *your reputation* that suffers.

At Ansonia, electrical cable is engineered to meet *all* necessary requirements as far as that is possible. And, thanks to ANKOSEAL, a remarkable thermoplastic insulation, our engineers are usually able to combine in one cable all the qualities you need.

Simply tell us what you *want* in a cable—we'll design and produce it. It won't be the cheapest cable—but *it will be right!* The difference will result in longer life and better performance.

We'll be glad to describe in detail what Ansonia can offer you in the form of *job-engineered* cable. Write now for fuller information.

### *Why* ANKOSEAL *solves cable problems*

Ankoseal, a thermoplastic insulation, can help solve many electrical engineering problems, now and in the future. *Polyvinyl* Ankoseal possesses notable flame-retarding and oil resisting characteristics; is highly resistant to acids, alkalies, sunlight, moisture, and most solvents. Polyethylene Ankoseal is outstanding for its low dielectric loss in high-frequency transmission. Both have many uses, particularly in the radio and audio fields. Ankoseal cables are the result of extensive laboratory research at Ansonia—the same laboratories apply engineering technique in the solution of cable problems of all types.

**THE ANSONIA ELECTRICAL COMPANY**

*Specializing in "Ankoseal" a Thermoplastic Insulation*

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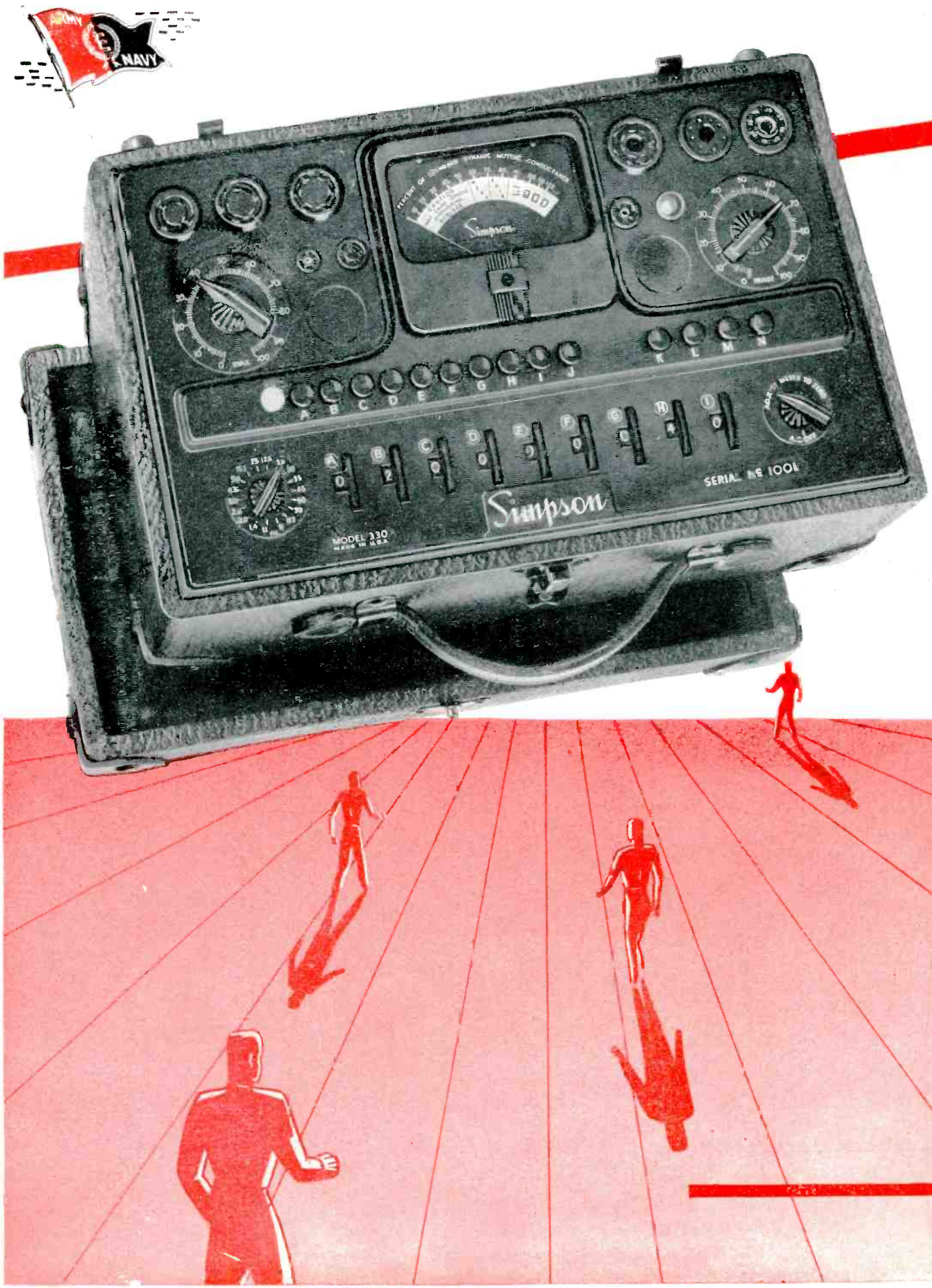

ARMY
NAVY
Simpson
MODEL 330
SERIAL NO 1001

# With this instrument a new era in tube testing begins

## . . . Remember . . .

As you read below the many other features of this pioneering instrument, remember this: It is a Simpson instrument, with all that implies in creative engineering research, in controlled testing and manufacture. Simpson products are not "assembled", they are engineered and built in the Simpson plant. Practically every component part, from the dial and movement to the beautifully designed panels and the bakelite cases and panels, is made by Simpson. It is this that makes Simpson's the "instruments that *stay* accurate" with ideas that *stay* ahead.

### SIMPSON MODEL 330 MUTUAL CONDUCTANCE TUBE TESTER

1. Size—15½" x 9½" x 6½".
2. Case—Sturdy plywood construction, with heavy fabricoid covering, corners trimmed in leather, rustproof hardware—removable cover with slip type hinges.
3. Panel—Heavy molded bakelite, beautiful satin grained finish. All characters, numerals, and dial divisions are engraved and filled in white, insuring long wearing qualities.
4. Meter—4½" rectangular of modern design with artistic four-colored dial indicating good, fair, doubtful, and bad—also "Percentage of Mutual Conductance" scale.
5. Sockets provided for all types of tubes with two spare socket positions.
6. Neon glow tube incorporated to indicate shorted tubes.
7. New simplified revolutionary switching arrangement (see description above).
8. The tube chart provided is arranged for quickly identifying the tube and setting the controls.
9. Tests tubes with voltage applied automatically over the entire operating range and under conditions approximating actual operation in a radio set.

***Ask Your Jobber***

## The New Simpson Mutual Conductance Tube Tester Brings To Radio Servicemen and Dealers An Entirely New Method of Testing Tubes And A Revolutionary New Switching Arrangement!

Tube manufacturers consider that a radio tube has reached the end of its usable life when it falls to 70% of its rated value. Until now there has never been an instrument to test tubes in percentage terms.

But now here *is* such an instrument. The new Simpson Model 330 tests tubes in terms of percentage of rated dynamic mutual conductance—a comparison of the tube under test against the standard rated micromho value of that tube. The colored zones on the dial coincide with the micromho rating or the percent of mutual conductance, indicating that the tube is good, fair, doubtful or definitely bad. Thus, at a glance, you can check the tube against manufacturers' ratings. If, for any reason, it becomes desirable to know the actual value in micromhos, the percentage reading may be easily converted.

This is the way tubes should be tested—the way testers always should have worked—but Simpson is first again in bringing this needed development. It tests tubes with voltage applied automatically over the entire operating range, reproducing more completely than ever before the actual conditions under which a tube functions in a radio set. No instrument, not even delicately adjusted laboratory devices, can do this 100%. But this new Simpson Mutual Conductance Tester approaches perfection as never before.

Besides this revolutionary new method, Simpson offers you an equally revolutionary switching arrangement. The circuit is so arranged that, even though there are numerous combinations possible, very few switches require moving to test any one tube. Many of the popular tubes are tested in the "normal" position without moving any of the nine tube circuit switches.

Ten push button switches and nine rotating switches of six positions each provide infinite combinations in tube element and circuit selection. Only a few settings are necessary for the most complicated tube. The tube chart provided is arranged for quickly identifying the tube and setting the controls.

When you have finished a tube test, the Automatic Reset takes over to speed and simplify the next test. Just press the reset button and instantly all switches, both push button and rotary, return to normal automatically!

Here is the test instrument you have had a right to expect from Simpson. With greater flexibility in its circuit and switching arrangement than any other tester can provide, it gives maximum provision against obsolescence. It's the tester of a new era.

SIMPSON ELECTRIC COMPANY
5216 W. KINZIE ST., CHICAGO 44, ILLINOIS

Simpson

INSTRUMENTS THAT STAY ACCURATE

***WATCH FOR OTHER SIMPSON DEVELOPMENTS . . . THEY ARE EQUALLY WORTH WAITING FOR***

# FM does it

## with *triple* the tone range

## to bring new program brilliance to your listeners


In the range of tone from low to high, a present-day AM broadcast system reproduces the values of tone from approximately 100 to 5,000 vibrations per second. Compare this range with that of an FM broadcast system which is capable of reproducing *all values of tone from 50 to 15,000 vibrations per second*—a range that matches the ability of the normal ear to hear! Within this extended range provided by FM is ample room for all the highs and all the lows of natural sound. Here is space for the vital lacework of overtones that gives sound its "natural color"—that enables the listener to distinguish the piano from the banjo, the oboe from the flute, each voice and instrument from all others.

Nor are these values lost in the FM broadcast receiver. Here each tone and overtone is clearly heard against a background of silence, for FM does away with background noise that normally masks AM reception, particularly at low sound levels. Each crescendo reaches its true value, for an FM receiver is designed to handle without distortion the entire range of sound intensities from the softest whisper to the swell of the full concert orchestra.

FM gives broadcasting "natural-color" reception. To your audience this means fuller program enjoyment. To you, this means stimulated audience interest and improved service to your advertisers.

When you plan your FM station make full use of General Electric's vast background of experience in the FM field. G.E. is the one radio manufacturer with experience in designing and building complete FM broadcast systems—from transmitters to receivers. G.E. has designed and built more FM broadcast transmitters than any other manufacturer. G.E. built the first FM home receivers and has furnished a large percentage of the half million now in use. Today, the six studio-transmitter FM relay links now operating in the 340-megacycle band are all G.E.—with thousands of hours of regular operation to their credit. And at Schenectady, G.E. operates its own FM proving-ground station, WGFM. For information on General Electric FM broadcast equipment, write *Electronics Department, General Electric Company, Schenectady 5, N. Y.*

***AM** brings listeners only one-third the range of tone the ear can hear. Many tones and overtones are missing. Realism is lost.*

STUDIO AND STATION EQUIPMENT • TRANSMITTERS

**GENERAL ELECTRIC**

160 D3-6914


**FM** *FM broadcasting brings listeners all the tones and overtones the ear can hear. Reproduction is true and natural.*

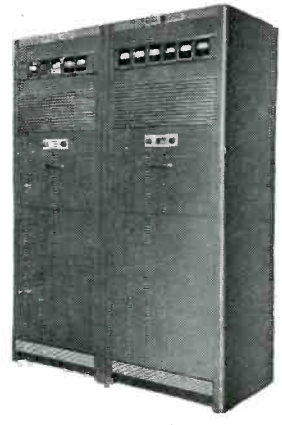
**50 FM BROADCAST STATIONS ARE ON THE AIR: OVER 400 APPLICATIONS ARE PENDING**

FM DOES IT—

- FM gives your audience programs with virtually no man-made *noise* or *static.*
- FM multiplies your effective *coverage* day and night
- FM minimizes station *interference.*
- FM gives programs vivid naturalness with greater *dynamic sound range.*
- FM gives your programs truer realism with triple the *tone range.*
- FM contributes to the *economy* of your broadcast system.

For earliest possible delivery of your broadcast equipment, place your order now.

**Use G-E Electronic Tubes in your station for maximum dependability and finer performance.**



*The G-E 1,000-watt FM transmitter*

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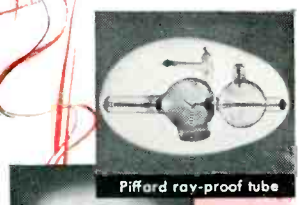
# AM • TELEVISION • FM

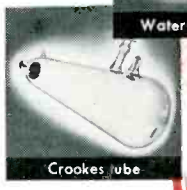
*See G.E. for all three!*

# 50 YEARS OF X-RAYS

# 48 YEARS OF MACHLETT ELECTRON TUBES







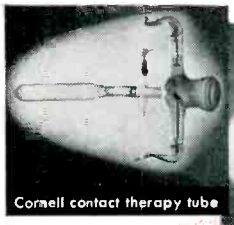

## X-RAY HISTORY IS

IT WAS 50 YEARS AGO, on November 8, 1895, that scientific investigation led Roentgen to the discovery of X-rays. In this semi-centennial year we honor his work, and the work of the pioneers who, sometimes at the sacrifice of their own lives, developed the theory and practice of a science that today means so much to all mankind.

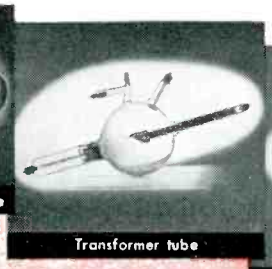
Very soon after Roentgen publicly announced his discovery in 1896, Robert H. Machlett made the first practical American X-ray tube. Quickly he improved his techniques, creating a whole series of "firsts" such as the first ray-proof tube, the first cooled by water, the first for contact therapy. The organization he founded carries on his principle of constant research, improvement and initiative, and has many other firsts to its credit, culminating in the amazing and unique 2,000,000-volt, direct current, sealed-off, precision X-ray tube.

To a large extent, X-ray history is Machlett history, a history of service to mankind. Today, Machlett tubes are in use by doctors, hospitals, laboratories and factories in many parts of the world, saving lives, inspecting products, performing delicate analyses, expanding man's knowledge, serving with unmatched exactitude and economy. For the future, Machlett's talents will create other and still more valuable applications, for Machlett never stands still, is always creative, improving its tubes, developing new ones for old and new services.

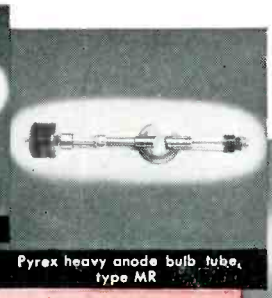
In addition to X-ray tubes for all purposes, we also make oscillators, amplifiers and rectifiers for radio and industrial uses, all to the same high (and unmatched) standards to which our X-ray tubes are held. It will pay you to buy Machlett tubes. For information as to the available types, write Machlett Laboratories, Inc., Springdale, Connecticut.



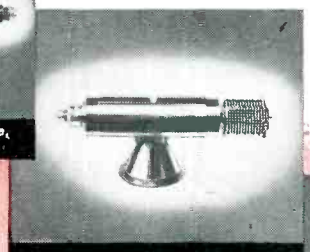
Cornell contact therapy tube



Transformer tube



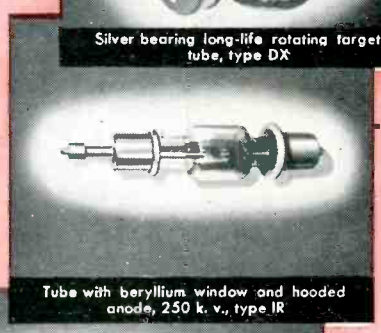
Pyrex heavy anode bulb tube, type MR



Compact ray-proof tube, type CYR

Small shockproof tube, type CYS

Silver bearing long-life rotating target tube, type DX



Tube with beryllium window and hooded anode, 250 k. v., type IR

Tube with vacuum-tight beryllium window in envelope—the Diffraction Tube

# first MACHLETT HISTORY!

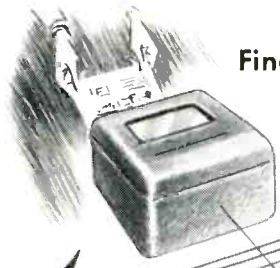
## From the Beginning

"When in 1895 Professor Roentgen announced his discovery, Machlett was immediately interested and began experiments to reproduce the results of Roentgen. He was ideally equipped for such work, for just at that time he had perfected a mercury pump capable of producing a very high vacuum. He attacked the difficult task and before many days had passed, succeeded in producing the first X-ray tube in this country."—I. S. Hirsch, *Radiology* 8:254, 1927.

2,000,000 volt direct current precision radiographic tube, type VM

MACHLETT

APPLIES TO RADIO AND INDUSTRIAL USES ITS 48 YEARS OF ELECTRON-TUBE EXPERIENCE



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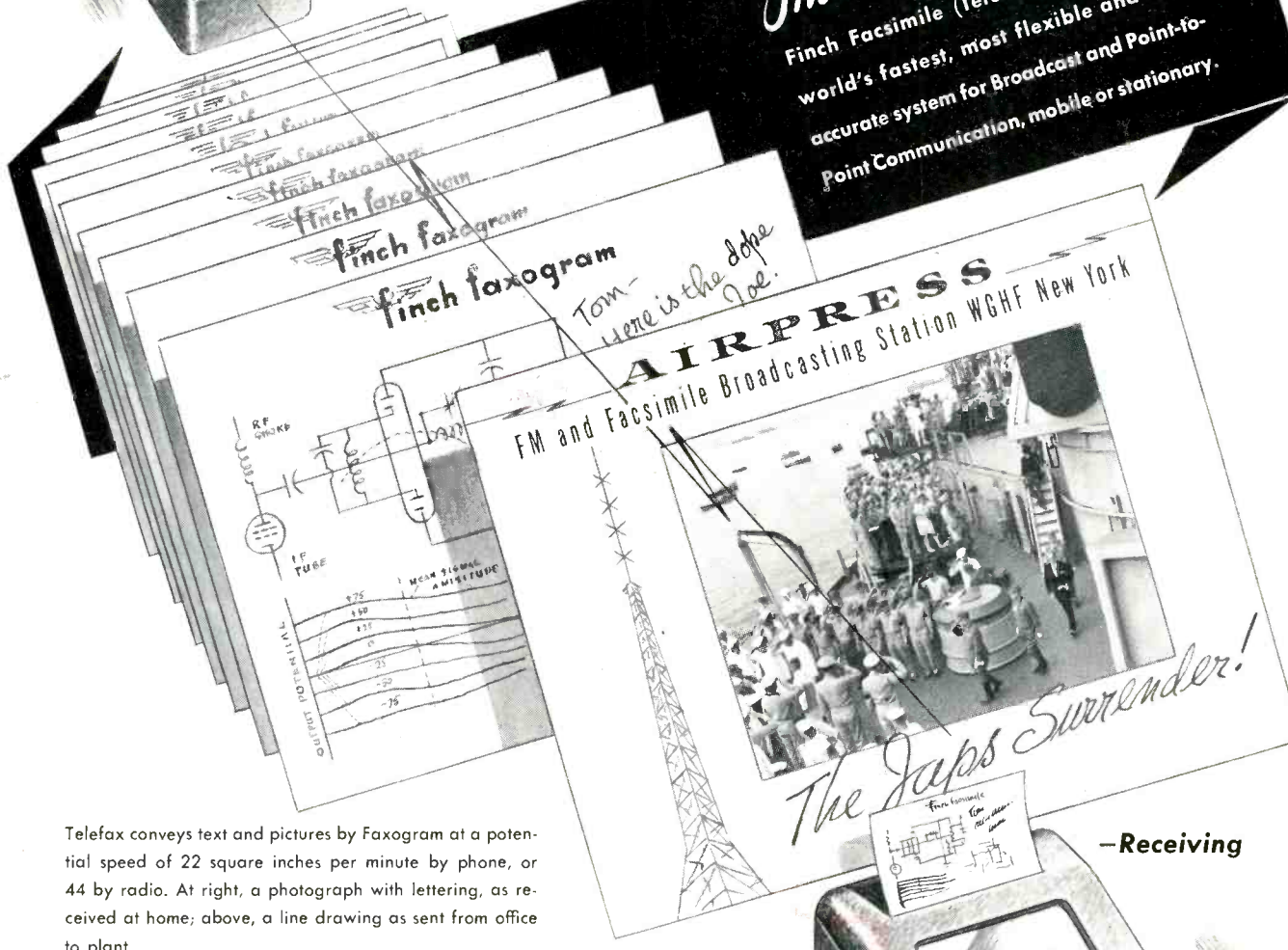


Telefax conveys text and pictures by Faxogram at a potential speed of 22 square inches per minute by phone, or 44 by radio. At right, a photograph with lettering, as received at home; above, a line drawing as sent from office to plant.

***—Receiving***


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# Stromberg-Carlsons

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A WHOLE *new* line of Stromberg-Carlsons—and just wait till you see and hear them! *New* in their engineering. *New* in their cabinet designs. *New* in their price range. *New* in their broader scope of models. They'll give new meaning to the old saying, "There is nothing finer than a Stromberg-Carlson!"

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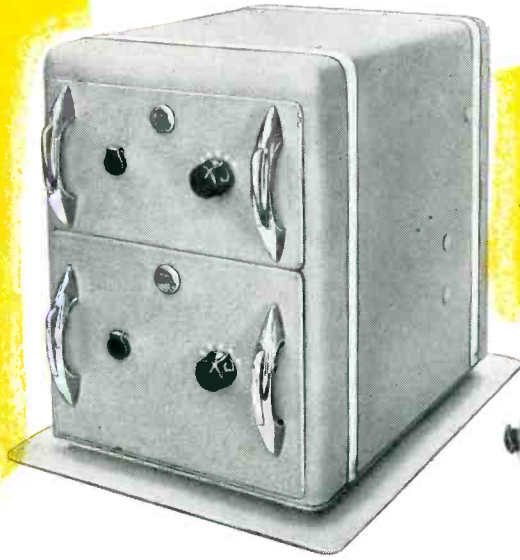

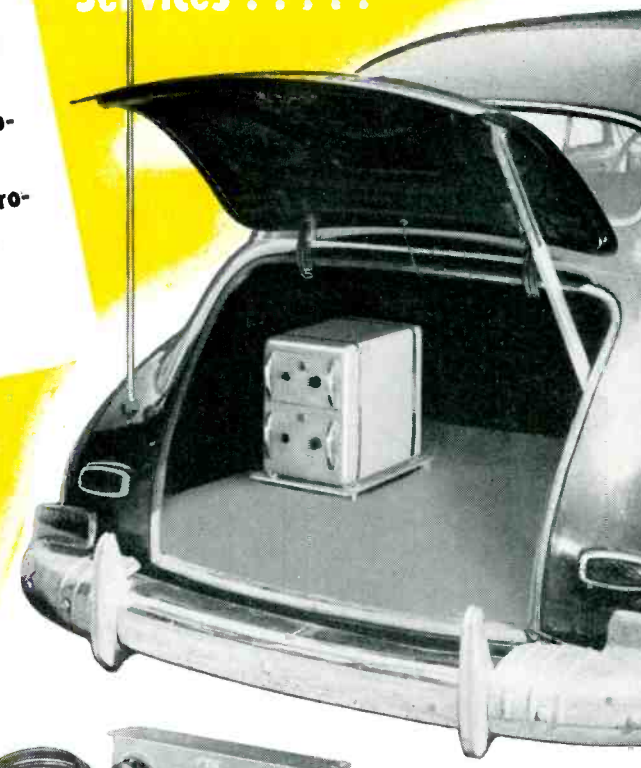

Here is mobile radio equipment built to "specifications" provided by the field, fundamentally different in design to meet the particular demands and solve the difficult problems of users of this type of installation. Backed by Federal's long experience and leadership in radio, this equipment incorporates rugged compactness, greater ease of operation, real economy, unrivalled dependability and total satisfaction. Its exclusive "Selecto-Call" and its many other unique features, makes it the outstanding equipment for police, fire, forestry, conservation, taxi and bus dispatching and all other emergency services. Write for information.

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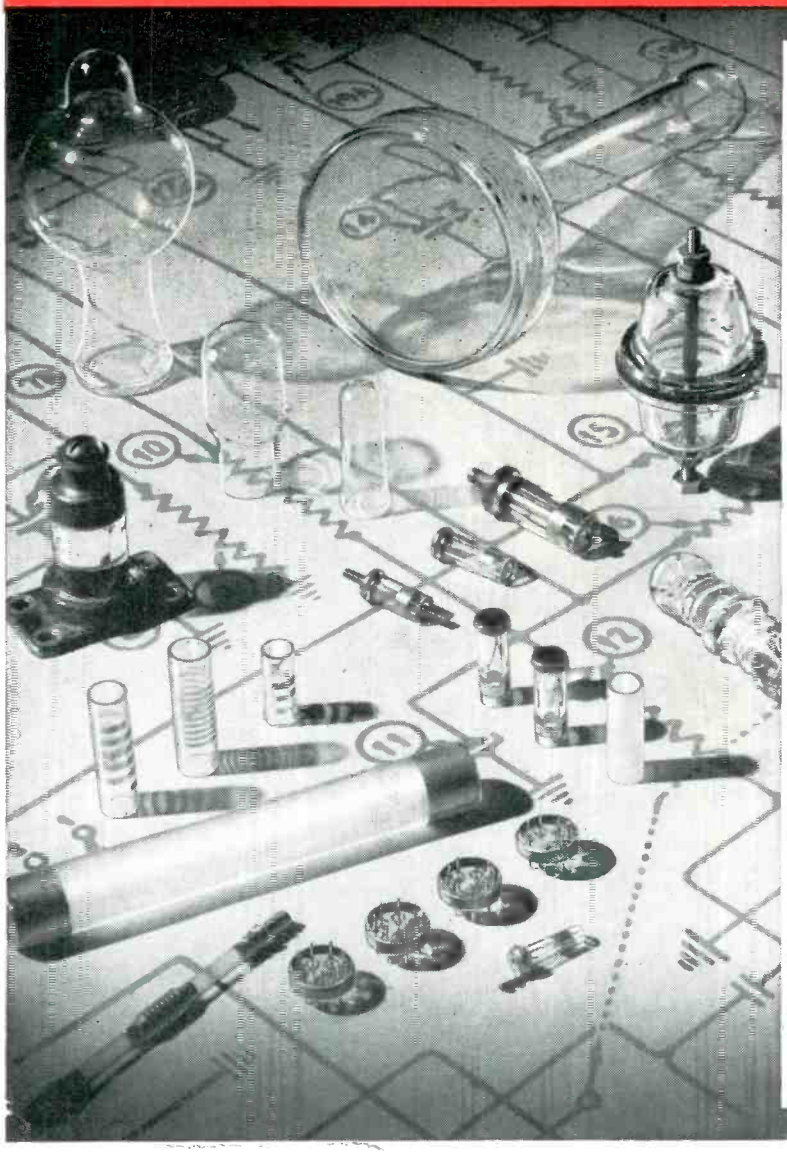
## CORNING GLASS GIVES YOU



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High dielectric strength — high resistivity—low power factor—wide range of dielectric constants—low losses at all frequencies.

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AS YOU plan post-war electronic products, give a thought to versatile glass. We really mean glasses, for Corning has, at its fingertips, 25,000 different glass formulae from which to select those especially suited to your electronic applications. Let us show what glass can do for you. We may already have a solution — or Corning Research can find the answer for you. Phone Corning 2852 or wire Electronic Sales Dept., F-11, Bulb and Tubing Division, Corning Glass Works, Corning, New York. We'll have a man on the job promptly.

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DIVISION OF BENDIX AVIATION CORPORATION

BALTIMORE 4, MARYLAND

August 3,1945

Mr. M. B. Kahn
Transmitter Equipment Mfg. Co.
345 Hudson Street
New York-14, New York

Dear Mr. Kahn:

May we take this opportunity of expressing our appreciation and thanks for the efficient manner in which your firm has handled our orders for subcontracted items on the MPG equipment.

Your Company, by the all-out effort of yourself, your subordinates, and your personnel, have consistently met the requirements under the most trying conditions possible.

You are to be complemented on the flexibility and versatility of your operation. This has enabled you to put into effect with a minimum of effort the many changes necessary without jeopardizing our delivery requirements.

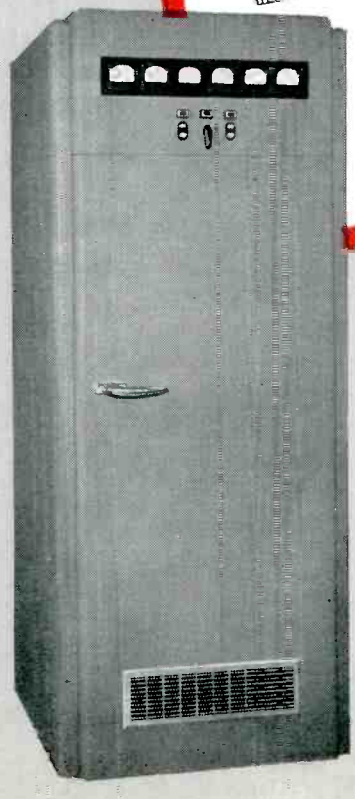
We have been advised that this is the first radar equipment ever ordered by the Army on which the schedules have been consistently met. For this also, we can thank TEMCO as you are building about seventy per cent of all the electrical components used on this contract.

In conclusion, may we convey our appreciation and thanks to the officers, supervisors and personnel of TEMCO for a job well done under the most trying conditions.

Cordially yours,

BENDIX RADIO, Division of
Bendix Aviation Corporation

R.A.Anderson
Procurement Manager



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*Write for complete descriptive data, prices and information for filing with FCC for license application.*

TEMCO

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# CLAIM STAKING

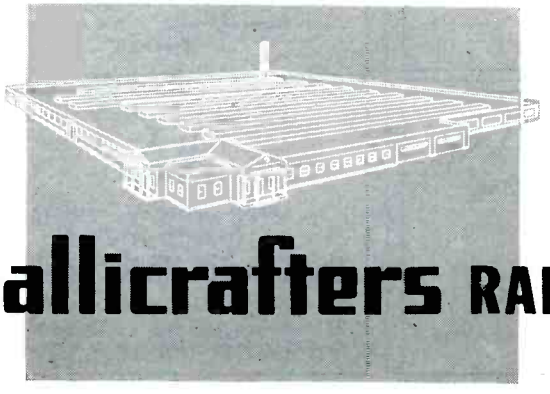
## Hallicrafters and Very High Frequency

Based on the facts in the case, Hallicrafters can stake out a very strong claim to leadership in the very high frequency field. The facts include such things as the Model S-37, FM-AM receiver for very high frequency work. The Model S-37 operates from 130 to 210 Mc.—the highest frequency range of any general coverage commercial type receiver.

Hallicrafters further supports its claim to domination in the high frequency field with the Model S-36A, FM-A M-CW receiver. The 36A operates from 27.8 to 143 Mc., covers both old and new FM bands and is the only commercially built receiver covering this range.

*Further developments in this direction can soon be revealed—adding further support to Hallicrafters claim to continued supremacy in the high frequency field.*

HALLICRAFTERS NEW $600,000 HOME NOW UNDER CONSTRUCTION.



**hallicrafters RADIO**

**THE HALLICRAFTERS CO., MANUFACTURERS OF RADIO AND ELECTRONIC EQUIPMENT • CHICAGO 16, U. S. A.**

# OBSERVATIONS OF AN AM LISTENER

## Why Radio Listeners Won't Let Anyone Delay FM, Once New Receivers Are Available

BY MILTON B. SLEEPER

RADIO HILL, some eight miles east of Great Barrington, Mass., is distinguished from the surrounding Berkshires only by a 100-ft. Wincharger tower and FM antenna which at this time of writing is in process of erection. Otherwise, Radio Hill is important only to us, because that is where we live, and where we listen to radio broadcasting.

We don't know how much our new tower will cost by the time it is surmounted by a mast carrying dipoles. There will be further expense for the concentric cable run through conduit in a trench across 150 ft. of lawn. But whatever the cost, it will be necessary if we are to have enjoyable radio reception after FM broadcasting has been made over into a perfect system in accordance with the ideas of such experts as Kenneth Norton and William Lodge.

You may ask: "Why not get along with AM reception, as millions of others do?" Well, there's an answer to that, and here it is: For a year and a half we have listened to Yankee's station WGTR with Mutual programs, Doolittle station WDRC-FM with CBS programs, Major Armstrong's Alpine station with recordings sans commercials, and NBC's Empire State transmitter which came in except at those times when the trees broke off our little antenna wire running up to the chimney.

And even though the programs weren't sparked with the realism of prewar high-fidelity that made us sit up and pay attention, at least they sounded clean and clear.

Well, after Sunny Jim put the October 29th bee on the networks and Yankee's WGTR cut its FM schedule, we didn't have any more FM news with our morning coffee. Since *The New York Times* isn't delivered until noon, we had to take back a $24.95 AM rat trap we had loaned to a neighbor whose only set had quit from old age.

At that time, we had decided not to think unkindly any more of Chairman Porter, Paul Kesten, Bill Lodge, Kenneth Norton, and the manufacturers of cheap AM receivers. After all, that little set *had* given our neighbors much satisfaction, so its performance couldn't have been *too* bad. But when we tried to get our morning news on the AM squawk-box, that old feeling came back again!

G. E.'s station WGY, Schenectady, makes the loudest daytime noise at our house, but what a noise! Voices sound as if they are produced by tonsils beating against adenoids, and what is identified as music would be poor quality if it came from Edison's original phonograph.

The other station that comes in during the daylight hours is Westinghouse WBZ or WBZA. We aren't sure which is which, because part of the time we hear only one, and part of the time we hear one as an echo of the other. As a sound effect, it is ghastly. The two stations are supposed to be synchronized, but their performance, as we hear it, reminds us that AM broadcasting is supposed to be a lot of things it isn't.

Such as the squeals we aren't supposed to hear on AM at night. The FCC engineers fixed those up some time ago. We once made a reference in these pages to squeals in the AM band, and were promptly corrected by a broadcast engineer. He said we must be mistaken because the FCC had tightened up its regulations so that stations couldn't squeal any more. We didn't argue the point, but we'll make room any evening for anyone who wants to hear heterodyne whistles on the AM broadcast band.

This is another one of the facts of life that the Commission and the AM broadcasters could learn if they did more listening. What we hear on AM confirms a long-held suspicion that the Commissioners and their engineers are so busy running the radio business they don't have any time to find out what it's all about, while the broadcast executives spend all their time studying listener surveys, instead of surveying what listeners hear.

Anyway, all regulations to the contrary, we hear squeals on AM, and there is no doubt about it. That's not all we hear, though. For instance, we tune WOR right on the nose, and settle down to hear what happens to Bulldog Drummond when he goes out into the night. Then, just as he opens the door and is ready to step forth, the whole picture fades from the loudspeaker and we find that it's a woman sleuth peeking through the boudoir keyhole of some Hollywood actress! Now we've learned not to spoil a good dinner trying to hear anything on WOR in the evening. It doesn't come in at all in the daytime.

On Tuesdays, whatever was going on, we have always stopped at 9:30 to hear Fibber and Molly. We used to get them on WEAF-FM, although the volume was down, since the FM transmitter only puts two kilowatts or so into the antenna. On AM, WEAF's 50 kilowatts can't be heard at all. We didn't mean to let that stop us from hearing Fibber and Molly, though. We knew they would come in at other points on the dial. So they did, for a minute at a time. When they faded out we got them somewhere else. Our loudest station after dark is WTAM, Cleveland. Next choice on NBC is the Canadian station CBA, New Brunswick. When these faded, we just took pot luck. Of course, it meant tuning through a number of other programs and getting some dreadful hash in transit. Not one station held for more than two or three minutes.

Half way through the program, we were told, gently but very firmly: "You may enjoy that racket, but I can't stand it. I wish you'd just turn it off!" So we did.

We won't bore you with any more of the sordid details of our AM listening. By now, you have the general idea that our opinion cannot be expressed in type. Any broadcaster who thinks we'll listen to that kind of reception because we can't live without the Lux Theatre or Col. McCormack is crazy. We'll take recordings on FM transmission any time.

Perhaps we should be very angry with that pot-bellied little runt who runs the AFM, and who stopped our enjoyment of hearing Fibber and Molly on FM. Perhaps we should be up in arms because broadcasting in these United States is controlled by a man so intellectually low that he couldn't get past the fourth grade after nine years in public school. But we don't seem to feel that way.

Rather, we wonder how men smart enough to own the broadcasting facilities in this country can be so negligent of their responsibilities to serve public interest, convenience, and necessity as to allow such a character to gain and hold dominion over them. Yes, he's a pain in the neck to us, but he's the broadcasters' headache, and it seems to us that if they are going to let him interfere with broadcast service to radio listeners, it's time to ask why their station licenses should be renewed.

What's worrying us more is the future

(CONTINUED ON PAGE 88)

# DATA ON RCA FM BROADCAST TRANSMITTERS

## Motor-Driven Frequency Control, Grounded-Grid Amplifiers, and New High-Frequency Tube

BY C. M. LEWIS*

THREE new FM broadcast transmitters, of 250 watts, 1 k.w., and 3 kw., have been put into production by RCA, while designs for transmitters of still higher power are nearing completion. Designated as the BTF series (for Broadcast Transmitters Frequency modulated) they are completely new postwar designs, from exciter to power amplifier. They employ an exciter of an entirely different type, a new tube especially designed for 100-mc. operation, and grounded-grid circuits which offer important advantages explained in subsequent paragraphs.

Possibly the most striking feature of the new BTF transmitters, illustrated in Figs. 1 to 3, is the manner in which the several power categories have been integrated in design. As a result of the wartime cessation of transmitter construction, an opportunity was presented to design a whole new line, and our engineers grasped this chance to show what they could really do in designing an integrated line. They began by standardizing on a unit enclosure which could be used on all power ratings, to assure matched appearance and to facilitate installation. Next, they worked out the use of grounded-grid amplifier circuits — circuits which are simpler and more stable at 100 mc. than conventional circuits — and which make amplifier step-up ratios of 3 to 1 not only economical, but actually more efficient than higher step-up ratios. Then, in conjunction with our tube engineers, they developed a new tube for use in these circuits which could satisfactorily and economically be used in 1-kw. and 3-kw. stages. Finally, they added a whole host of other features based on our experience in installing more than 300 of the country's present-day AM and FM broadcast stations.

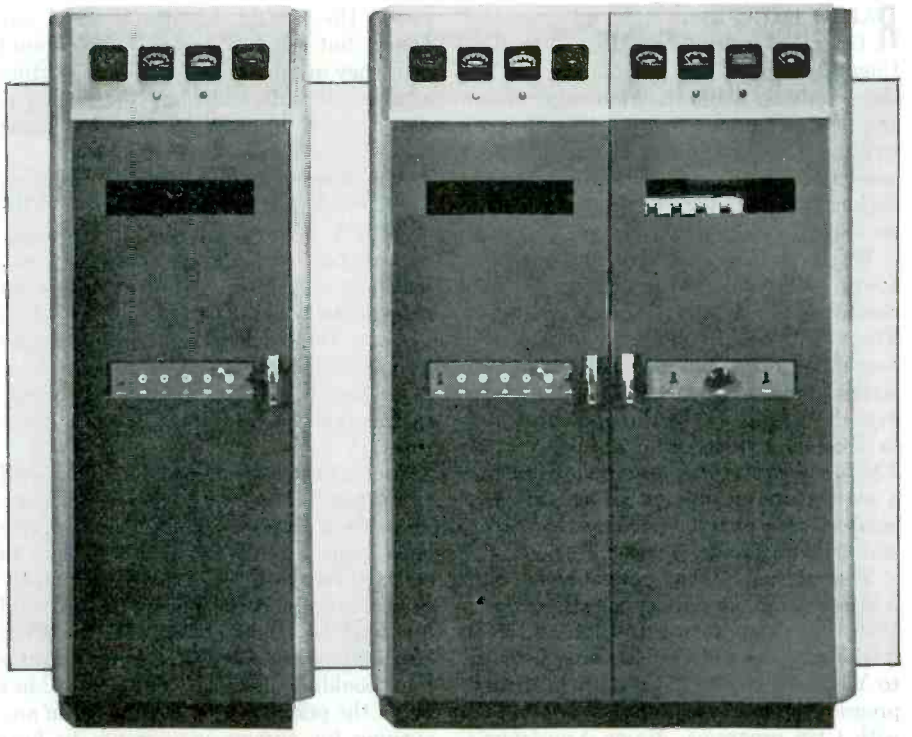


FIG. 1, LEFT. THE 250-WATT FM BROADCAST TRANSMITTER. FIG. 2, RIGHT. THE 1-KW. TRANSMITTER COMPRISES THE 250-WATT UNIT, AT THE LEFT, PLUS A POWER AMPLIFIER

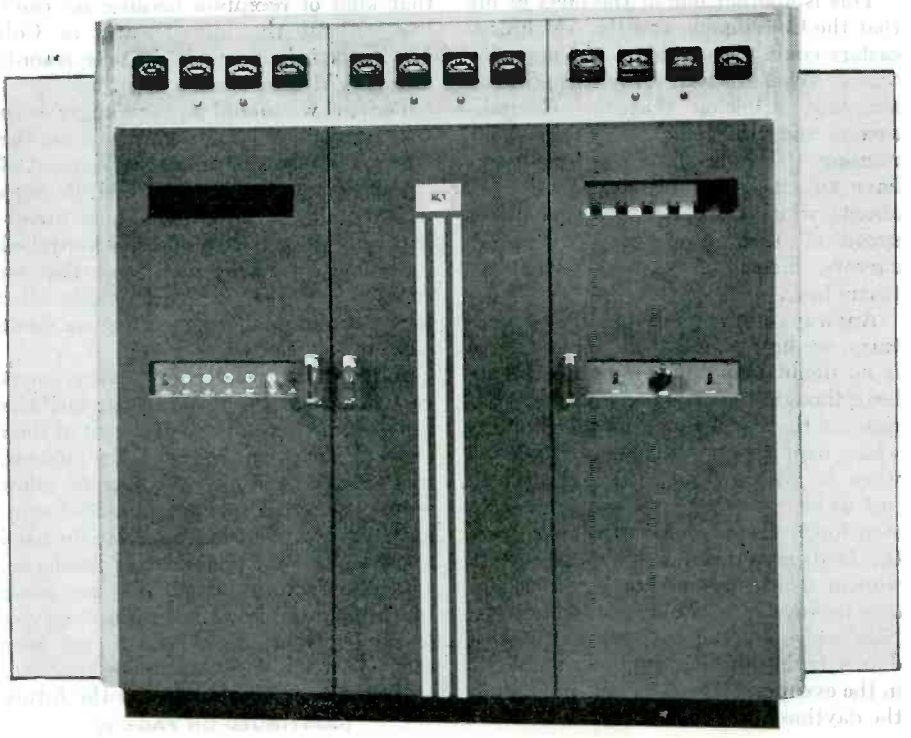


FIG. 3. BY ADDING ANOTHER AMPLIFIER, RIGHT, THE 1-KW. TRANSMITTER IS STEPPED UP TO 3 KW.

**Add-on Amplifier Design** ★ In the new FM transmitters, increase of power is made easy by the fact that each successive power rating is formed by adding an amplifier to the next lower-power unit. Thus the BTF-250 (250-watt) transmitter plus an amplifier becomes the BTF-1C (1-kw.)

*Manager, Broadcast Equipment Section, Engineering Products Division, Radio Corporation of America, Camden, N. J.

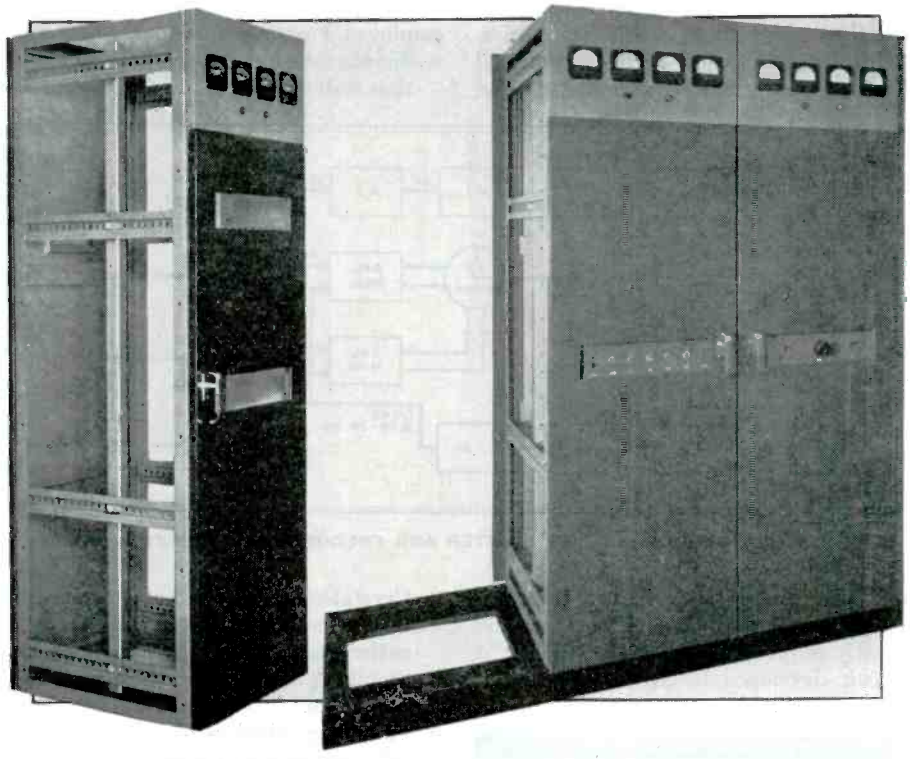


FIG. 4, LEFT. THE STANDARD ENCLOSURE. FIG. 5, RIGHT. DETAIL OF BASE FRAME MOUNTING

transmitter; the BTF-1C plus an amplifier becomes the BTF-3B (3-kw.) transmitter.

Ordinarily, it would not be economical to add an amplifier for a 3-to-1 step-up in power, because conventional tubes and circuits are usually designed for, and operate most efficiently at, step-up ratios of the order of 10 to 1. As a result, with conventional amplifiers, the combination of a low-power unit plus an amplifier may cost more than a single unit built originally for the higher power. However, when grounded-grid amplifiers are used, as in these new FM transmitters, that is not true, for with grounded-grid circuits the driver stages also contribute to the actual antenna output of the transmitter. Thus, a much smaller amplifier tube can be used than in conventional circuits, and a 3-to-1 step-up becomes more economical and more practical.

It is worth noting that another feature adds naturally to the ease of power increase. This is the mechanical design, whereby all of these transmitters are made up of standard cabinet units which go together like building blocks. With this type of construction, the addition of amplifier units is relatively easy. The extra units fit directly beside the original units. No additional air or wiring ducts are required, and the overall installation has a matching appearance. It looks like equipment designed originally as a single unit, which, as a matter of fact, it was.

**Simplified Installation** ★ All the new FM transmitters are housed in unit enclosures of a unique design, varying in number with the power of the transmitter. Thus, there is one unit for the 250-watt transmitter, two for the 1-kw. transmitter, and three for the 3-kw. transmitter. They all have the same framework, front and rear doors, air filter design, meter panel arrangement, and same overall dimensions. One of these enclosures is shown in Fig. 4.

This type of construction has several advantages. The most important is that it simplifies and reduces the cost of installation. Many FM transmitters will be located in relatively inaccessible places, so that moving equipment is, in itself, quite a problem. For example, in many instances they will be located on the top floors of tall buildings. In such cases, the elevators and passageways to be negotiated will limit the size and weight of the units to be moved. Other transmitters will be located on mountain tops — often accessible only by very poor roads. Here again size and weight of the units is a consideration.

The unit enclosures have maximum dimensions of 15 by 28 by 80 ins. They can be handled easily by two men, wheeled on a small dolly, taken through an ordinary door, and can be managed easily on small passenger elevators. The heaviest unit weighs less than 500 lbs. This weight is less certain demountable parts, such as the heavier transformers, which are shipped separately.

Another feature which makes installation simpler and less expensive is the provision of a base frame, Fig. 5, on which the unit enclosures are mounted. This frame, 4 ins. high, has screened openings at the front through which air enters the filters. No other air ducts are required. At the rear of the frame is a 4- by 4-in. wiring duct for the inter-unit wiring runs. Complete wiring kits are furnished with each transmitter. When the few external connections have been made, the equipment is ready for tune-up. In transmitters of

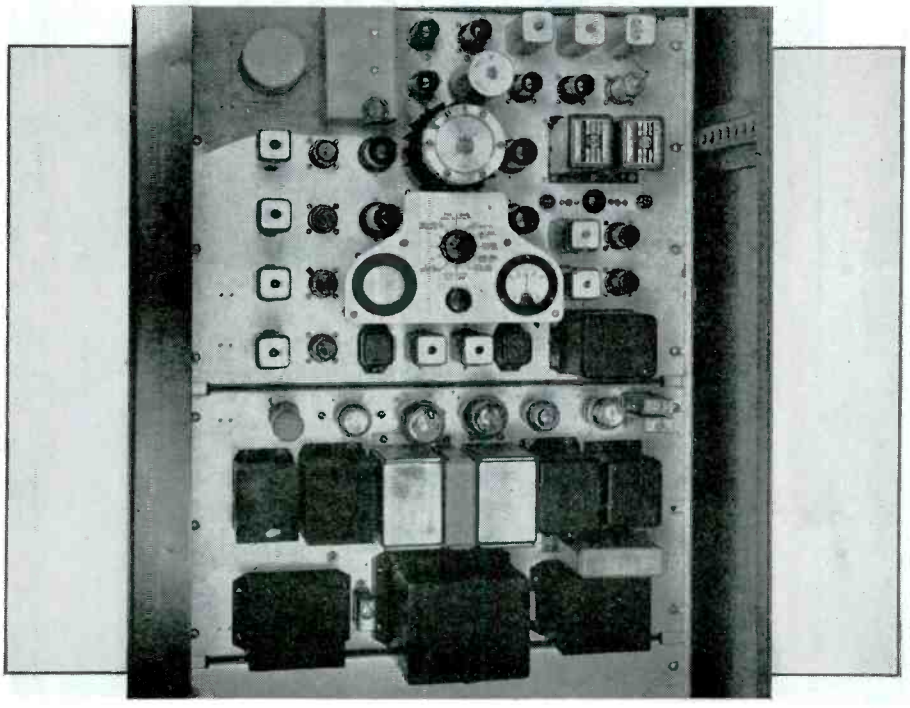


FIG. 6. EXCITER ASSEMBLY, RF AND MODULATOR CIRCUITS ABOVE, POWER SUPPLY BELOW

3 kw. or less, no other wire duct or conduit is necessary except for incoming power, audio, and monitoring leads.

**Direct FM Exciter Circuit** ★ An exciter unit of entirely new design is used in all the new models. The new exciter is assembled on two vertical panels, as shown in Fig. 6. One panel contains the RF and modulator circuits, and the other the regulated power supply. All tubes and main components are mounted on the front of the panel. Wiring on the rear is "in the clear" with all terminals plainly marked and easily accessible. Doors on the front and back of the cabinet provide quick access to either side of the panels.

In the transmitters of 3-kw. and higher power, space is provided for mounting an additional exciter unit, as shown at the left in Fig. 7. The spare exciter can be cut in quickly in case of failure. If it is desired to provide a spare unit with the lower-power transmitters, an additional cabinet unit can be furnished to house this together with other circuit accessories.

Electrically, the new exciter includes all the frequency generating, modulating, and frequency multiplying circuits of the transmitter, except the final doubler. A new and greatly improved form of the direct-FM circuit developed by RCA engineers is employed. Features of this new design are:

1. Simplicity of reactance-tube modulation system.

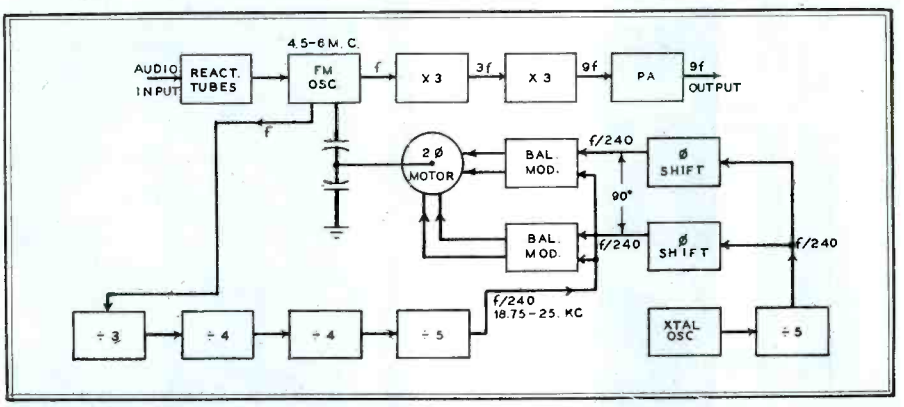



FIG. 8. BLOCK DIAGRAM OF THE EXCITER AND FREQUENCY-CORRECTING MOTOR

2. Crystal-controlled frequency stability.
3. Distortion of less than 1% through entire range of 30 to 15,000 cycles.
4. Stability independent of circuit adjustments.
5. Frequency dividers of relatively high ratio and similar design, thus reducing the number of tubes and circuits.
6. Only crystal unit is temperature controlled.
7. Every component and connection is easily accessible.
8. An ingenious built-in checking device which includes everything necessary for checking performance of frequency-control circuits, frequency multipliers, and reactance modulators.

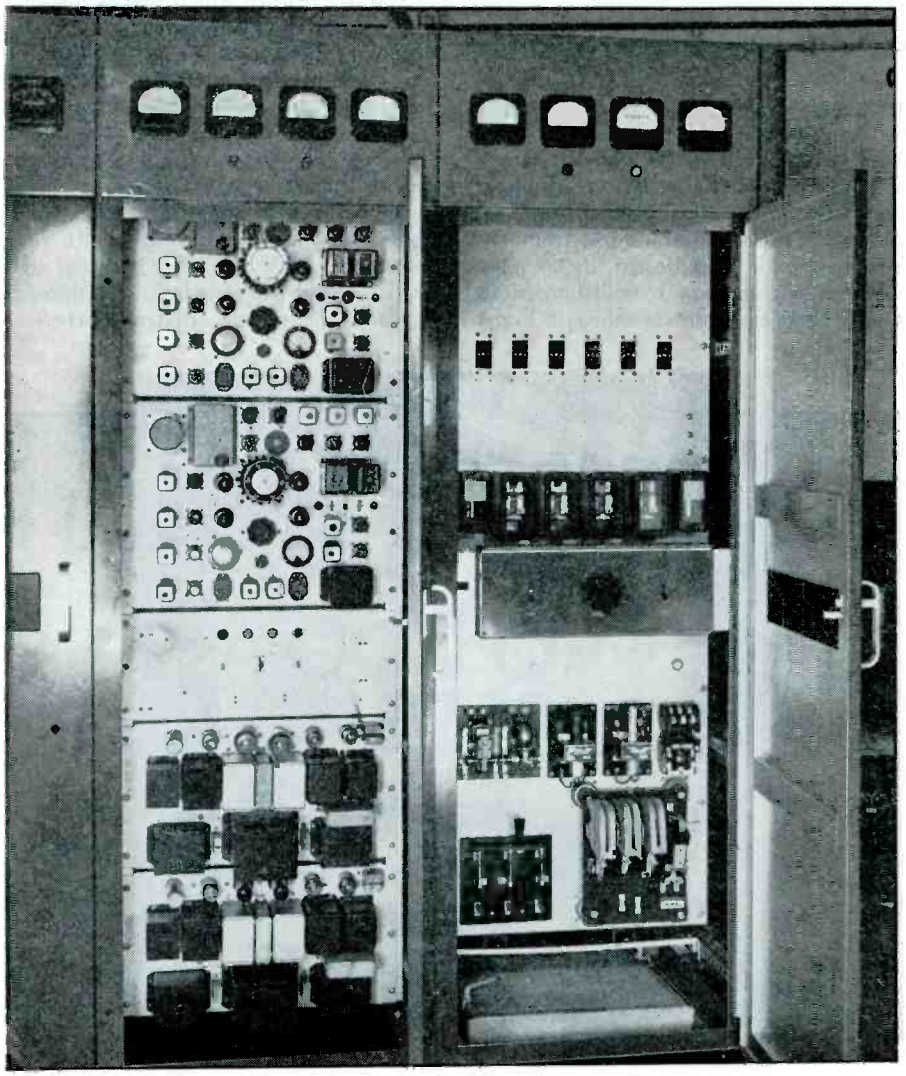


FIG. 7. CENTER UNIT OF THE 8-KW. TRANSMITTER CONTAINS A SPARE EXCITER

The circuit retains the advantages of simplicity and fewer tubes which are inherent in reactance-tube modulation. At the same time, it provides the frequency stability of crystal control. In this direct-FM circuit, the carrier, or center frequency, is generated by an oscillator operating at a medium frequency. This oscillator is modulated by push-pull reactance tubes. Thus frequency modulation is accomplished directly, and without the necessity of proceeding through numerous multiplier and converter stages.

Center-frequency stability is maintained by comparing a subharmonic of the modulated signal with a standard frequency developed by a temperature-controlled quartz-crystal oscillator. Any difference between the mean frequency of the modulated signal and that of the standard actuates a two-phase motor which drives a frequency compensating condenser mounted on its shaft, connected across the tuned circuit of the modulated oscillator. The motor turns until the condenser reaches a position at which the center frequency is exactly synchronized with the proper multiple of the standard frequency. Thus the transmitted frequency is main-

tained at the same degree of precision as the crystal.

This automatic frequency control circuit is completely independent of the modulation circuit. Frequency subdivision is obtained through locked-in oscillators used as frequency dividers.

The final circuit of the exciter is shown by a block diagram in Fig. 8. The tubes in the top row are, from left to right, the reactance tubes, modulated oscillator, first frequency tripler, second tripler, and a power amplifier. The power amplifier is used to get sufficient power to feed through a transmission line to the main transmitter. The output frequency of the exciter will fall in the range of 44 to 54 mc. With a multiplication of 2 in the main transmitter, a frequency range of 88 to 108 mc. is provided.

A lead shown at the left in Fig. 8 conducts synchronizing voltage from the modulated oscillator to the first divider at the lower left. The dividers are set up as shown with 4 stages, giving a total division of 240. This brings the output frequency of the last divider within the range of 18.75 to 25 kc. The output of the last divider is connected directly to the two balanced modulators.

The crystal oscillator shown at the lower right operates any frequency between 94 and 125 kc. This is accomplished without the use of any tuning adjustments. The crystal output synchronizes a divider at $\frac{1}{5}$ the crystal frequency. This frequency is also fed to the balanced modulators, but in this case a phase shifting network is included in the lead to each modulator adjusted to maintain a 90° displacement in phase between the modulators over the range of frequencies involved. The only tuning required in the crystal or reference frequency part of the circuit is to set the slug in the divider so that its frequency is locked to $\frac{1}{5}$ of the crystal higher frequency.

Each balanced modulator has a pair of 6L6 tubes biased to cut-off, and connected push-pull. The induction motor has high impedance center-tapped windings on each phase so that it can work in the plate circuit of the balanced modulator tubes without the use of matching transformers. In this way the motor receives full voltage down to DC beat frequency.

The absence of gearing and the use of viscous damping establish a condition in which there is little or no resistance to small or slow rotation of the motor shaft. The motor responds to frequencies up to 1,000 cycles, whereas the motors used in previous exciters of this general type were limited to 60 cycles, thereby requiring comparison at about 5 kc. instead of the higher frequency.

The operation of the circuits can be checked easily and rapidly by means of test equipment built into the exciter, as shown in Fig. 9. A cathode ray oscilloscope, and selector switch make it possible to check the operation of each divider and also the tripler amplifiers.

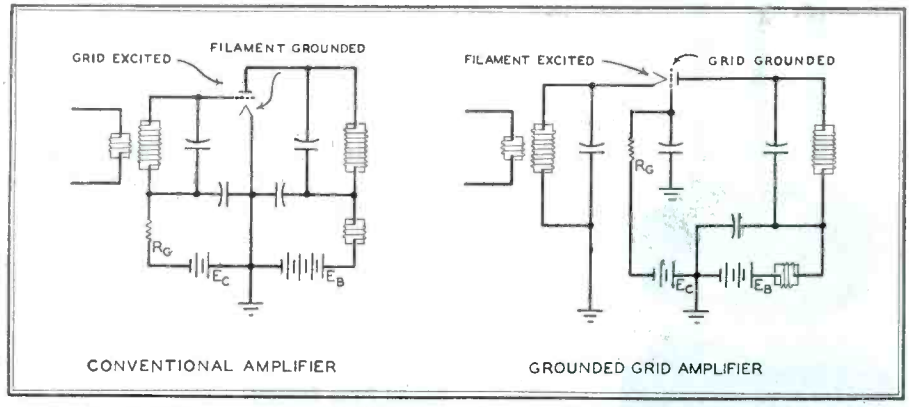



FIG. 10. COMPARISON OF THE CONVENTIONAL AND GROUNDED-GRID AMPLIFIER CIRCUITS

**Grounded-Grid Amplifiers** ★ The use of grounded-grid amplifiers merits detailed discussion. The grounded-grid circuit has several very important advantages at FM frequencies. These are:

1. Circuits are simpler and require fewer components than other amplifiers.

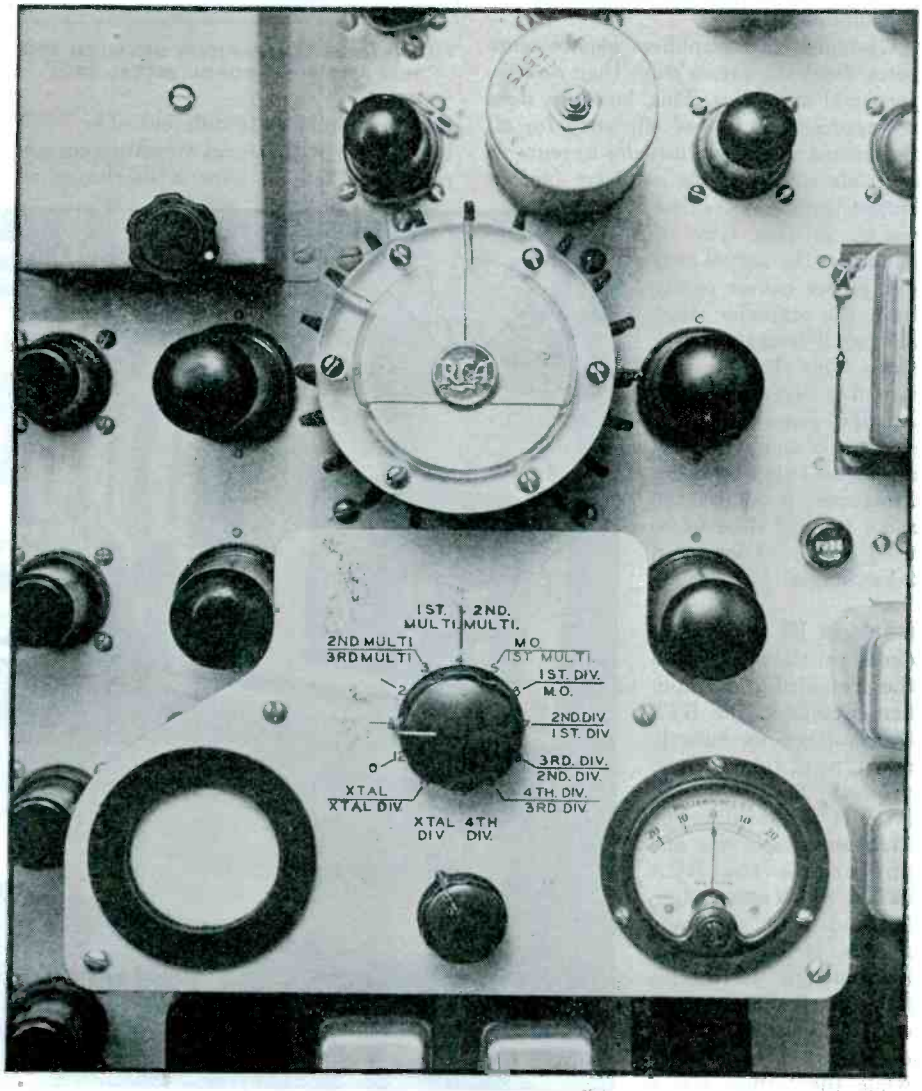



FIG. 9. CATHODE-RAY TUBE, LOWER LEFT, PROVIDES VISIBLE CHECK OF THE CIRCUITS

2. Neutralizing, if necessary, is very simple and, in fact, not required at all for low powers.
3. High stability and lack of critical adjustment at 100 mc.
4. Greater output from an amplifier using a tube of a given size, making possible the use of smaller, less expensive types.
5. Use of same tube types in driver and power amplifier, reducing number of tube types required.

In the grounded-grid amplifier, as the name indicates, the grid of the tube is at RF ground potential, instead of the filament, as in conventional amplifiers. This is made clear in Fig. 10. Normal bias is necessary, and is supplied in the same manner as that of the conventional grounded-cathode circuit. Since the grid is at ground potential, it performs the dual function of acting as the control grid and as a screen between plate and cathode circuits. It follows that if a tube is used which has been designed to take full advantage of the screening action, no neutralizing circuits are required.

Grounded-grid amplifiers require more power from the driver stage than do conventional amplifiers. This, however, does not represent a loss of efficiency for *all the extra driver power actually appears in the plate circuit of the amplifier tube as output power*. In other words, in this type of amplifier, the actual output power comes partly from the amplifier stage and partly from the driver stage. This characteristic is used to advantage, since it makes possible the efficient use of amplifiers having a 3-to-1 step-up ratio. Moreover, it allows the same type of tube to be used in the 1-kw. and 3-kw. stages.

**A Tube for 100 mc.** ★ In order to get the most out of the grounded-grid amplifier circuits in the BTF transmitters, an entirely new type of tube was developed. This tube, the RCA 7C24 shown in Fig. 11, resembles in size and appearance the RCA 827-R, which was a popular and very successful feature of RCA prewar transmitters. In design, however, it differs markedly from the 827-R. For one thing, it is a triode, while the former was a tetrode. Moreover, the

FIG. 11. SIZE COMPARISON BETWEEN THE 7C24 AND A STANDARD METAL 6AC7

construction is quite different. The 7C24 is provided with a grid structure specifically designed to offer a maximum of shielding between the plate and filament electrodes, resulting in a very low plate-filament capacity. The grid connection is a disc seal brought out through the glass all the way around the tube. When this is utilized in connection with an external shield, the input (filament) and output (plate) circuits of the amplifiers are very well isolated.

The RCA 7C24, in combination with the grounded-grid amplifier circuits, results in the use of the same type tube in the 1-kw. and 3-kw. stages. This has the very considerable advantage of reducing the number of types used and, thereby, lessening the number of spares that must be kept on hand.

**Vertical Panel Assembly** ★ One feature of the new transmitters is new only in the way it is used; this is the vertical panel construction. RCA engineers used vertical panel construction in AM transmitters some 10 years ago, and in recent years all our broadcast transmitters, and many others as well, have been built in this fashion. This type of construction, in which all components are mounted on vertical panels, has numerous advantages. Most obvious is that air entering through the filters at the bottom travels upward in an unobstructed manner, thus providing most efficient cooling. This is in contrast to the old-style shelf-mounted types in which components were mounted on horizontal shelves or chassis which almost blocked the passage of air.

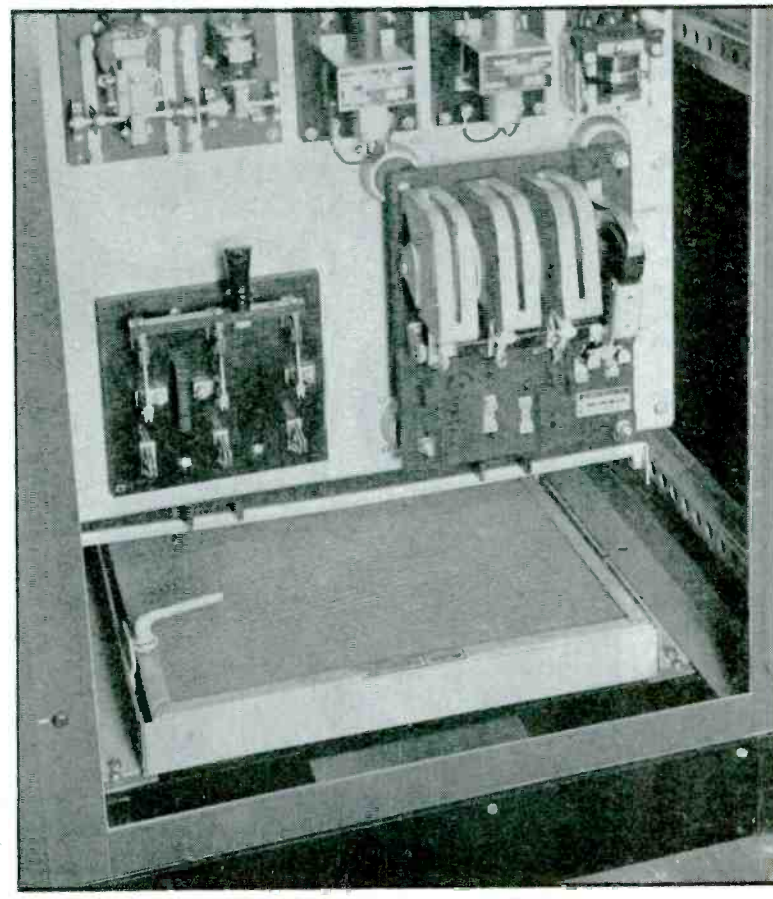


FIG. 12. AIR IS DRAWN UP FROM THE BASE THROUGH RENEWABLE FILTER

The front doors of the enclosures give immediate access to the front of the vertical panels on which the circuit components are mounted, while the rear doors afford access to the wiring and other parts. All wiring is in the clear, with every terminal legibly marked and easily accessible. Still another advantage is that these panels can be assembled and wired on the bench and, after completion, mounted in the enclosure.

**Air Filter System** ★ Early broadcast transmitters had open sides, or sides with many louvres. Circulation of air was uncontrolled and dust in great quantities collected on all the components. Several years ago when our engineers introduced forced-air-cooled tubes, they

provided dust filters in the inlets. Low-power stages, however, were still unprotected. In the new transmitters, the trend has been carried a step further.

Each compartment is equipped with an air filter located in the bottom of the compartment frame, as in Fig. 12. The 4-in. base contains cutouts along the front which act as air inlets. In compartments containing air-cooled tubes, individual blowers pull the air through the inlets and the filter, and deliver it to the tubes. The exhaust air is expelled at the top. Compartments not containing air-cooled tubes also receive their air through a filter, and exhaust it by means of a fan located in the roof of the compartment. Special dust shields prevent dirt from settling inside the cabinet while the transmitter is shut down. There are no louvres in the enclosures, and the doors close snugly so that no air can enter. Thus, very little dust can reach the equipment either during operation or standby. As a result, troubles due to dust on contacts are lessened and maintenance time and cost are reduced, cooling is more efficient and, with components operating well below temperature ratings, failures are less likely to occur.

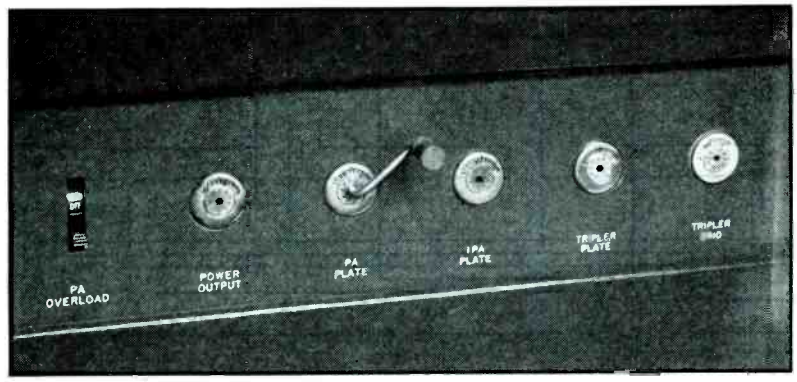



FIG. 13. REMOVABLE CRANK IS USED TO ADJUST THE CIRCUITS

**Centralized Control Strips** ★ For neatness and convenience, all the necessary power and tuning controls are grouped on strips. One of these is shown in Fig. 13. Openings in the doors of the enclosures are provided so that the panel is flush when the door is closed, while the controls project just enough for satisfactory operation.

In general, there is a control for each tuned circuit, plus an additional control which allows the power output to be smoothly varied through a ratio of 3 or 4 to 1. The controls are of two types: the vernier control and the lever switch. The vernier type is operated by a hand crank, and incorporates a calibration dial which provides pre-set tuning information for future reference. The tuning handle is inserted only during actual tuning, thereby avoiding possibility of inadvertent detuning during operation. The lever type switches control the motors used in the motor-driven tuning units of the grounded-grid amplifiers.

**Automatic Overload Protection** ★ All power circuits are protected by magnetically- or thermally-tripped circuit breaker switches. These circuit breakers open automatically under overload conditions, and isolate the fault from the AC bus. They are used in high power, filament, blower, and low-power circuits. Their use eliminates the delay and danger involved in replacing fuses in these circuits. The only fuses in these transmitters are the two in the crystal-heater circuits for the exciter unit. In the 3-kw. transmitter, high-speed overload relays are provided in the high power circuits in order to give additional protection to expensive components. In all transmitters, an interlocking control prevents the application of plate power until the rectifier filaments have reached operating temperature.

**50- to 250-Watt Transmitter** ★ The type BTF-250A transmitter, Fig. 1, is designed for operation at output powers of 50 to 250 watts. While this transmitter is the smallest of the new RCA FM transmitters, it incorporates the same circuits as those in the larger transmitters, uses the same type of components and is built to the same standards as the larger equipments. In fact, this same unit is used, with minor modifications, as the driver unit of the higher-power transmitters. Thus it makes available to community and educational stations a transmitter which will meet the same standards of performance and reliability as the largest installations.

Electrically, it consists of a standard exciter followed by two RF amplifier stages. The output frequency of the exciter falls in the range of 44 to 54 mc. This is doubled to the final operating frequency in the first 4–125A stage. This stage drives a final amplifier with two 4–125A tubes in parallel. There are two rectifiers; a low-voltage unit utilizing one 5U4G, and a high-voltage unit employing two 866A/866's.

Mechanically, the transmitter consists of a single cabinet containing the FM exciter unit, its power supply, the RF amplifiers, their power supplies, and the necessary control circuits.

**1-Kw. Transmitter** ★ The type BTF-1C transmitter is intended for operation at output powers of 250 watts to 1 kw. It can be increased in power, at reasonable cost, by the addition of standard amplifier units. It is well suited for the requirements of stations in metropolitan centers of medium size, and can also be used by larger educational stations.

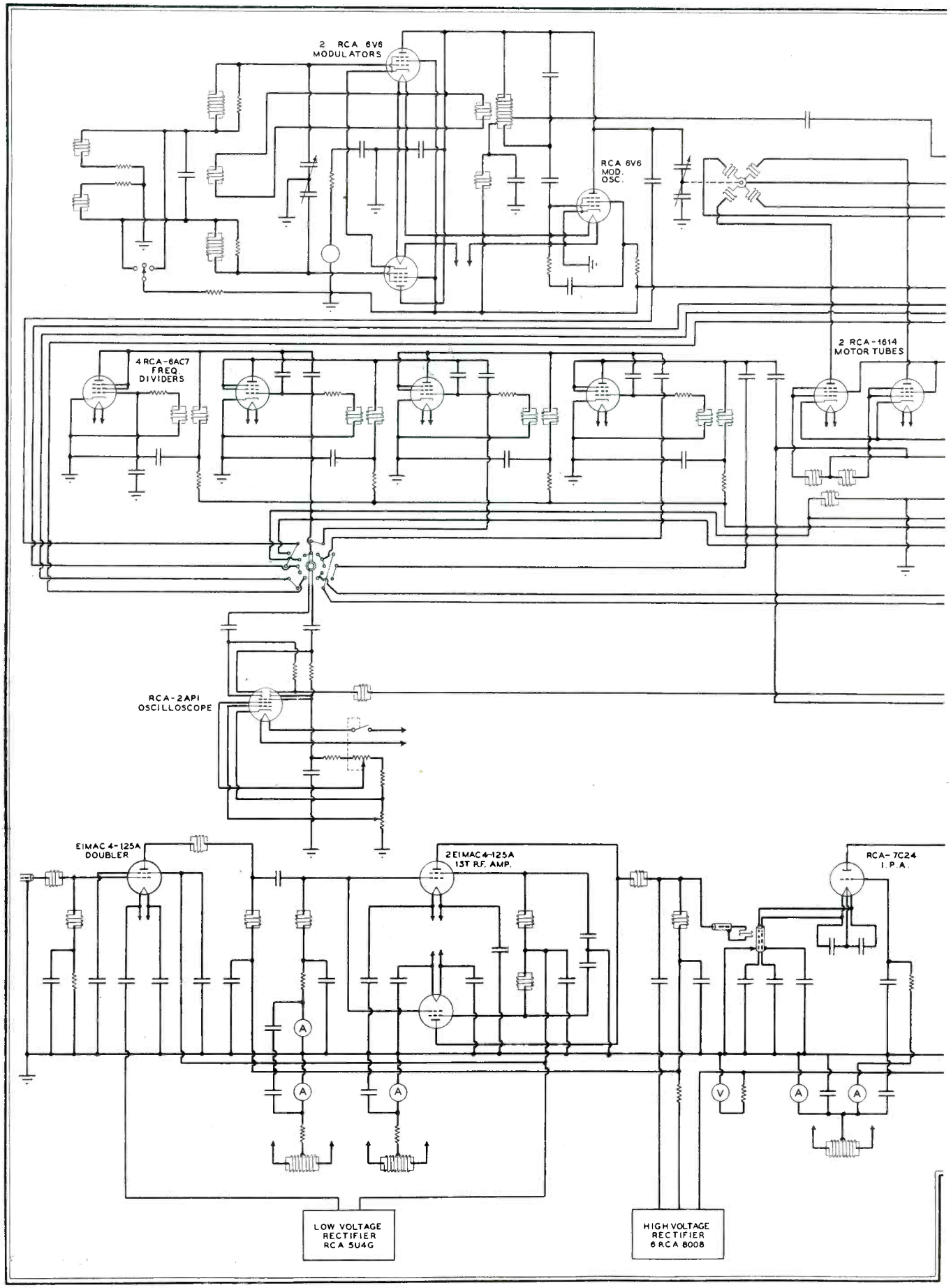
The electrical circuits are similar to those of the BTF-250A, with the addition of an extra amplifier stage to give the increased power. A standard exciter is followed by a 4–125A tube as a doubler. This is followed by an intermediate RF stage employing two 4–125A's in parallel. This stage acts as the driver for a grounded-grid amplifier stage in which one of the new 7C24's is used to furnish the required power to the antenna transmission line. In addition, there is a low-power rectifier using one 5U4G and a high-voltage rectifier using four 8008's.

The components are mounted in two cabinets, as shown in Fig. 2. In the right-hand cabinet are the high-voltage rectifier and the standard FM exciter unit; in the left-hand cabinet, the RF amplifiers. Space is left in this cabinet for adding a power stage in case it should be desired to increase the output above 1 kw.

**3-Kw. Transmitter** ★ The type BTF-3B transmitter is suitable for stations requiring a power output to the transmission line of 1 to 3 kw. Circuits, components and construction are essentially the same as those of the other transmitters. It is probable that this transmitter will be used by many stations in metropolitan areas and this possibility has been given special consideration in the design.

Electrically it has the same circuits as the BTF-1C, plus an additional amplifier stage, as indicated by the schematic diagram in Fig. 14. The standard exciter unit is followed by a doubler stage with a 4–125A tube and two RF amplifier stages using, respectively, two 4–125A's and a 7C24, the latter operating as a grounded-grid amplifier. This stage acts as the driver for a final grounded-grid output stage with another 7C24 tube.

The use of the same size tube in driver and output stages is made practical by the fact that with the grounded-grid circuit, the driver stage contributes a substantial share of the output power, thereby making it possible to use a much smaller tube in the output stage than would be required with a conventional grounded-filament circuit. Rectifiers for this transmitter include a low-voltage unit using one 5U4G. and a high-voltage unit using six 8008's,


2 RCA 6V6 MODULATORS
RCA 6V6 MOD. OSC.
4 RCA-6AC7 FREQ. DIVIDERS
2 RCA-1614 MOTOR TUBES
RCA-2API OSCILLOSCOPE
EIMAC 4-125A DOUBLER
2 EIMAC 4-125A 1ST R.F. AMP.
RCA-7C24 I.P.A.
A
V
LOW VOLTAGE RECTIFIER RCA 5U4G
HIGH VOLTAGE RECTIFIER 6 RCA 8008

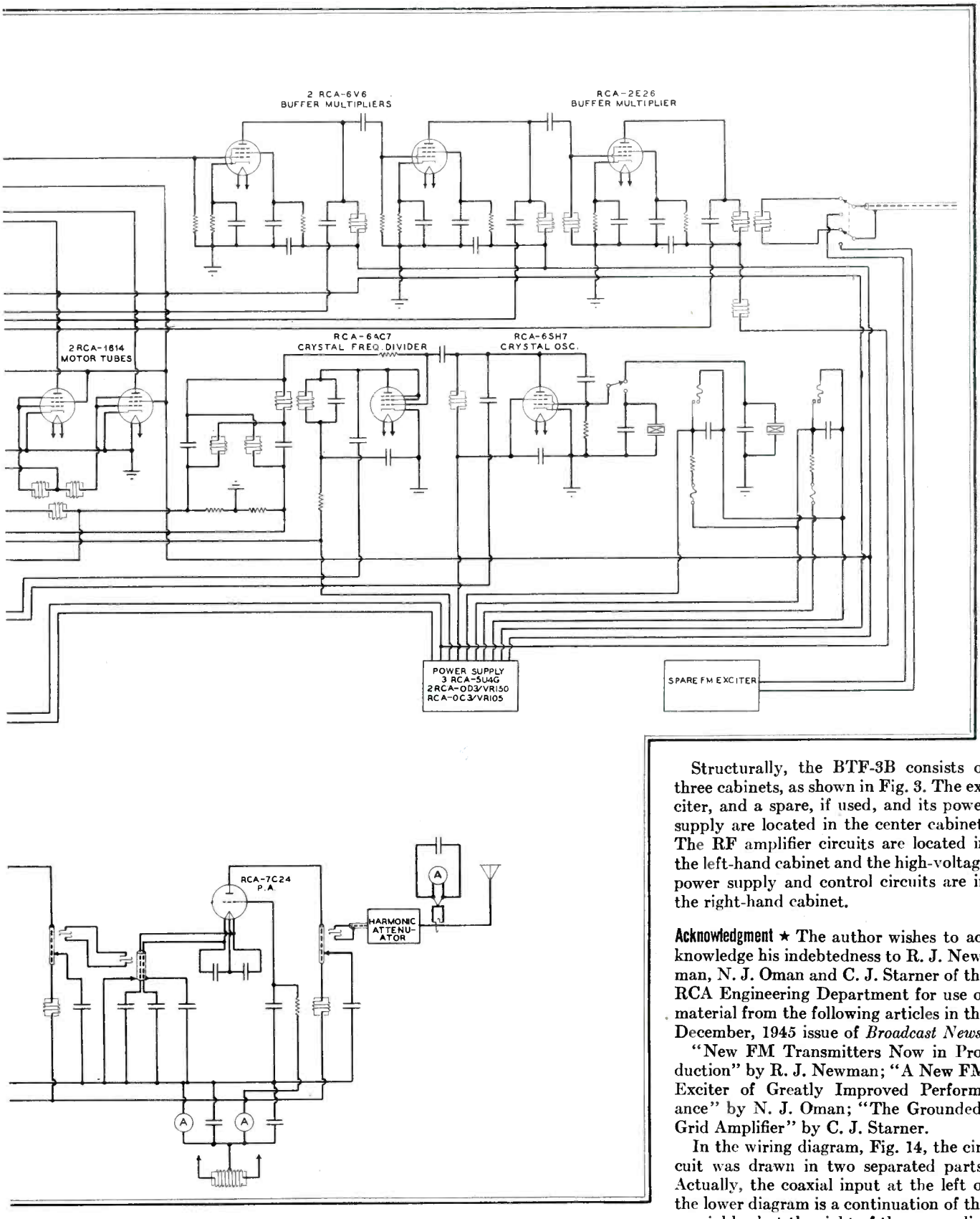



FIG. 14. COMPLETE CIRCUIT OF THE 3-KW. RCA FM BROADCAST TRANSMITTER. THE LOWER DIAGRAM IS A CONTINUATION OF THE OUTPUT OF EXCITER, WHICH TERMINATES IN A COAXIAL LEAD AT THE RIGHT, ABOVE. CIRCUIT OF THE SPARE EXCITER IS A DUPLICATE OF THAT SHOWN HERE, AS INDICATED IN FIG. 7, LEFT

Structurally, the BTF-3B consists of three cabinets, as shown in Fig. 3. The exciter, and a spare, if used, and its power supply are located in the center cabinet. The RF amplifier circuits are located in the left-hand cabinet and the high-voltage power supply and control circuits are in the right-hand cabinet.

**Acknowledgment** ★ The author wishes to acknowledge his indebtedness to R. J. Newman, N. J. Oman and C. J. Starner of the RCA Engineering Department for use of material from the following articles in the December, 1945 issue of *Broadcast News:*

"New FM Transmitters Now in Production" by R. J. Newman; "A New FM Exciter of Greatly Improved Performance" by N. J. Oman; "The Grounded-Grid Amplifier" by C. J. Starner.

In the wiring diagram, Fig. 14, the circuit was drawn in two separated parts. Actually, the coaxial input at the left of the lower diagram is a continuation of the coaxial lead at the right of the upper diagram. The spare exciter, indicated by a single block, contains the same circuits as those shown in the upper schematic.

# SPOT NEWS NOTES

**Items and comments, personal and otherwise, about manufacturing, broadcasting, communications, and television activities**

**Realistic Appraisal:** "In recognition of a quarter-century of public service," NAB will be presented by RMA president Cosgrove with a statue. Appropriately, it is of a man, flanked by a radio tower and a flash of static, surrounded by storm clouds. The man holds in his hand one of those $14.95 squawk-box receivers.

**Stratovision:** FCC has authorized Westinghouse to test FM and television transmission from 30,000 ft. Ground reflections, plane-to-plane relay, antenna designs, service area, and ground-to-plane transmission will be studied. These tests should produce some extremely interesting data on FM aircraft communications.

**Cleveland:** Radiart Corporation has been purchased by Maguire Industries, Inc., and will be operated as a wholly-owned subsidiary.

**Taxi Cab Radio:** Communications Equipment Corp. of Pasadena has made a 2-way test installation for Tanner Motor Livery in that city. If operation continues to be as successful as initial results indicate, the entire Tanner system, extending from Santa Maria to San Diego, and east into Arizona, will use radio dispatching.

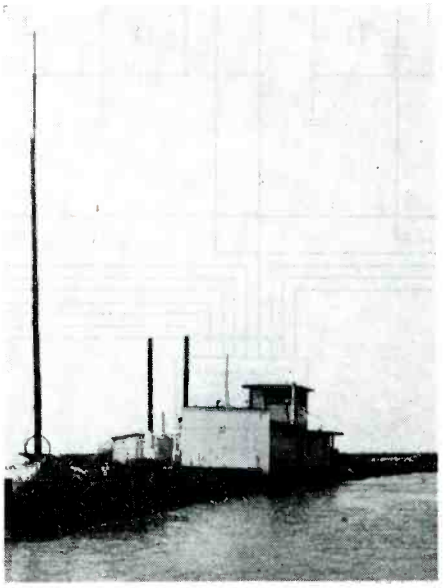
**New Officers:** Of J-B-T Instruments are: first vice president, R. L. Triplett, president of Triplett Electrical Instrument Company; vice president in charge of sales and public relations, Phillip Stevens; assistant treasurer, Eric Ericson.

**FCC Chairman Porter:** Speaking by transcription over WRVA, Richmond, Va., on November 2nd: "One of the great improvements to broadcasting following in the wake of victory is FM. . . . You can gauge the size of the FM boom by the fact that 700 applications for stations have already been received by the Commission, and the number is expected soon to equal the number of standard stations, totalling 940, now on the air. Within the next five years, there may be from 2,000 to 3,000 FM stations in operation."

**Tube Shortage:** No wonder standard tubes were scarce during the war. Toward the end, 5 tubes were going into each of the 100,000 proximity fuses being produced daily. That took about one-half of our total tube production.

**I.R.E. Officers:** Elected for 1946 are Dr. Frederick B. Llewellyn, of Bell Telephone Laboratories, president, succeeding Dr. William L. Everitt, and E. M. Deloraine, president of International Telecommunications Laboratories, vice president. New directors are Dr. W. R. G. Baker of G.E., Dr. Donald B. Sinclair of General Radio, and Virgil Graham of Sylvania.

**FM Communications:** There's so much discussion of FM broadcasting that FM communications doesn't get much public attention. Actually, there is a rapidly increasing expansion of the latter, not only in police and fire service but by public utilities and other organizations to which frequencies and suitable equipment



FM COMMUNICATIONS FOR PIPE-LINE MAINTENANCE IN LOUISIANA SWAMP

was not available. In fact, the field commercial communications will be greater in dollar volume than sales of broadcast equipment. This illustration shows a Motorola installation which handles an average of 200 calls a day with 12 portable units and 5 mobile units. This system is operated by the Union Sulphur Company, for maintaining a 100-mile pipe line that runs through Louisiana swamps.

**Capt. Norman S. Kornetz:** M.I.T. '35, recently returned from service with the Signal Corps in India, is now in charge of television receiver design for Westinghouse, at Sunbury, Pa.

**Los Gatos, Calif.:** Lewis Electronics, Inc. has been acquired by Aireon Manufacturing Corporation of Kansas City, Kans.

**WHFM:** Stromberg-Carlson's FM station at Rochester, N. Y. is now transmitting with 50 watts on 98.9 mc., in addition to their regular transmission on 45.1 mc. Power on the new frequency will be stepped up to 1 kw. about December 1st, and will be raised subsequently to the authorized rating of 20 kw.

**Military Secret:** Vitamin Q isn't a vitamin at all, but a nickname given by Sprague engineers to the classified dielectric used in condensers for Mickey radar equipment. American Medical Association heard of it, and filed a protest, but Company officials assured the doctors that it was only put in condensers, and not taken internally by radio engineers.

**Dr. Howard Doolittle:** Boss of the NDRC pulse-modulator group at Radiation Laboratories, is now in charge of high-frequency research and development for Machlett Laboratories, Inc., Norwalk, Conn.

**Educational FM:** State of Wisconsin has filed applications for the first 2 stations in a system of 7 which will provide a statewide educational network. A 10-kw. transmitter at Milwaukee will serve the lakeshore area, and one of 3 kw. will be located on the University campus at Madison. H. B. McCarty is executive director of the State Radio Council.

**Employment:** Sylvania expects to employ at least 13,000 people in 1946, compared to 6,000 in 1941. New buildings and a warehouse will be erected at Salem, Mass., and at Sylvania Center, Bayside, N. Y., two other buildings will be put up, one for research, and the other for administration centralization.

**Reorganization:** Following acquisition of full control of Allen D. Cardwell Mfg. Corp. by Grenby Mfg. Company of Plainville, Conn., Ralph E. Soby has succeeded Mr. Cardwell, recently retired, as president of the Cardwell Corporation. Sales and development engineering will be continued at 81 Prospect Street, Brooklyn, with Joseph K. Fabel still in charge of sales for that division. Ray L. Morehouse will continue as sales manager of the commercial products division. Manufacturing has been moved to Plainville, Conn.

**Two New Plants:** Colonial Radio, now a Sylvania subsidiary, will soon occupy a new plant at Bloomington, Ill., and will build another at Riverside, Calif. Result will be to speed delivery of sets to Sears

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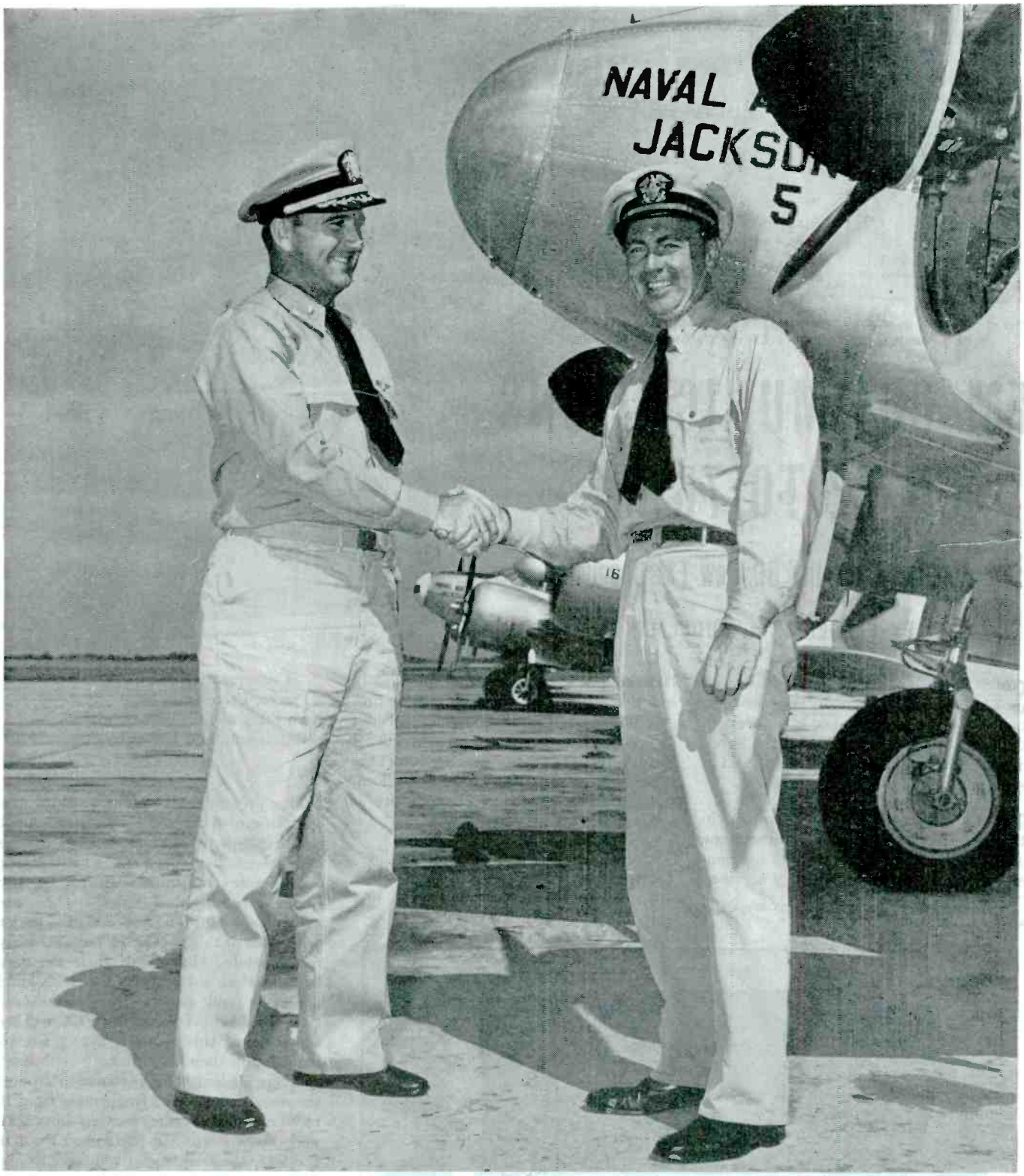


# NEWS PICTURE

LIEUT. COMDR. ARNOLD NYGREN, right, said farewell to Comdr. W. E. Gentner and the U. S. Navy when he left NOATC, Jacksonville, to take over the associate editorship of *FM* AND TELEVISION Magazine.

Arnold Nygren has had an unusually well-rounded experience in the radio industry, and ranks among the pioneers in FM broadcast experience. A radio amateur since 1923, he had three years in retail radio and three years as studio and field engineer at NBC's Radio City in New York.

Then, as technical supervisor and later chief engineer of WFIL, Philadelphia, he installed the first FM transmitter in that city, W53PH, now WFIL-FM. Then, in the Navy, Comdr. Nygren had a unique

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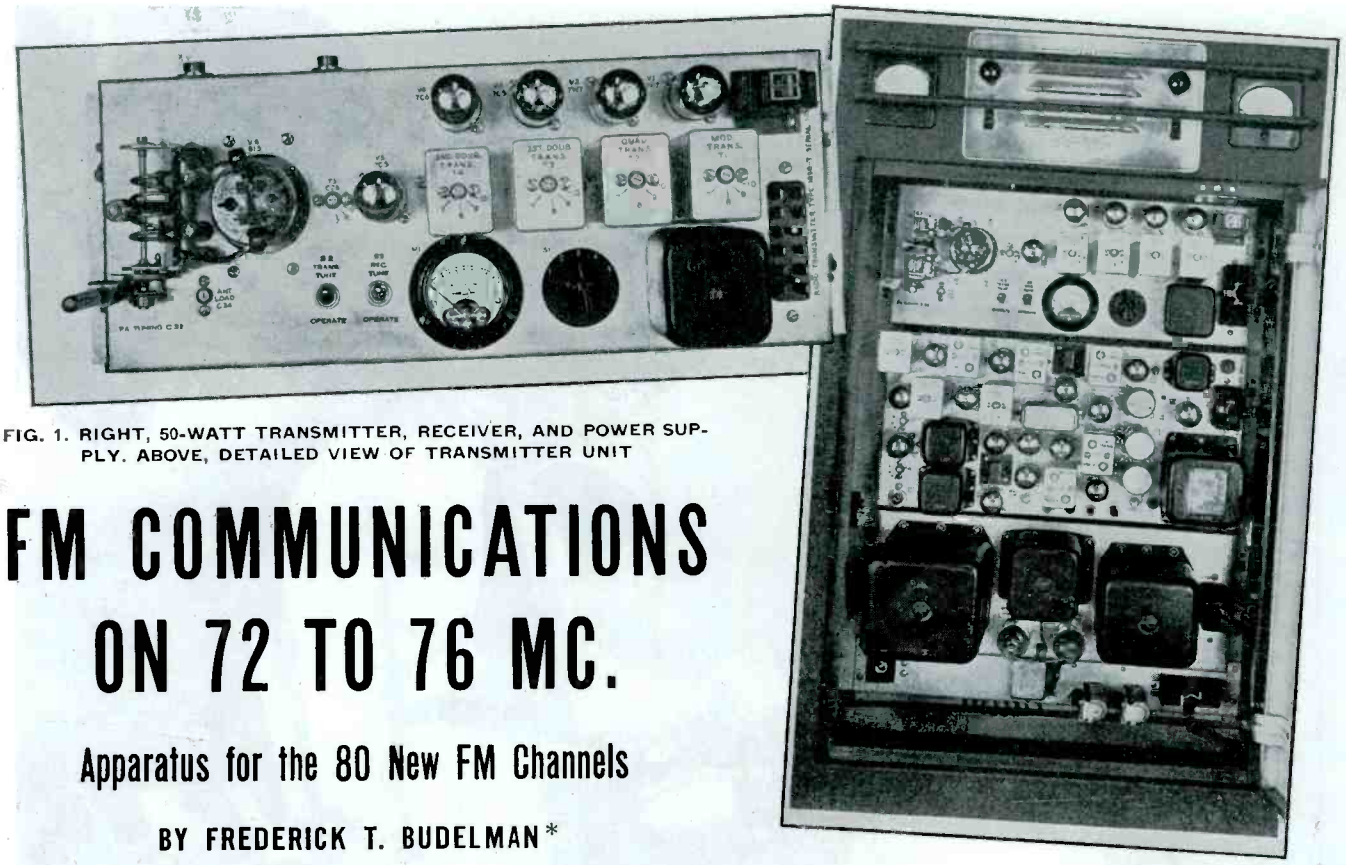


FIG. 1. RIGHT, 50-WATT TRANSMITTER, RECEIVER, AND POWER SUPPLY. ABOVE, DETAILED VIEW OF TRANSMITTER UNIT

# FM COMMUNICATIONS ON 72 TO 76 MC.

## Apparatus for the 80 New FM Channels

BY FREDERICK T. BUDELMAN*

SINCE the assignment of frequencies from 72 to 76 mc. to the emergency services, there has been a great deal of interest in the operating characteristics of the band, in past results on those frequencies, and in equipment available for use on them.

**Channel Assignments** ★ The 80 channels in that band, each 50 kc. wide, represent one of the most important blocks of frequencies available to the emergency services. It is the next logical step from the already crowded 30- to 40-mc. range, and the proposed 42- to 44-mc. band which must first be vacated by existing FM broadcast stations before it can be used for the emergency services. The proposed allocations of the 80 available channels are as follows:

| | |
|---|---|
| Police | 36 |
| Fire | 12 |
| Special Emergency | 10 |
| Urban Transit, Forestry and Conservation | 6 |
| Power, Petroleum, etc. | 6 |
| Forestry and Conservation | 8 |
| Provisional and Experimental | 2 |
| | 80 |

The present FCC plans call for the operation of fixed and mobile equipment on these new frequencies, but no definite assignments have been made for relaying and remote transmitter control on any frequencies suitable for paths which are not line-of-sight. The police, as the major occupants of this new band, have strongly recommended that 12 of their channels be allocated exclusively for relay and operation and remote transmitter controls. It is believed that the FCC will see the logic of this request, and grant its inclusion in their final plan.

There is plenty of experience to support the assignment of the frequencies from 72 to 76 mc. to emergency services in general and relaying work in particular. Prior to the war, the frequencies between 70 and 100 mc. were almost entirely unused, except for a few isolated experimental point-to-point assignments. During the war, however, this frequency range came to be one of the most important and heavily-used in the available spectrum. FM played a large rôle in these operations.

**Military Services on 70 to 100 Mc.** ★ The widespread use of FM in the 70- to 100-mc.

* Chief Engineer, Fred M. Link, 125 West 17th Street, New York 11, N. Y.

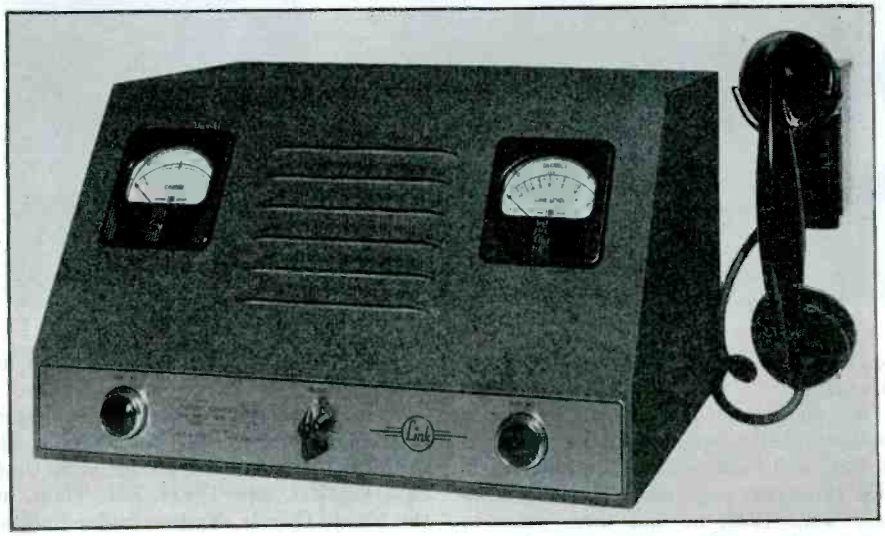


FIG. 2. CONSOLE FOR REMOTE CONTROL OF TRANSMITTER-RECEIVER


FIG. 3. THE ADJUSTMENTS ARE PROVIDED AT THE REAR OF THE CONSOLE

range started with the use by the AAF of the Link 1498 and 1505 equipments for point-to-point and relaying service in connection with radar early-warning nets, and with fighter control nets. The 1498, shown in Fig. 1, is a transmitter-receiver combination with a rated power output of 50 watts. The transmitter is crystal-controlled and phase-shift modulated. Frequency multiplication of 32 times permits a maximum carrier deviation of ±15 kc. The receiver is a triple superheterodyne with intermediate frequencies of approximately 45 mc., 5 mc., and 456 kc.

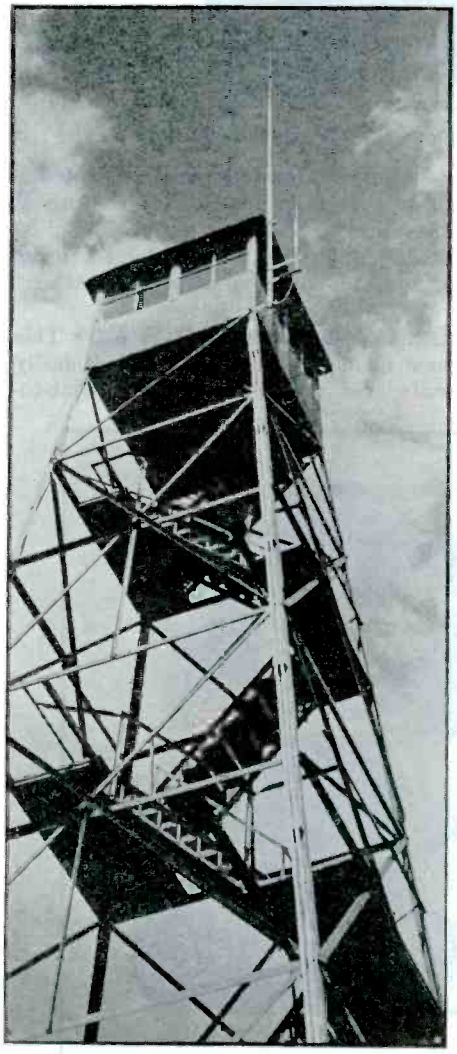


FIG. 4. ADJUSTABLE COAXIAL ANTENNA OF THE TYPE USED FOR 70 MC.

The transmitter is particularly designed to have high attenuation to spurious radiations, and the receiver to have a high attenuation to spurious or image responses to permit using many equipments in the same area with a minimum of cross-channel interference. The receiver sensitivity is of the order of 0.4 microvolt. A carrier-operated relay is incorporated for automatic relaying.

The entire equipment is set up for three different modes of control:

1. Local control from a push-to-talk handset located on or near the equipment cabinet, and utilizing the loudspeaker located at the top of the cabinet.

2. Remote control over 2-wire telephone lines up to 10 miles in length, using the special remote control unit type 1504 supplied with each equipment. This remote control unit, illustrated in Figs. 2 and 3, includes a microphone pre-amplifier with VI meter, line amplifier and loud-speaker for received signals, and a carrier indicator circuit and meter to indicate when the transmitter is actually on the air.

3. Automatic relay operation by means of the receiver carrier-operated relay. In this service the transmitter and receiver are on different frequencies and use separate antennas. When a signal is received the carrier-operated relay functions to turn on the transmitter and connect the receiver audio-output to the transmitter audio input, so that the message is automatically repeated on to the next station. The repeated messages are heard at both the local and remote control points. The remote control point is allowed to take control over the repeater function, and local control is given preference, electrically, over remote control.

The antenna most commonly used for these purposes was the adjustable coaxial type shown in Fig. 4. For special cases, where high directivity was desired, vertically polarized rhombic antennas proved very effective in extending the range. The normal communication range of these sets with coaxial antennas 50 ft. high was considered to be approximately 35 miles in military service, although ranges of several times this figure were often obtained by proper station location.

When greater ranges were desired, the Link-type 1505 transmitter-receiver, Figs. 5 and 6, was used. With 250 watts output, this unit provided increased range and more reliable operation. Except for higher power output, it is essentially identical to the type 1498, Fig. 1.

When the need for a radio relay system for carrying multi-channel carrier-telephone circuits became urgent, the Signal Corps set up experimental circuits utilizing the 1498 equipment. The results of these tests led to the development of the famous "Radio Link" radio relay system AN/TRC-1, AN/TRC-3 and AN/TRC-4.[1]

In this equipment the necessity of transmitting a wide band of audio frequencies, from 20 to 12,000 cycles, led to the use of the greater carrier deviation of ±30 kc. The receiving equipment, Fig. 7, retained the high sensitivity, high selectivity, and carrier-operated relay fea-

[1] For additional details, see "How FM Links Army Wire Systems" by Lieut. Robert W. Eberlich, *FM* AND TELEVISION, April 1945.

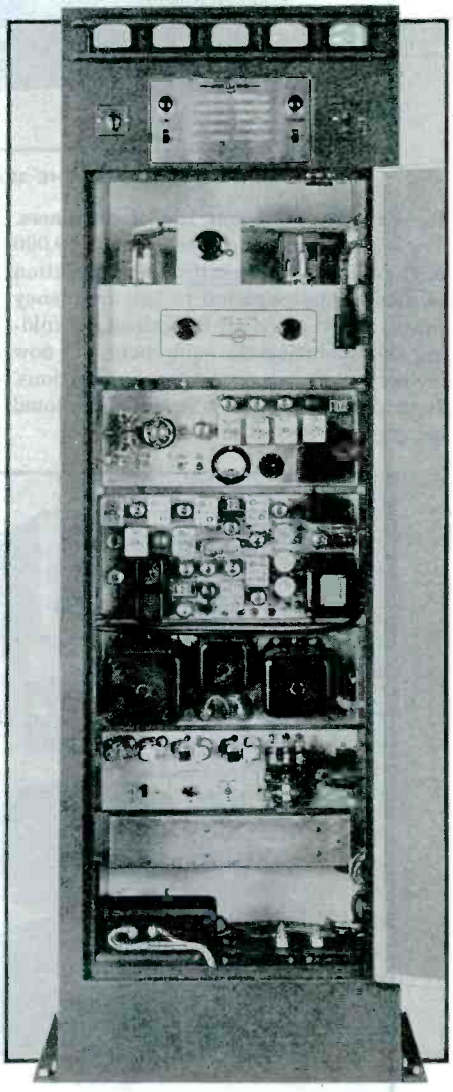


FIG. 5. THE 250-WATT TRANSMITTER AND RECEIVER UNIT FOR 72 TO 76 MC.

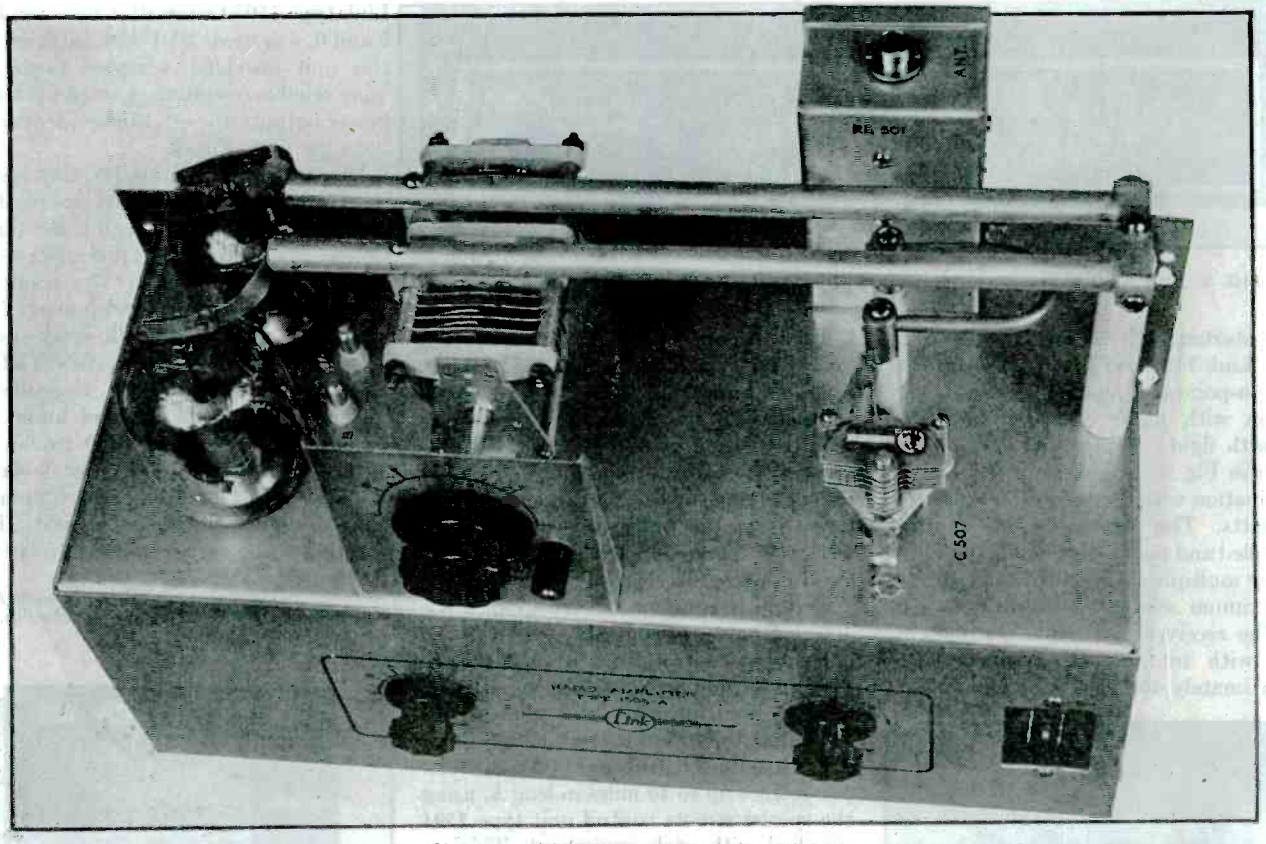



FIG. 6. OUTPUT STAGE OF THE 250-WATT TRANSMITTER, SHOWING THE ARRANGEMENT OF THE 257B (4E27) TUBES

tures of the 1498 and 1505 forerunners. The highly successful use of over 10,000 of these units, the resulting accumulation of data on propagation in this frequency range, and the knowledge gained in building and operating the equipment will now be very useful in peacetime applications. In addition, two very useful directional arrays were perfected.

Two 3-element arrays were developed, one vertically polarized and one horizontally polarized. The radiation patterns in a horizontal plane are shown in Figs. 8 and 9. Either antenna provides a gain of about 6 db over a single half-wave dipole, and either one is extremely useful in point-to-point relay or remote transmitter control circuits. Fig. 10 illustrates the use of the 3-element horizontally polarized antenna in a radio relay system. By the use of these arrays, point-to-point circuits of 50 to 100 miles can be maintained, using transmitter powers well under 50 watts.

**Emergency Services on 72 to 76 Mc.** ★ This new band of frequencies seems ideally suited for use in establishing point-to-

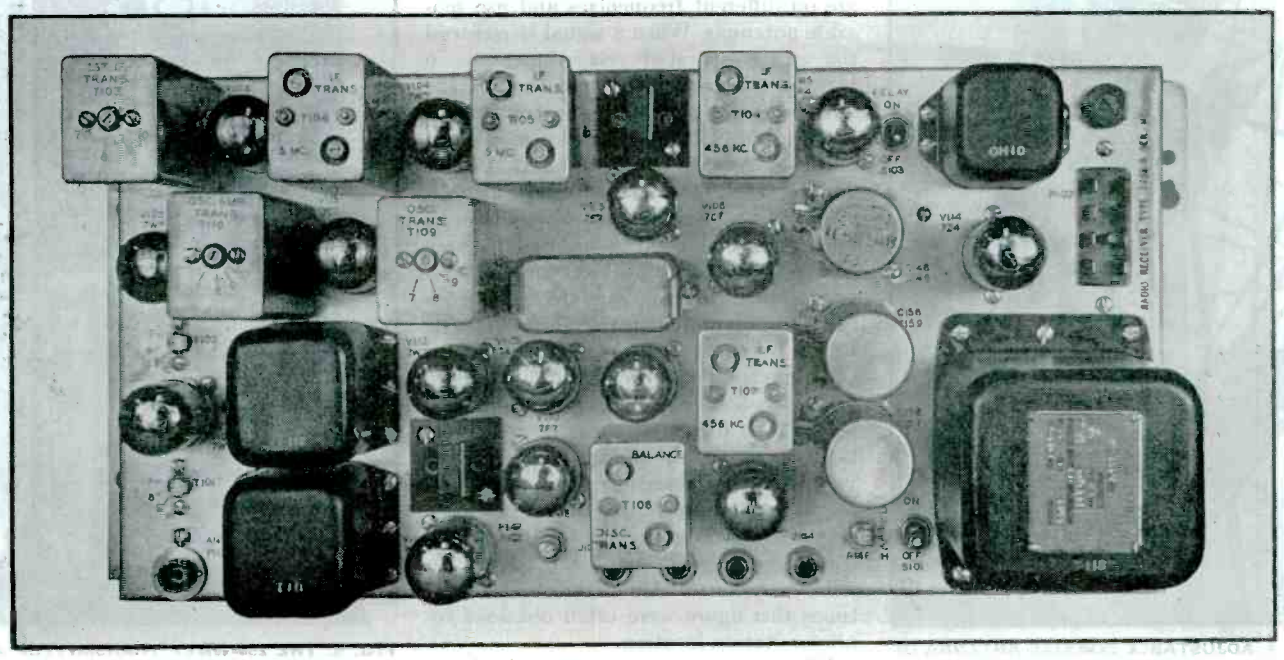
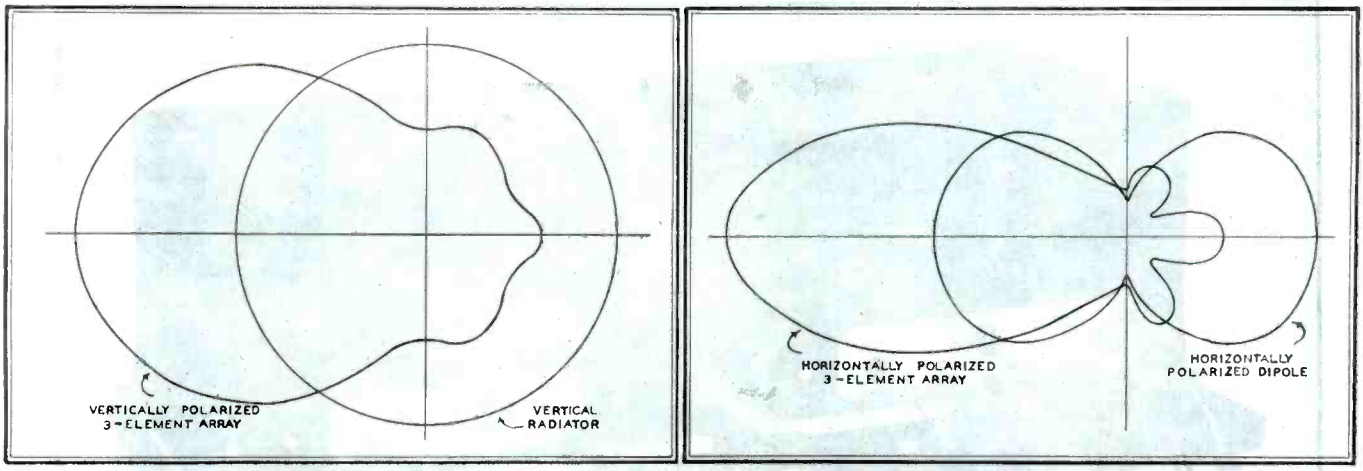



FIG. 7. TOP VIEW OF THE RECEIVER CHASSIS, USED WITH THE 50-WATT AND 250-WATT TRANSMITTERS




FIGS. 8 AND 9. COMPARISONS OF RADIATION PATTERNS OF VERTICALLY AND HORIZONTALLY POLARIZED ANTENNAS

point circuits for relaying, remote transmitter control, and facsimile in the emergency services. The state police, for example, have found that in the majority of cases where relaying, remote transmitter control, or facsimile operation are of greatest value and are economically desirable, the paths are long, and not line-of-sight. The relaying frequencies in the neighborhood of 1,000 mc., proposed by the FCC, require essentially line-of-sight paths. Frequencies in the neighborhood of 160 mc. have also failed in a number of cases to provide communication under conditions that do not interfere with satisfactory operation at 72 to 76 mc.

The type 1498 transmitter-receiver unit, Fig. 1, designed for 72 to 76 mc., is ideally suited for relaying the output of remote pick-up receivers to a central control point. A receiver, tuned to the mobile transmitters in the system, usually on 30 to 44 mc., is substituted in the 1498 cabinet to complete the relay unit. The carrier-operated relay feature is used to energize the relay transmitter only when a signal is actually coming in on the 30- to 40-mc. receiver.

When the 1498 is used to remotely control and modulate a transmitter, auxiliary equipment is added to prevent unauthorized signals on the relay channel from turning on or modulating the controlled transmitter. An audio tone, above the voice frequency range, is used to modulate the transmitter which controls

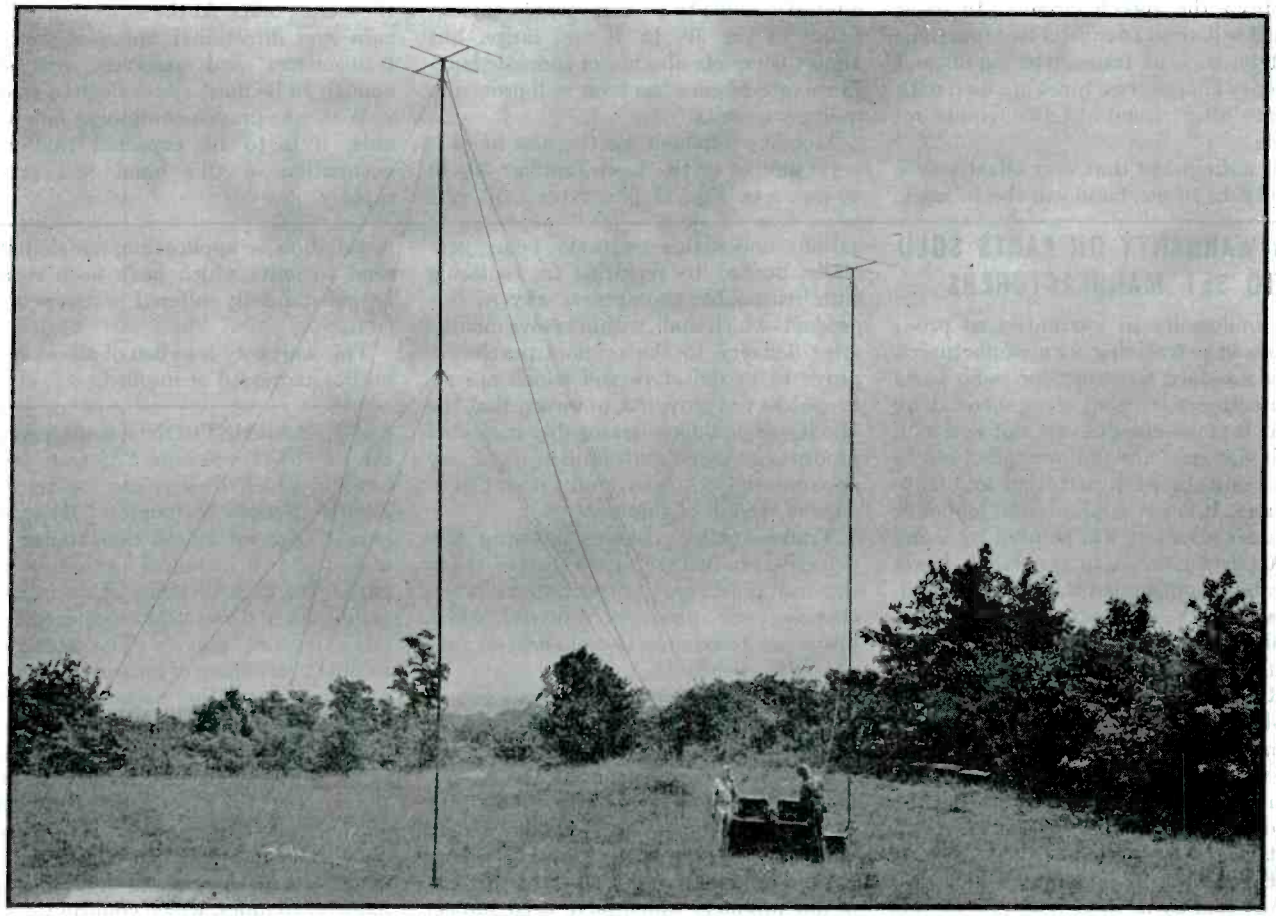


FIG. 10. 3-ELEMENT HORIZONTALLY POLARIZED ANTENNAS USED FOR MILITARY RELAY PURPOSES ON 70 TO 100 MC

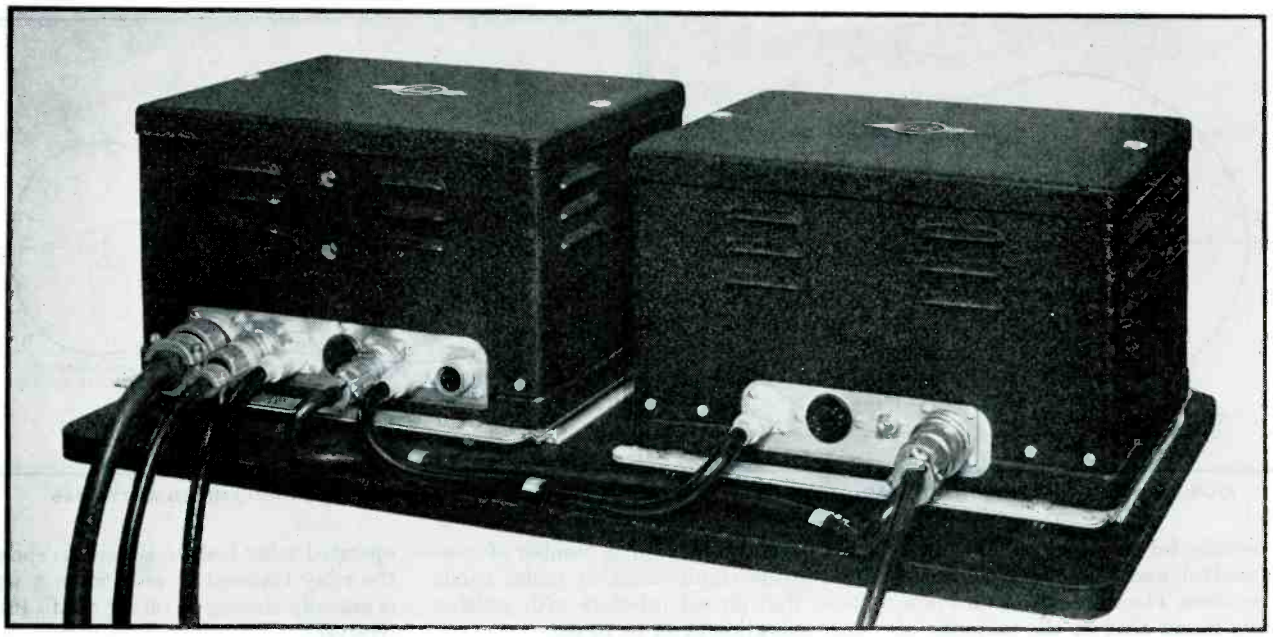


FIG. 11. COMPLETE MOBILE TRANSMITTER AND RECEIVER FOR EMERGENCY SERVICE ON THE 72- TO 76-MC. BAND

the distant installation. The remote receiver energizes the controlled transmitter only when this tone is present. Resonant filters at the receiver admit only the predetermined frequency. The reception of any other modulation frequency has no effect. The filters also remove the control tone from the speech circuits. In cases where it is desired to control two functions remotely, such as transmitter on-off and frequency change, two tones are used with separate filter circuits at the remote receiver.

It is anticipated that very effective use of the 72- to 76-mc. band will also be made in the mobile services. Police groups, representing the major using service, have gone on record as recommending the use of these frequencies for medium long-range applications such as small states or large counties. Field tests bear out the soundness of this recommendation. The noise intensity seems to be comparable to that found in the 30- to 40-mc. range, but almost complete absence of sporadic long-range interference has been well proven in military circuits.

Mobile equipment for the new band is very similar to the more familiar 30- to 40-mc. sets. Fig. 11 illustrates a 50-watt mobile transmitter and receiver for 72 to 76 mc. Vacuum tube efficiencies are still high in this range, and the mobile equipment has no more drain than at 30 mc. for equivalent power output. The smaller mobile antennas, about 3 ft. in length, can be mounted conveniently on the roofs of the mobile units. At the same time, power-gain and directional antennas for fixed transmitters and receivers are small enough to be most convenient to erect.

With war-proven equipment now available, it is to be expected that rapid occupation of this band will proceed rapidly.

## RMA WARRANTY ON PARTS SOLD TO SET MANUFACTURERS

FOR uniformity in warranties on products sold to receiving set manufacturers, a new standard warranty for radio parts manufacturers is being recommended by RMA. It is not compulsory, but optional, and is designed for uniform practices in transactions between parts and set manufacturers. It is not applicable to jobber or consumer sales but will be used by many RMA parts manufacturers. RMA has a separate recommended warranty on products sold to the consumer.

This recommended standard RMA manufacturers' warranty, proposed by the RMA Parts Division under the chairmanship of R. C. Sprague of North Adams, Mass., was developed in coöperation with a committee of receiving set manufacturers, approved by the RMA Board of Directors at its meeting October 11, at Rye, New York:

WE WARRANT all products manufactured or sold by us to be free from defects in materials and workmanship; our obligations under this warranty being generally limited to repairing or replacing with reasonable promptness any of our products which shall, within twelve months after delivery to the original purchaser, prove to be defective and which are returned to us; provided, however, that the purchaser shall have reasonably inspected products received and notified us of any apparent defects discovered within fifteen days of receipt of shipment.

Transportation charges covering any defective products returned shall be at our expense; however, transportation charges covering any products returned which prove not to be defective shall be at purchaser's expense.

Material delivered by us shall not be considered as defective or not in compliance with the order therefor, even though not in exact accordance with specifications, if it satisfactorily fulfills purchaser's performance requirements and/or is in accordance with approved samples.

This warranty does not extend to any of our products which have been subject to misuse, neglect, accident, or improper installation or application, nor shall it extend to units which have been repaired or substantially altered outside of our factory.

This warranty is in lieu of all other warranties expressed or implied.

MAJOR ARMSTRONG, commenting on the FCC's 20-mile FM tests on the basis of which they refute the results of Zenith's tests over 76 miles: "Every competent engineer knows that transmission over the two distances cannot be compared, for at a distance of 20 miles the tropospheric difficulties experienced at 75 miles do not appear. The attempt to refute the accuracy of measurements made at 75 miles by citing measurements made at 20 miles shows a lack of engineering integrity that is impossible to understand.

"It is the more inexplicable in view of the fact that the Engineering Department of the Commission has in its possession measurements made at Andalusia, Pa., over the same distance as the Zenith tests, namely, 75 miles, which confirm the result of the Zenith tests."

# FM BROADCASTING & COMMUNICATIONS HANDBOOK

## Chapter 8: Principles of Automatic Frequency Control, and Applications to FM Receivers

BY BURT ZIMET*

UNLESS a radio receiver is tuned accurately to the frequency of the incoming signals, the audio quality is distorted and there is heavy background noise. Slight mistuning may result from careless manual adjustment or lack of precise resetting in the mechanisms of automatic tuning devices. Even when the initial tuning is accurate, variations in line voltage or thermal drift in circuit components which are affected by changes in ambient temperature may result in mistuning.

Automatic frequency control circuits for AM receivers were introduced about 1936 on remote-controlled models to compensate for errors in the tuning mechanism. For this purpose, AFC proved highly satisfactory. It is doubtful, however, if the use of AFC is justified on manually-operated broadcast receivers as a substitute for accurate adjustment by hand.

**Application of AFC to FM Sets** ★ On FM receivers, AFC has two useful applications:

1. It is practically a requirement on broadcast receivers which employ automatic tuning of the mechanical type. At least, no mechanical device has been perfected so far to the point where it is accurate enough to reset a tuning condenser repeatedly at exact resonance. Also, in the band from 88 to 108 mc., it may prove less expensive to employ AFC than to compensate for drift due to thermal changes.

2. In communications services operating at 152 to 162 mc., and perhaps in the 70-mc. band, AFC will be used to compensate for drift in both mobile and remote relay installations.

Some engineers have expressed the opinion that AFC cannot be used successfully on FM receivers. However, such receivers were developed by Freed Radio Corporation early in the last war, and were produced in great numbers for the U. S. Navy.[1] The circumstances which called for this development are extremely interesting.

In 1942, engineers of the NDRC Underwater Sound Laboratory at New London, Conn., conceived the idea that sounds from a submarine could be picked up in patrol planes by parachuting a radio telephone transmitter down to the surface of the water. The plan was to equip the transmitter with a microphone and a length of cable to be released upon contact with the water. A crude model of the device was built at New London, and a contract was awarded Freed Radio to design and perfect the transmitter and a suitable receiver to pick up the signals.

Transmitters of several different frequencies were used, identified as to their frequency by colored bands. Corresponding color markings were put on the receiver dial to facilitate tuning.

Because the transmitters were not crystal-controlled, they drifted considerably in frequency after they were dropped into the water. And because the aircraft receiver could not be adjusted constantly to follow the transmitter drift, it was necessary to use AFC in the receiver.

The successful operation of this equipment is indicated by the high score of submarines sunk and captured through their use, particularly by planes from the baby flat-tops.

It was possible to observe the AFC action in the tuning eye with which this receiver was equipped. As the tuning was varied, and the circuits were brought near the point of resonance with the incoming signals, the eye closed suddenly and remained closed even beyond the resonance point. There was no critical frequency adjustment, since the AFC action produced a response curve with steep sides and a relatively wide, flat top.

**Elements of the AFC System** ★ An automatic frequency system for AM receivers consists of two major networks. These are:

1. A frequency discriminator which produces a direct current or voltage whose polarity and magnitude are determined by the degree of difference between the nominal IF frequency of the receiver and the heterodyne frequency produced by mixing the incoming signals with the local oscillator frequency.

2. A control circuit to which is applied the direct current or voltage from the discriminator, and which serves to shift the oscillator frequency enough to bring the heterodyne frequency into resonance [2] with the IF circuits.

The use of AFC in FM circuits is somewhat simplified, since the discriminator is an essential part of an FM receiver. This

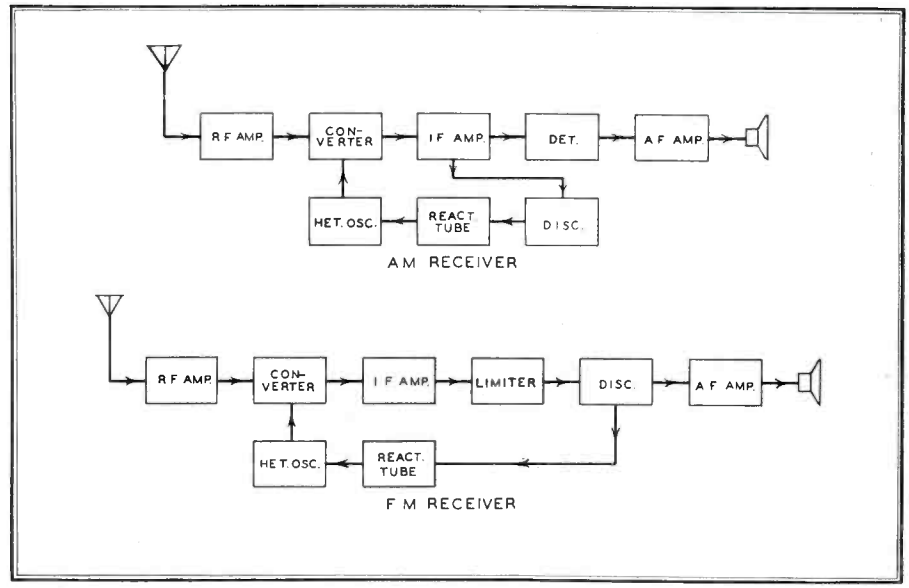



FIG. 71. BLOCK DIAGRAMS SHOWING THE DIFFERENCE BETWEEN AUTOMATIC FREQUENCY CONTROL CIRCUITS FOR AM RECEPTION, ABOVE, AND FOR FM, BELOW

* 2017 E. 24th Street, Brooklyn 29, N. Y.

[1] It should be noted that this was one of the first, if not the very first, uses of FM in Navy radio equipment. Considerable pressure was brought to bear on the Underwater Sound Laboratories to use AM, but in exhaustive comparative tests, FM was found to be so much superior to AM in performance that the FM design was finally adopted.

[2] Absolute compensation is impossible because the correcting voltage results from off-resonance tuning. However, a correction ratio of 100 to 1 or better can be obtained in commercial practice.

is illustrated in Fig. 71, which shows the elements of AM and FM superheterodyne receivers employing AFC. The chief difference, then, between the AM and FM systems is that the FM discriminator stage which is required to demodulate the incoming signals also furnishes the voltage to operate the AFC control on the oscillator.

**AFC Control Circuit** ★ Before discussing the control circuit itself, it might be well to consider first the heterodyne oscillator and to determine just how to best accomplish the desired control of its frequency adjustment. One commonly-used oscillator circuit is the Hartley type, shown in Fig. 72. The frequency of oscillation is determined by the tuned circuit LC. Grid excitation voltage of the proper phase is obtained by connecting the grid and plate of the tube to the ends of inductance L, and connecting the cathode to a tap on the coil. The ratio of the RF plate voltage $E_P$ to the grid exciting voltage $E_G$ is determined by the position of the cathode tap on the coil.

To shift the frequency of oscillation, it is necessary to change the value of the inductance L or the capacity C. While it is possible to do this mechanically, such a method would not serve the purpose of AFC action. However, if we can cause a current which is out of phase with the circulating current to flow through the tank circuit LC, it will appear to the oscillator as though L or C has been varied, thereby causing the reactances to become unbalanced. The oscillator will then shift frequency until the capacitive and inductive reactances are in balance again.

What is necessary to produce AFC action, therefore, is a circuit or network which will produce a varying out-of-phase current flow through the oscillator tank circuit in response to variations in the DC output voltage from the discriminator. This can be accomplished most easily by using a simple vacuum tube circuit, such as is illustrated in Fig. 73. A pentode tube is used, with the plate-cathode circuit shunted across the oscillator tuned circuit, and the control grid bias supplied by a phase-shifting network across the tuned oscillator circuit. The grid voltage

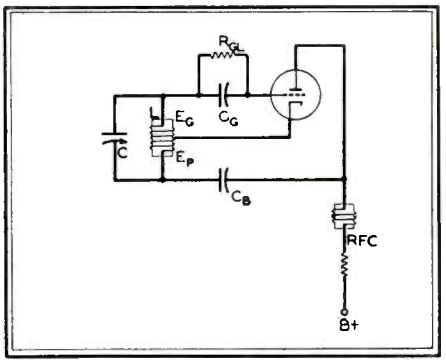



FIG. 72. HARTLEY OSCILLATOR USED FOR SUPERHETERODYNE RECEIVER

is 90° out of phase with the voltage across the tuned circuit, and the resulting plate current is likewise 90° out of phase with the tuned circuit voltage.

Thus the control tube appears as a shunting reactance, the value of which depends upon the transconductance of the pentode and, hence, upon the bias applied to the grid. The disciminator output voltage, applied as a bias on the control grid, varies the transconductance about a value determined by the bias obtained from the tuned circuit. The tube used in this manner is commonly called a reactance tube, since it appears as a reactance to the circuit across which it is connected.

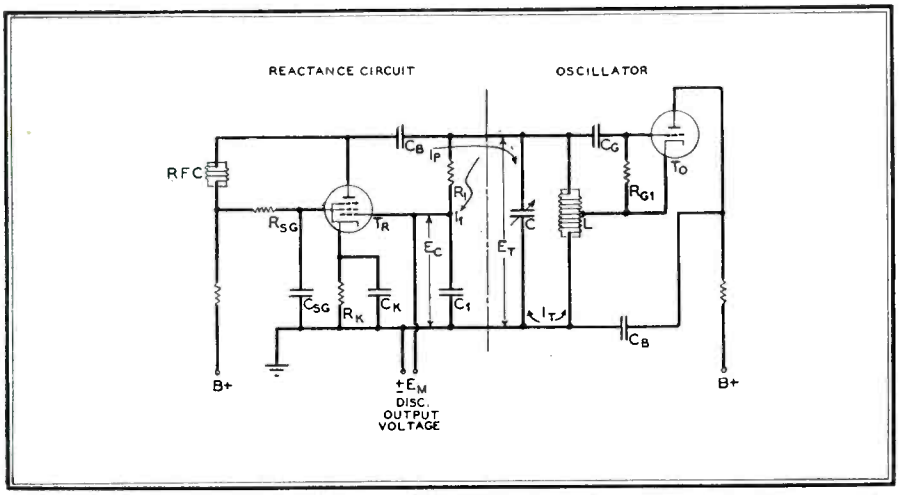



FIG. 73. FREQUENCY OF THE OSCILLATOR, RIGHT, IS VARIED BY THE REACTANCE TUBE, LEFT, WHICH APPEARS TO THE OSCILLATOR AS A VARIABLE REACTANCE

In Fig. 73, the current $I_T$ is in phase with voltage $E_T$. This voltage across the tuned circuit causes the current $I_1$ to flow through the series combination of resistance $R_1$ and capacitance $C_1$. The resistance of $R_1$ is several times larger than the reactance of $C_1$, so that $I_1$ will be in phase with $E_T$. Since $C_1$ presents a practically pure reactance, the voltage $E_C$ across $C_1$ will lag $I_1$ by 90°. This voltage is applied to the grid of the reactance tube $T_R$. The plate current $I_P$ will be in phase with $E_C$, and thus will lag the tuned circuit voltage $E_T$ by 90°. Plate current $I_P$ will essentially flow only through the oscillator tuned circuit, since the impedance of every other possible path is considerably higher than that of LC. (The impedance presented at the operating frequencies is relatively high for the RF choke RFC, and relatively low for the blocking capacitors $C_B$.) To the oscillator, the lagging current flowing through its tuned circuit appears as a decrease in the inductive reactance of L. Therefore, the frequency of oscillation will increase until the inductive and capacitive reactances are balanced, and the oscillator is stable again.

If an inductance is used in the phase-shifting network, in place of capacitor $C_1$, the excitation voltage would lead the current $I_1$, and current $I_P$ would lead voltage $E_T$. This condition would appear as a decrease in capacitive reactance, and the oscillator frequency would decrease to restore stability.

However, it is preferable to use a capacitor at $C_1$, rather than an inductance, for a number of reasons. The $Q$ of a capacitor is generally higher than that of an inductance, which would make the phase shift more nearly 90°. The distributed capacity of an inductance may resonate it within the frequency range used, causing the control action to disappear at the resonant frequency.

It is important that the plate current $I_P$ and the tuned circuit voltage $E_T$ be as nearly 90° apart in phase as is possible, in order that there will be no resistive component of $I_P$. If such a component exists, it will act as a resistance shunted across the tuned circuit LC, causing the amplitude of the oscillator output to vary with the magnitude of the frequency shift which the AFC circuit is correcting.

The magnitude of the apparent reactance shunted across LC by the reactance tube varies inversely with the plate current $I_P$. Current $I_P$ depends directly upon the transconductance of the reactance tube, which is, in turn, controlled by the grid voltage $E_C$. The total static grid voltage locates the operating point on a linear portion of the transconductance characteristic, and the discriminator output voltage $\pm E_M$ varies the transconductance about the operating point. Since there will be a certain amount of reactance added to the tuned circuit LC even when there is no frequency shift, i.e., when $E_M = 0$, it is necessary to take this into account when designing the tuned cir-

cuit, in order to have it cover the desired frequency range.

It is interesting to compare the use of the reactance tube for AFC with its application to frequency modulation for FM transmitters, the details of which were set forth in Chapter 4.

**Discriminator Circuits** ★ Either the detuned-circuit discriminator or the center-tuned discriminator can be used in conjunction with the AFC control circuit. Both types of discriminators are described in Chapter 7, together with an explanation of their functions.

From either type, a DC voltage can be obtained, the magnitude and polarity of which are determined by the extent of the difference between the heterodyne frequency and the nominal IF frequency of the receiver, as is required to operate the AFC control circuit.

**AFC Operation** ★ There are a number of other possible methods of controlling the frequency of oscillation, but the one discussed herein has proved to be highly satisfactory in commercial practice. Of course, in the practical application of the system to any particular receiver there will be considerable variation in details, but the basic circuit would be retained.

It may be helpful to review briefly the sequence of operation of the entire system, from the input to the discriminator transformer to the final correction of the heterodyne oscillator frequency.

A complete circuit, combining a discriminator and control, is shown in Fig. 74. The discriminator transformer is tuned to the IF frequency, and the oscillator is adjusted to the proper frequency to produce the IF beat frequency when heterodyned with the incoming signal.

When the receiver is correctly tuned and there have been no changes in components or adjustments due to thermal effects, the IF signal applied to the discriminator transformer primary produces equal and opposite voltages across the secondary. The primary voltage appears, with essentially the same magnitude and phase, across the RF choke. One secondary voltage leads this primary voltage by 90°, the other secondary voltage lags the primary voltage by 90°. The total voltage applied to each diode rectifier consists of the voltage across the RF choke, i.e., the primary voltage, plus the voltage across the corresponding half of the secondary. Since the secondary voltages are equal, and the primary voltage is common to both diodes, the DC output voltages across the load resistors are equal and opposite, hence, there is zero voltage applied to the grid of the reactance tube.

The quadrature voltage developed across $C_1$, due to the in-phase current flow produced by the oscillator tuned circuit voltage, is also applied to the grid of the reactance tube, in addition to the self-bias due to the voltage drop across the cathode resistor. This excitation causes a lagging current to flow through the oscillator tuned circuit. To the oscillator it appears as though an inductive reactance were shunted across its tuned circuit. However, these conditions are termed quiescent, or normal, stable conditions, and the apparent reactance produced by the reactance tube has already been taken into account in designing the tuned circuit for proper frequency range.

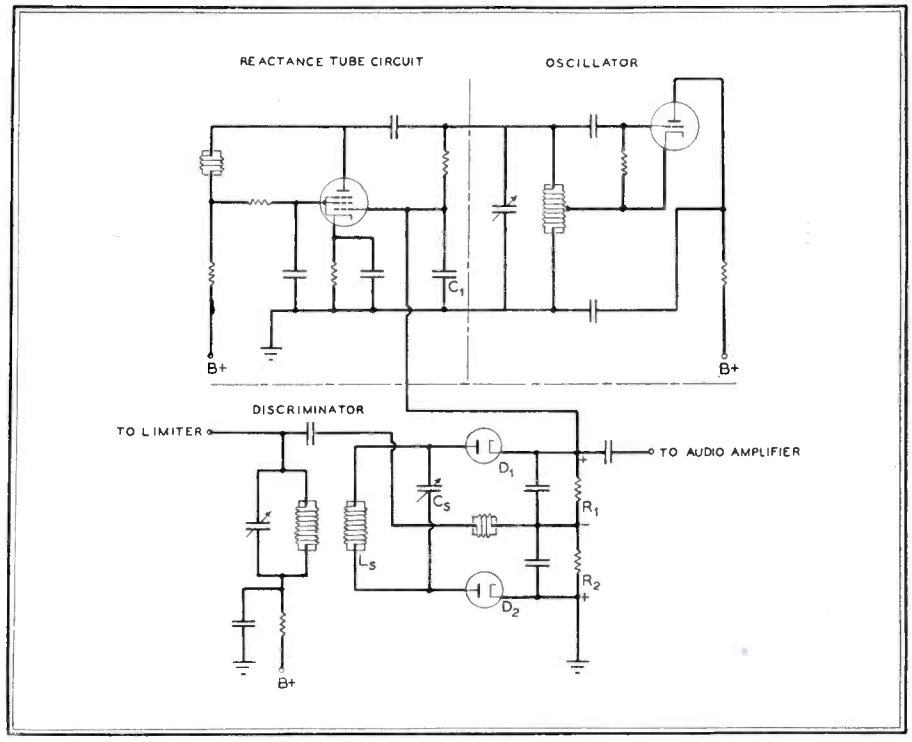



**FIG. 74. COMPLETE AFC CIRCUIT, SHOWING THE FM DISCRIMINATOR WHICH SUPPLIES A VOLTAGE TO THE REACTANCE TUBE ACROSS THE OSCILLATOR CIRCUIT**

Now, if the receiver is tuned slightly below the desired frequency, so that the signal applied to the IF amplifier is slightly higher in frequency than the amplifier resonant frequency, it will be necessary for the AFC system to retune the oscillator. The same requirements would exist if thermal changes caused the oscillator to drift to a lower frequency.

With the applied frequency higher than the resonant frequency, the inductive reactance of $L_S$ will exceed the capacitive reactance of $C_S$, hence the voltages across $L_S$ will lag. The AC voltage applied to diode $D_1$ will be greater than that applied to diode $D_2$, and the DC voltage across $R_1$ will then be the larger, applying a positive bias to the reactance tube grid. A less negative total bias will cause an increase in the reactive plate current flowing in the oscillator tuned circuit, the total effective inductive reactance will be reduced, and the oscillator will increase frequency to balance the tuned circuit reactances and restore the IF signal to the resonant frequency of the amplifier.

If the receiver is off-tune on the high side of the desired signal, so that the signal is lower in frequency than the resonant frequency of the IF amplifier, or thermal changes in the oscillator circuit cause the oscillator frequency to increase, the capacitive reactance of $C_S$ will predominate over the inductive reactance of $L_S$. Thus, the secondary voltages will lead, making the voltage across $R_2$ the larger, and a negative bias will be applied to the reactance tube. The increase in negative bias reduces the reactive plate current, and therefore increases the apparent reactance shunted across the oscillator tuned circuit. To restore reactance balance and bring the IF frequency signal to the proper frequency, the oscillator will lower its frequency.

## EMERGENCY RADIO ISSUE

The January issues of *FM* and TELEVISION will contain the semi-annual Directory of Emergency Stations. In addition to listing police, fire, forestry, and public utility radio stations and the names of the radio supervisors, the new Directory will include stations by railroads, bus lines, taxis, and trucking companies. The Directory listings will be completely revised and brought up to date.

# CONDITIONAL GRANTS FOR NEW FM STATIONS

## 129 FM Grants Issued by FCC up to November 2, 1945 Left 550 Applications to Be Acted Upon

| City | Applicant | AM Affiliate |
|---|---|---|
| **ALABAMA** | | |
| Birmingham | [1]Johnston B/C Co. | WJLD |
| Mobile | [1]W. O. Pape tr/as Pape B/C Co. | WALA |
| Mobile | [1]Mobile Dly. Nsp. Inc. | —— |
| Montgomery | [1]G. W. Covington, Jr. | WCOV |
| Montgomery | [2]Mont. B/C Co., Inc. | WSFA |
| **ARKANSAS** | | |
| Fort Smith | [2]Donald W. Reynolds | —— |
| **CALIFORNIA** | | |
| Fresno | [2]J. E. Rodman | KFRE |
| **FLORIDA** | | |
| Ft. Lauderdale | [1]Gore Pub. Co. | —— |
| Jacksonville | [1]Florida B/C Co. | WMBR |
| Miami | [1]Isle of Dreams B/C Corp. | WIOD |
| Miami | [1]Miami B/C Co. | WQAM |
| Miami Beach | [1]A. Frank Katzentine | WKAT |
| Orlando | [2]Orlando Dly. Nsp., Inc. | —— |
| St. Petersburg | [1]Pinellas B/C Co. | WTSP |
| Tampa | [1]The Tribune Co. | WFLA |
| **GEORGIA** | | |
| Atlanta | [1]The Constitution Pub. Co. | —— |
| Augusta | [1]Augusta B/C Co. | WRDW |
| Columbus | [1]Ga.-Ala. B/C Corp. | —— |
| Macon | [1]Middle Ga. B/C Co. | WBML |
| Macon | [1]Southeastern B/C Co. | WMAZ |
| Moultrie | [1]Frank R. Pidcock, Sr. | WMGA |
| **IDAHO** | | |
| Boise | [1]Georgia Phillips, d/b as Boise B/C Station | KIDO |
| Pocatello | [1]Radio Service Corp. | KSEI |
| **ILLINOIS** | | |
| Bloomington | [1]Arthur Malcolm McGregor & Hugh L. Gately, ptnshp. d/b as Radio Station WJBC | WJBC |
| Champaign | [3]The Champaign News-Gazette, Inc. | WDWS |
| Freeport | [1]Free. Jnl-Stand. Pub. Co. | —— |
| Herrin | [2]Orville W. Lyerla | WJPF |
| Rock Island | [1]Rock Island B/C Co. | WHBF |
| **INDIANA** | | |
| Connersville | [1]News-Examiner Co. | —— |
| Elkhart | [1]Truth Pub. Co., Inc. | WTRC |
| Kokomo | [1]Kokomo B/C Corp. | WKMO |
| Lafayette | [1]WFAM, Inc. | WASK |
| **IOWA** | | |
| Burlington | [2]Burlington B/C Co. | KBUR |
| Cedar Rapids | [1]The Gazette Co. | —— |
| Des Moines | [2]Central B/C Co. | WHO |
| Dubuque | [2]Dubuque B/C Co. | WKBB |
| Dubuque | [2]Telegraph-Herald | KDTH |
| Waterloo | [2]Josh Higgins B/C Co. | KXEL |
| **KANSAS** | | |
| Lawrence | [1]The World Co. | —— |
| Topeka | [1]Topeka B/C Assoc., Inc. | WIBW |
| Wichita | [1]The Farmers & Bankers B/C Corp. | KFBI |
| **KENTUCKY** | | |
| Louisville | [1]WAVE, Inc. | WAVE |
| Louisville | [1]Courier-Jnl. & Louis. Times Co. | WHAS |
| Louisville | [1]Northside B/C Corp. | WGRC |
| Owensboro | [1]Owensboro B/C Co., Inc. | WOMI |
| Paducah | [1]Paducah B/C Co., Inc. | WPAD |
| **LOUISIANA** | | |
| Alexandria | [1]Alex. B/C Co., Inc. | KALB |
| New Orleans | [1]The Times Picayune Pub. Co. | —— |
| New Orleans | [1]Loyola University | WWL |
| **MAINE** | | |
| Bangor | [1]Portland B/C System, Inc. | WGAN |
| **MINNESOTA** | | |
| Mankato | [1]Southern Minn. Sup. Co. | KYSM |
| Minneapolis | [1]Minn. B/C Corp. | WTCN |
| St. Paul | [2]KSTP, Inc. | KSTP |
| St. Paul | [1]WMIN B/C Co. | WMIN |
| **MISSOURI** | | |
| Kansas City | [1]The Kansas City Star Co. | WDAF |
| Kansas City | [1]WHB B/C Co. | WHB |
| St. Louis | [1]Mo. B/C Corp. | WIL |
| St. Louis | [1]The Pulitzer Pub. Co. | KSD |
| St. Louis | [1]Star-Times Pub. Co. | KXOK |
| St. Louis | [1]Thomas Patrick Inc. | KWK |
| **NEBRASKA** | | |
| Lincoln | [1]Cornbelt B/C Corp. | KFOR |
| Omaha | [1]Inland B/C Co. | KBON |
| Omaha | [2]World Pub. Co. | KOWH |
| **NEVADA** | | |
| Las Vegas | [3]Nevada B/C Co. | KENO |
| Reno | [1]Reno Newspapers, Inc. | —— |
| **NORTH CAROLINA** | | |
| Burlington | [1]Alamance B/C Co., Inc. | WBBB |
| Durham | [1]Durham Radio Corp. | WDNC |
| Greensboro | [1]Greens. News Co. | —— |
| High Point | [1]James E. Lambeth, et al., d/b as R. Sta. WMFR | WMFR |
| Raleigh | [2]WPTF Radio Co. | WPTF |
| Roanoke Rapids | [1]Telecast Inc. | —— |
| Roanoke Rapids | [1]WCBT, Inc. | WCBT |
| Rocky Mount | [1]Josh L. Horne | —— |
| Rocky Mount | [1]William Avera Wynne | WEED |
| Salisbury | [1]Piedmont B/C Corp. | WSTP |
| Washington | [1]Tar Heel B/C Sys., Inc. | WRRF |
| Wilmington | [1]Richard Austin Dunlea | WMFD |
| Winston-Salem | [1]WAIR B/C Co. | WAIR |
| **OKLAHOMA** | | |
| Muskogee | [1]Muskogee B/C Co. | —— |
| Oklahoma City | [2]KOMA, Inc. | KOMA |
| Oklahoma City | [2]Plaza Court B/C Co. | KOCY |
| Oklahoma City | [2]WKY Radiophone Co. | WKY |
| Oklahoma City | [1]O. L. Taylor | KTOK |
| Shawnee | [1]KGFF B/C Co. | KGFF |
| Tulsa | [1]Fred Jones B/C Co. | —— |
| **OREGON** | | |
| Medford | [1]Mrs. W. J. Virgin | KMED |
| Portland | [2]KXL Broadcasters | KXL |
| Portland | [1]KOIN, Inc. | KOIN |
| Portland | [1]Oregonian Pub. Co. | KGW |
| Portland | [1]Pacific Rad. Avt. Ser. a ptns. composed of John C. Egan & Wilbur J. Jerman. | KWJJ |
| Portland | [1]Stanley M. Goard, et al., d/b as Broadcasters Oregon, Ltd. | —— |
| **SOUTH CAROLINA** | | |
| Anderson | [2]Wilton E. Hall | WAIM |
| Charleston | [1]Atlantic Coast B/C Co. | WTMA |
| Columbia | [1]Surety Life Ins. Co. | WIS |
| Greenville | [1]Textile B/C Co. | WMRC |
| Greenville | [1]The Green. News-Piedmont Co. | WFBC |
| Spartanburg | [2]Spartanburg Avt. Co. | WSPA |
| **TENNESSEE** | | |
| Chattanooga | [1]WDOD B/C Corp. | WDOD |
| Clarksville | [1]Leaf-Chronicle Co. | —— |
| Jackson | [1]The Sun Pub. Co., Inc. | WTJS |
| Knoxville | [1]S. E. Adock | WROL |
| Knoxville | [1]Knoxville Pub. Co. | —— |
| Memphis | [1]Herbert Herff | —— |
| Nashville | [1]Jack M. Draughon & Louis R. Draughon d/b as WSIX B/C Station | WSIX |
| **TEXAS** | | |
| Beaumont | [1]KRIC, Inc. | KRIC |
| Brownsville | [2]Browns. Herald Pub. Co. | —— |
| Galveston | [1]The KLUF B/C Co., Inc. | KLUF |
| Harlingen | [1]Harbenito B/C Co., Inc. | KGBS |
| Houston | [1]Houston Printing Corp. | KPRC |
| Houston | [1]KTRH B/C Co. | KTRH |
| San Antonio | [1]The Walmac Co. | KMAC |
| Texarkana | [1]KCMC Inc. | KCMC |
| **UTAH** | | |
| Salt Lake City | [1]Intermountain B/C Corp. | KDY |
| **VIRGINIA** | | |
| Norfolk | [1]WTAR Radio Corp. | WTAR |
| Portsmouth | [1]Portsmouth Rad. Corp. | WSAP |
| Richmond | [1]Havens & Martin, Inc. | WMBG |
| **WASHINGTON** | | |
| Seattle | [2]Queen City B.C. Co., Inc. | KIRO |
| Seattle | [1]Evergreen B/C Corp. | KEVR-KTYW |
| Seattle | [1]Radio Sales Corp. | KRSC |
| Seattle | [2]Fisher's Blend Sta. Inc. | KOMO |
| **WEST VIRGINIA** | | |
| Beckley | [2]Joe L. Smith, Jr. | WJLS |
| Beckley | [1]Beckley Nsp. Corp. | —— |
| Bluefield | [2]Daily Tele. Print Co. | WHIS |
| **WISCONSIN** | | |
| LaCrosse | [2]WKBH, Inc. | WKBH |
| Madison | [2]Badger B/C Co. | WIBA |
| Milwaukee | [1]Glenn D. Roberts, et al., d/b as Milwaukee B/C Co. | WEMP |
| Racine | [1]Racine B/C Corp. | WRJN |
| Sheboygan | [1]Press Publishing Co. | WHBL |
| **WYOMING** | | |
| Cheyenne | [1]Frontier B/C Co. | KFBC |

[1] Indicates Metropolitan station.
[2] Metropolitan station, possibly Rural.
[3] Community station.

## FCC LABORATORY DIVISION

A NEW Laboratory Division has been set up within the FCC Engineering Department, to study civilian uses of radar as they affect frequency allocations, to conduct propagation studies, develop new monitoring equipment, test all types of transmitters for type approval, and check diathermy and industrial heating equipment.

Charles A. Ellert, formerly technical supervisor of the Radio Intelligence Division, will be Chief of the new Division, with Wilmar K. Roberts, formerly engineer in charge of the Laurel Laboratory, as Assistant Chief.

# DISCUSSION OF THE SECRET FM HEARING

## An Examination of the Testimony, Now Declassified, of the FCC Hearing on March 12th and 13th, 1945

BY PAUL A. DE MARS*

IN ORDER that the issues under consideration at the secret hearing before the Federal Communications Commission on March 12th and 13th, 1945, may be presented with proper perspective and orientation, there is first presented a brief historical background.

**Background** ★ Frequency Modulation was disclosed to the radio art in October, 1935. The occasion was a demonstration before the Institute of Radio Engineers in New York City. Hardly a ripple of interest was aroused by this disclosure and it is interesting to note that the revolutionary implications in the field of communications and broadcasting were missed by the attending engineers..

In June, 1936 the FCC held an informal engineering conference at Washington, D. C., in the matter of "the allocation of frequencies above 30,000 kc. and the review of present frequency allocations." At this conference, Major Armstrong presented a sound-on-film recording of a comparison of FM and AM reception. The comparison was between reception of FM signals from a transmitter radiating about 2 kw. on a frequency of 41 mc. from an antenna located on top of the Empire State Building in New York City, and the 50-kw. standard broadcast station WEAF. The receiving point was at Haddonfield, N. J., a distance of 85 miles. The recordings strikingly presented the marked superiority of FM at 41 mc. over the standard band in quality of service and reduction of noise. Nevertheless only Major Armstrong and the writer spoke for the inclusion of a band of frequencies above 40 mc. for the development of FM, and predicted the revolutionary implications of the demonstration. It is worth noting that the reception recorded at Haddonfield was at a distance of 85 miles from the transmitter, which is beyond the primary service range of the 50-kw. clear-channel AM standard broadcast stations in this area. The Commission did allocate the band 42.5 to 43.5 mc. for FM experimentation.

The pioneering in FM by Major Armstrong, the Yankee Network, F. M. Doolittle, and others directed the attention of the broadcasters to this new development. Of special significance was the fine reception demonstrated at distances of 75 miles and more from the high-power stations at Alpine and Paxton.

**FOLLOWING the Secret FM Hearing on March 12 and 13, 1945, there were intimations that serious errors in certain conclusions by the FCC's engineering department were suppressed by impounding the records under the cloak of military restrictions.**

**One of those conclusions was that F2-layer transmission would go twice as high in frequency as had been considered possible by others. Much publicity was given to this finding as a reason for shifting FM broadcasting to 88 to 108 mc. At the Secret Hearing, it was determined that the frequency increase was not 100%, but only 7%. Nevertheless, the Commission suppressed this information, and continued to offer the erroneous conclusion as a reason for shifting the FM band.**

**Although the records were declassified after V-J Day, nothing has been published on this subject, probably because few radio engineers have the background of knowledge and personal experience to analyze and discuss this testimony.**

**One of the engineers so qualified is Paul A. de Mars. For military reasons, he was not permitted to take part in the Allocations Hearings, as he was then commissioned as a Lieutenant Commander in the U. S. Navy. However, he did attend as an observer. His discussion of the Secret FM Hearing, therefore, is written from his own observation of the proceedings.**

Recognizing that broadcasting in the VHF band was inevitable, the FCC ordered a hearing in March, 1940. At that time, there were some who favored AM for this band, but the advantages of FM were so conclusively demonstrated that FM was selected for VHF broadcasting, and the band of 42 to 50 mc. was assigned.

Testimony at this hearing covered very thoroughly the propagation characteristics of frequencies above and below 40 mc. This testimony was in accord with the engineering facts, and recognized that a band from about 40 mc. up would provide the best service.

Then came the war, and the Radio Technical Planning Board was created at the request of the FCC. The RTPB reported that the consensus of its members favored the 42- to 50-mc. band for FM. However, upon the insistence of some network engineers who raised the question of the importance of the sky wave phenomena which might be expected to exist at certain positions of the sunspot cycle, the matter was referred to Dr. Dellinger, who resolved it in favor of the present band.

Dr. Dellinger's comment on the RTPB Panel 5 recommendation,

> "Be it hereby resolved that it is the consensus of this Committee that the present position of FM Broadcasting in the spectrum should not be changed,"

is worthy of being fully quoted:

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
WASHINGTON, D. C.

May 1, 1944

Mr. C. M. Jansky, Jr.,
970 National Press Bldg.,
Washington 4, D. C.

Dear Mr. Jansky:

I have your letter of April 20 requesting any information I can give on item 2 of the agenda for the April 11 meeting of RTPB Panel 5. I read pages 13 to 60 of the proceedings of the meeting as you suggested, and noted in particular that the motion on page 44 read: "I move you that subject to any information to the contrary from Dr. Dellinger, that this Panel adopt the recommendations of the Committee with respect to item 2 of this agenda." The Committee recommendation referred to was: "Be it hereby resolved that it is the consensus of this Committee that the present position of FM Broadcasting in the spectrum should not be changed."

The point in question is that the fre-

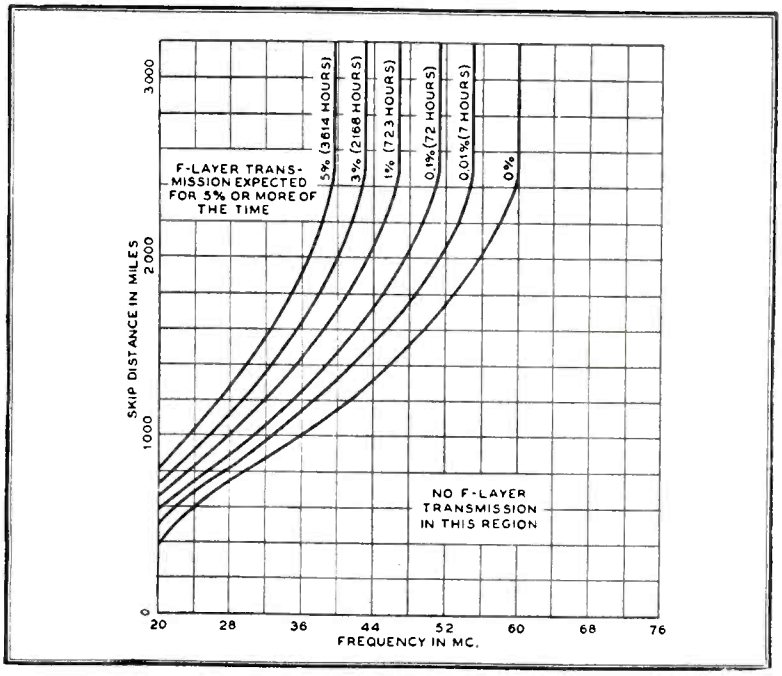
* 1469 Church Street, N. W., Washington 5, D. C.

quencies concerned are sometimes affected by long-distance interference, contrary to an expectation that was widely held at one time, and there is a fear that this interference may be so great as to seriously impair the usefulness of those frequencies for broadcasting. Essentially the Panel appears to request that I inform it whether that fear is well founded. *I believe I may with propriety respond to this request, and the answer is that the fear is not well founded.* (Author's italics.)

During certain years of the sunspot cycle F2-layer transmission at those frequencies occurs over long distances for short parts of the day, and sporadic-E transmission occurs at irregular times in all years. The phenomenon of very short bursts of long distance interference appears to be closely associated with, and possibly a manifestation of, sporadic E transmission. The extent of these effects, however, is not such as to seriously impair the value of these frequencies. *It may also be stated that no radio frequencies are free from transmission vagaries.* (Author's italics.)

I surmise that a general statement of this kind is all that the Panel wishes. If it desires specific propagation data so as to go into the subject quantitatively, I shall be glad to take up the request with the military committee which controls the work of my laboratory.

Very truly yours,
(signed) J. H. DELLINGER,
*Chief, Radio Section.*




**NORTON FIG. 1 — EXHIBIT 380**

PERCENTAGE of the listening hours and (in parentheses) the number of listening hours (6 A.M. to Midnight) during the last sunspot cycle (1933–1944) for which the F-layer skip distance was less than the values shown for particular frequencies. *Estimated from the National Bureau of Standards Ionosphere measurements at Washington, D. C.*

**FCC Hearings** ★ The work of the RTPB finally came to hearing before the FCC in October 1944 and, barring some desultory observations, no one undertook to challenge its findings until a few days before the ending of the hearing. Then came a bombshell. The FCC authority on propagation, K. A. Norton, on the basis of some recently declassified information, predicted world-wide interference from the F2 ionosphere layer at frequencies 100% higher than would be expected from any previous data.

Time did not permit thorough examination of the Norton figures, both with respect to the extrapolations and the assumptions from which they were derived. Furthermore, Mr. Norton's definite predictions of F2 skywave interference from without the country were based upon ionosphere measurements at a then unidentified part of the world. Declassification of this material permits the disclosure that the site of these measurements was the island of Maui, Territory of Hawaii.

Subsequently, Dr. Beverage pointed out in a supplemental statement certain errors in the Norton testimony.

Nevertheless, on January 15, 1945, the FCC issued its proposed allocations, with FM moved up in frequency, and on February 26, 1945, began its hearings of oral argument on its findings regarding FM.

The Norton's testimony and Exhibit 380 were reviewed carefully by the following group of men who have had long experience in propagation matters:

Dr. H. H. Beverage
Dr. G. W. Pickard
Dr. H. T. Stetson
Dr. C. R. Burrows
Mr. Stuart Bailey
Dr. Edwin H. Armstrong.

They were in agreement as to the existence of basic error in Mr. Norton's prediction concerning F2 layer interference. The conclusions reached are covered in a memorandum prepared by Doctors Beverage, Burrows, and Armstrong.

A separate Armstrong brief was presented with that memorandum at the oral argument. His brief and the memorandum were published in full in the March, 1945, issue of *FM* AND TELEVISION.

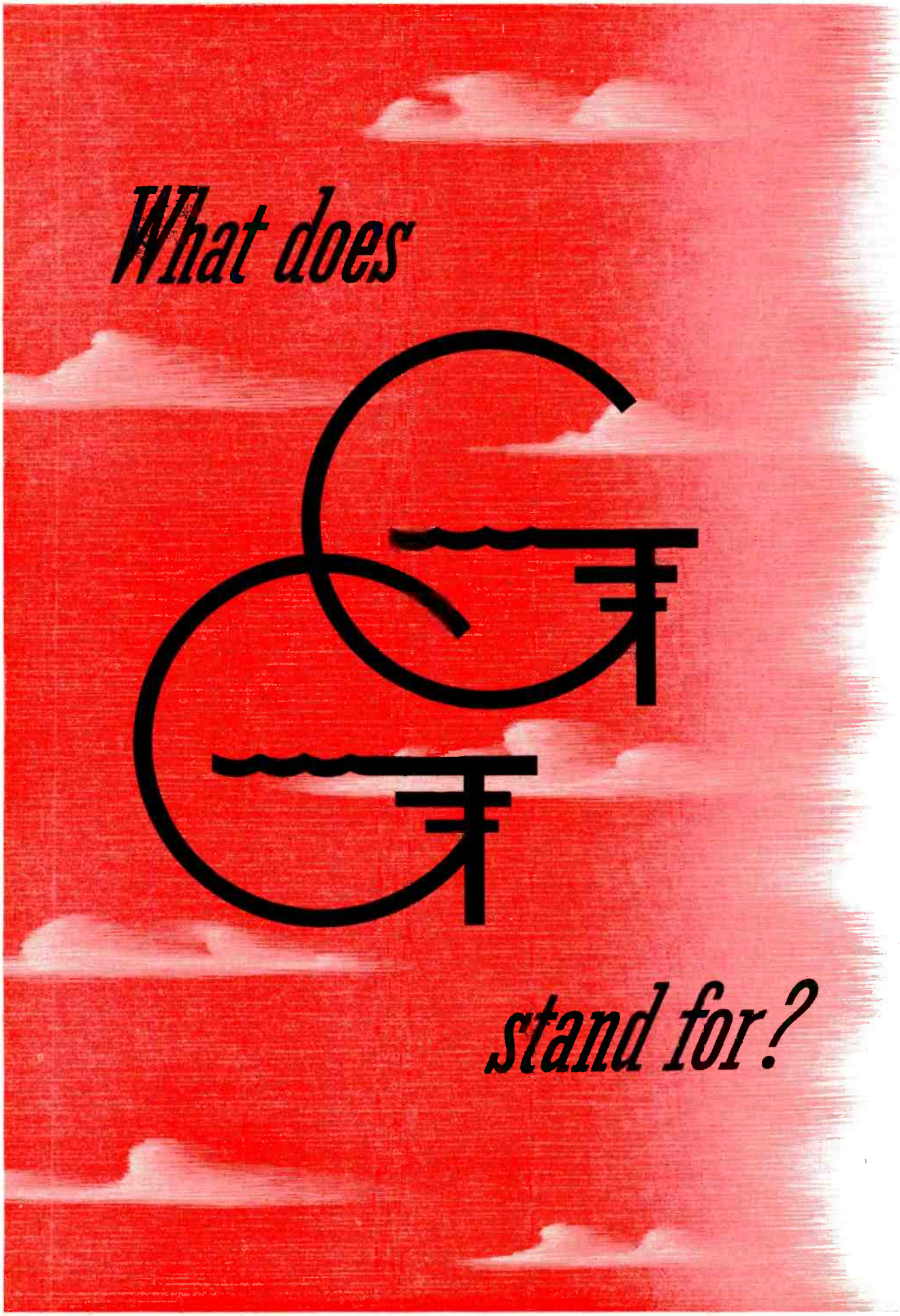
Summarized, this brief states in part that the difference of opinion between the Commission's proposals and the recommendations of the RTPB revolved about the evaluation of the amount of interference which may result from the reflection of radio waves from the various ionized strata above the earth. The problem was more involved by reason of the fact that the type of interference which had been emphasized as the most serious type, namely, F2-layer transmission, is not now being experienced in any of the channels of the present FM band, and so cannot be positively evaluated by direct measurement.

The Norton testimony at the October hearing, dealing with the skywave interference, centered about Exhibit 380, which undertook to predict by a series of curves the intensities of these interferences and the percentage of time over which they might be expected to occur within the boundaries of the United States. These curves, Figs. 1, 2 and 3 of Exhibit 380, are reproduced here for reference purposes.

**The Secret Hearing** ★ At the oral argument, the Armstrong brief and the memorandum prepared by Doctors Burrows, Beverage and Armstrong, which was also presented on behalf of Panel 5 of the RTPB, were not challenged. Mr. Norton, however, declined cross-examination on the subject of his conclusions with respect to F2-layer interference, stating that he was prevented from defending his position because of the military classification of the data, and suggesting that a closed hearing be held under the supervision of the military. Questioned by Mr. Denny if he would be able to substantiate the conclusions set forth in Exhibit 380, Mr. Norton replied: "Yes, I will certainly be able to substantiate those conclusions at such a session."

There followed the secret hearing on

(CONTINUED ON PAGE 53)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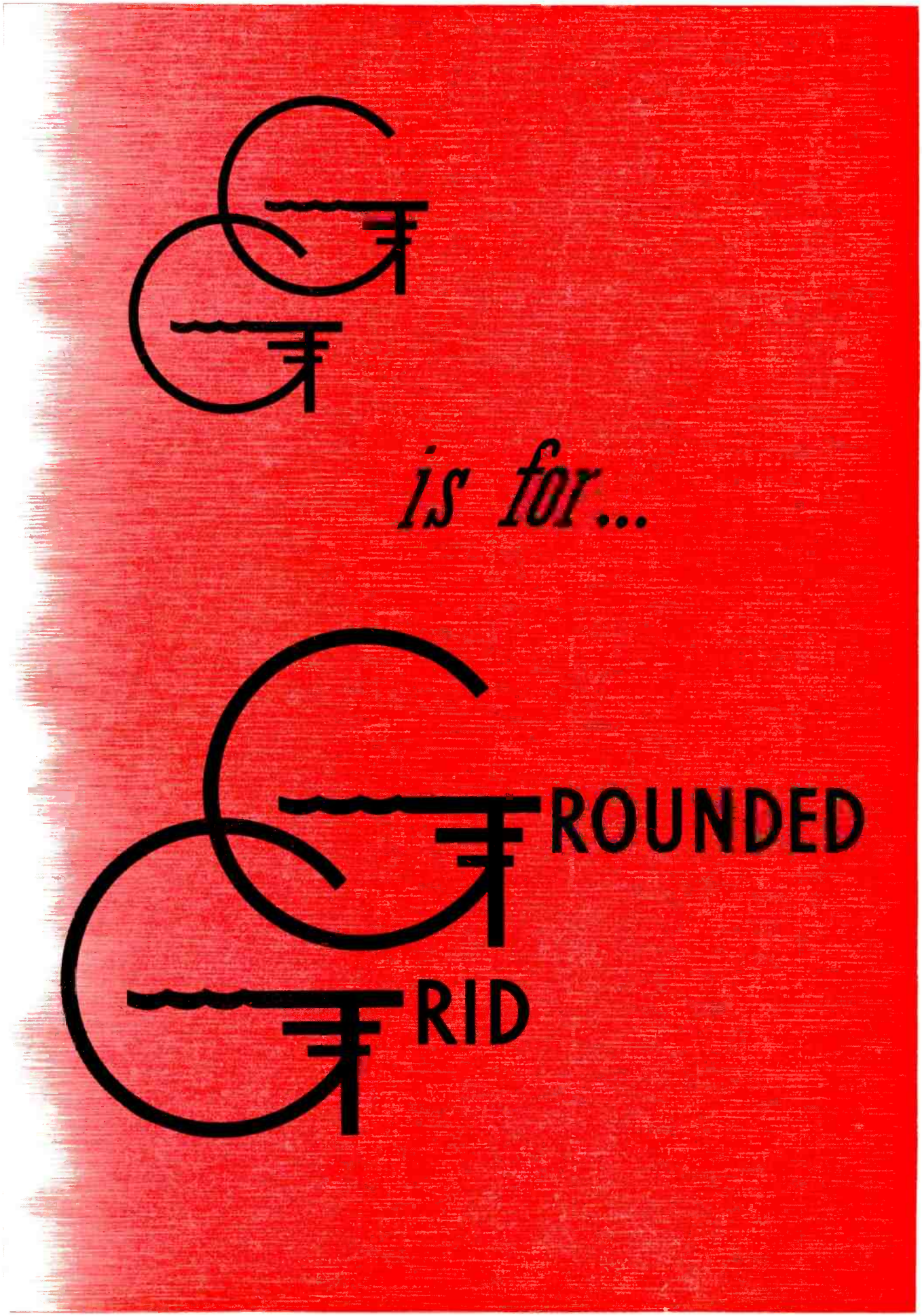
is for...
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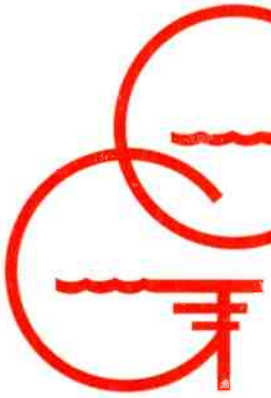
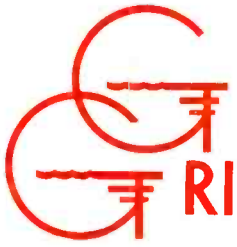


# ROUNDED RID... *AMPLIFIERS are a feature of the new RCA FM Transmitters*



# ROUNDED *means money* RID... *in your pocket ... and here's why!*

**1. GROUNDED-GRID** circuits provide greater output from an amplifier using a tube of given size—thus making possible the use of smaller, less-expensive tubes. Only a relatively few types are used, thereby reducing number of spares required. Overall *tube costs are less.*

**2. GROUNDED-GRID** amplifiers are more stable and require less critical adjustment than conventional-type 100 mc. amplifiers. Neutralizing is very simple—and not required at all for low powers. Maintenance problems are fewer and *maintenance costs are lower.*

**3. GROUNDED-GRID** circuits make feasible and economical an arrangement of amplifiers that are integral units. These units are small in size, easy to handle, and require a minimum of inter-unit wiring. Their use simplifies installation problems and *reduces installation costs.*

**4. GROUNDED-GRID** circuits are simpler and require fewer components than conventional amplifiers. They tune easier, introduce less distortion—thus *insure better program quality.*

**MAIL THIS COUPON for details about this important New RCA Line of FM Transmitters with the *GROUNDED GRID!***

**Broadcast Equipment Section**
**RCA, Camden, N. J.**

Please send me full information about your new RCA FM Transmitters with the new *Grounded Grid.*

**Name** .....
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97-6136-172

**The new RCA 250-Watt FM Transmitter— Type BTF-250**

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**Street Address** .....
**City and State** .....

97-6136.172

RCA

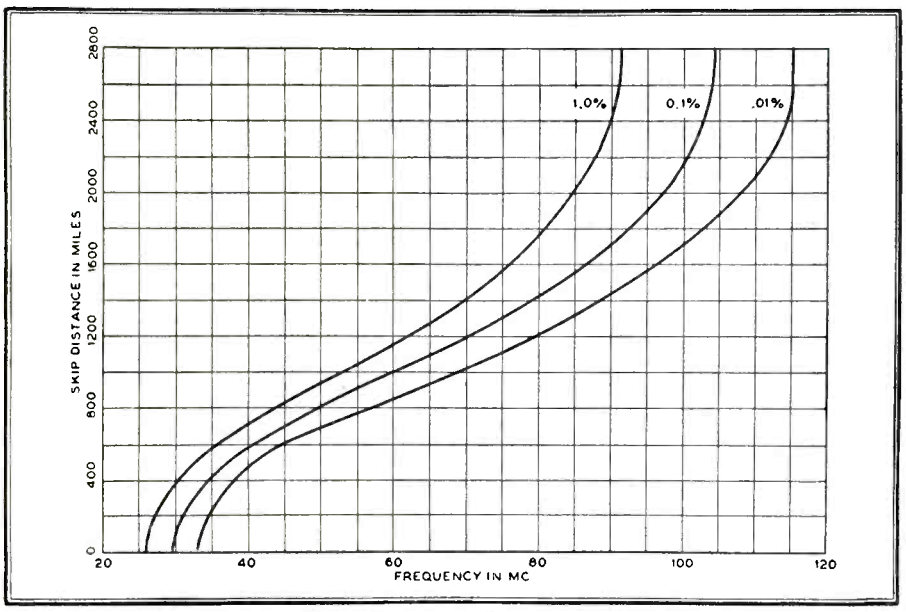
# RADIO CORPORATION OF AMERICA

RCA VICTOR DIVISION - CAMDEN, N. J.

In Canada, RCA VICTOR COMPANY LIMITED, Montreal

(CONTINUED FROM PAGE 48)

March 12th and 13th, 1945. Testimony covering all aspects of FM broadcasting with respect to the frequency bands under consideration was presented. Nothing appreciably modifying previous testimony developed, except in connection with the F2-layer interference controversy. The high spot of this hearing was the change in Mr. Norton's testimony, in which he reduced his prediction of F2-layer interference from 100% to 7% over the accepted Bureau of Standards measurements made at Washington. Cross examination forced




**NORTON FIG. 2 — EXHIBIT 380**

ESTIMATED percentage of the listening hours during the last sunspot cycle (1933–1944) for which the F-layer skip distance would have been expected to be less than the values shown for particular frequencies. (The conditions shown here are based on ionosphere measurements at the station having the highest presently-known critical frequencies and thus correspond to the worst anticipated conditions of potential F-layer interference to United States VHF stations from VHF stations in any part of the world. The measurements at this ionosphere station were available only from March through August 1944 and were estimated for sunspot cycle maximum conditions.)

him to admit that F2-layer reflections from the ionosphere over the equator had no bearing on interference in the U. S. unless the ionosphere within 1,250 miles of the border would support transmission. This was the point of the Beverage-Burrows-Armstrong memorandum which charged the basic error. Attempts to make public this change in the Norton testimony were unsuccessful. However, Mr. Denny, then General Counsel, suggested that Major Armstrong prepare a classified brief for the Commission for the purpose of pointing out the conflicts of the Norton testimony in the public and the secret record. Formerly classified as Restricted, this brief has never been published. It presents the comparison of the record of the open hearing and the secret hearing where conflicts exist, and where the public record has been repudiated.

Since it does not appear possible to present a more thorough, understandable, and concise account of this complex and confusing subject, it follows in full, with Major Armstrong's permission:

Docket No. 6651
April 18, 1945

This brief is prepared at the instance of Commissioner Denny, who made the suggestion while still General Counsel of the Commission.

Its purpose is to point out to the members of the Commission the conflicts between the record of the open hearing and that of the secret hearing and the important aspects wherein the testimony in the public record has been repudiated, not only by Mr. Norton himself but also by members of the engineering staff of the Commission.

The brief is long because the mistakes made in the public hearing were not freely admitted but were developed only after prolonged cross-examination in the secret hearing.

The conflicts arise entirely by reason of testimony given on October 28th by Mr. K. A. Norton a few days before the ending of the hearing. In his testimony at that time Mr. Norton characterized the Washington data of the Bureau of Standards, on which the art has relied for guidance for years, as inadequate both as a guide for F2 layer skywave interference between stations within the United States and for interference from foreign stations. As a second proposition, Mr. Norton and Dr. Wheeler then predicted F2 skywave transmission into the United States up to frequencies 100 per cent higher than that indicated by the Washington data.

The testimony given on behalf of the Commission in the secret hearing shows that both these propositions have now been withdrawn. It is now admitted that the Washington data applies throughout the United States. The highest increase which is now predicted above the Washington data, for F2 interference from foreign stations, for the same conditions under which 100 per cent was predicted in the October testimony, is less than 7 per cent.

The important parts of the testimony in the open and in the closed hearings are quoted hereinafter. Where the testimony quoted from the closed hearing modifies the public record, its importance is pointed out and references are made to the memorandum filed at the oral argument by Panel 5 and to my brief presented at that time. (Page references to my brief refer to the printed copy.)

**History of This Controversy** ★ Since the questions of fact revolve entirely about the testimony with respect to Exhibit 380, it is essential to review its history insofar as its figures relate to the F2 type of interference.[1] This Exhibit was first presented by Dr. L. P. Wheeler on October 26th, who described briefly its four figures. On October 28th Mr. K. A. Norton, formerly employed by the Commission but now employed in the Operations Analysis Division of the Army Air Force, testified about Exhibit 380 in detail.

On the basis of recently declassified ionospheric measurements made in other parts of the world, Mr. Norton predicted with great definiteness skywave interference (F2) from without the country at frequencies far higher than had ever been experienced in past sunspot maximums.

Fig. 2, based on an unnamed point without the country, shows F2-layer transmission at frequencies approximately twice as high (120 megacycles) as Fig. 1 based on the Washington measurements of the Bureau of Standards, where 60 megacycles is the absolute cutoff.

Referring to the measurements at other points throughout the world Mr. Norton testified:

> "When this world-wide picture of the ionosphere becomes available the inadequacy of the Bureau of Standards Washington data, made at a single geographical location, becomes apparent" (pp. 3763–3764).

On the basis of this figure Mr. Norton recommended placing FM and television

[1] No mention will be made of Sporadic E, as an agreement on a set of facts has been arrived at with the Engineering Department of the Commission.

above 120 megacycles (public record pp. 3771–3772).

While Dr. Wheeler made no allocation recommendations, he made the following statement about Fig. 2 after having described the curves of Fig. 1 based on the Washington measurements:

"The second figure shows a similar state, but the measurements used are taken at a station having the highest presently known critical frequencies, which will thus give us *the worst conditions which may be anticipated for potential F-layer interference to United States VHF stations* from VHF stations in any part of the world."

On cross-examination of Mr. Norton, the question of the applicability of the curves of Fig. 2 to interference conditions within the United States was raised. The cross-examination was handicapped by the fact that the location of the point for which the curves of Fig. 2 were predicted was unknown.

Mr. Norton repeatedly stated during his cross-examination that the Washington data did not govern interference within the United States. On pages 3794–3795, as part of an answer he volunteered this statement:

". . . But it does not follow that this Fig. 1 is applicable to the United States, interference in the United States, whereas Fig. 2 is applicable to interference only from points outside the United States. These two figures give extreme conditions between which I think the interference problem lies, and that is true both within the United States and outside of the United States. Unfortunately, because of the restricted character of this material we can't be more specific, but we can go that far."

On page 3799 he was asked the following question about interference between stations within the United States and made the following answer:

"Q. I just wanted to get the first point clear, that so far as we are concerned if we moved up to 60 megacycles — and I take 60 megacycles because it comes right on one of the curves and it is easier to read — we would accomplish two things *in our interference between our own high powered stations within the United States.* We would eliminate F2 layer interference practically entirely, I will say, because nothing is perfect in this world, and at the same time we would reduce the sporadic E from 1/10th of 1 percent of the time to 1/100th of 1 percent of the time."

"A. Well of course, as I mentioned before, this figure is not — Fig. 1 — is not applicable to the whole United States *and we do know that there are other places in the United States where the situation is more like Fig. 2, although not as high.* So I am afraid that relative to the F layer problem, 60 megacycles isn't high enough."

On page 3800 he was asked the following question:

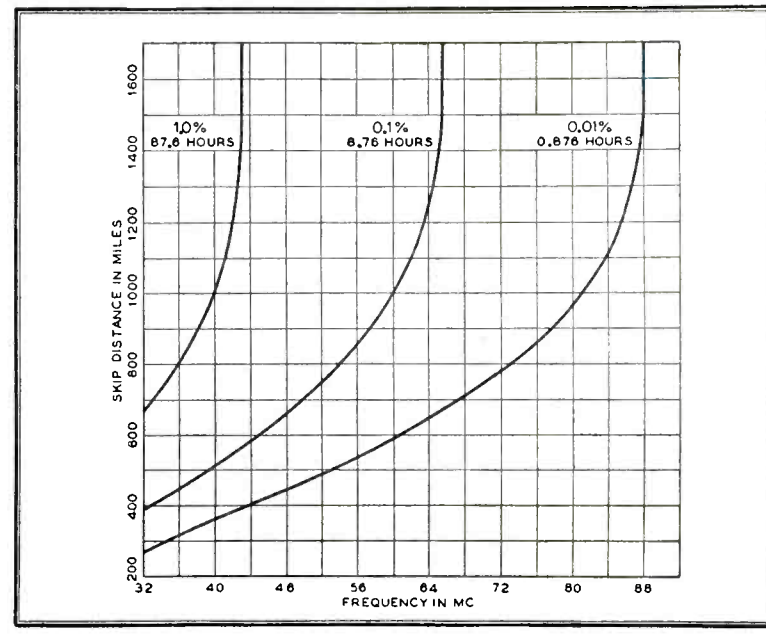
"Q. What would be the curve which would determine the percentage of interference and the value of it within the United States *among our own high power stations?* You said it is not Fig. 1 and it is not Fig. 2. Is there any curve which you could draw based on any data which you have which would enable us to estimate how much interference there would be?"

"A. Well, no I am afraid that it would not be desirable at this time to settle that question in a public hearing; that is, as far as I am concerned. It may be that you can find other witnesses who would be able to do that." [2]

Under date of November 1 in a supplemental statement filed with the Commission at its request, pp. 4485–4495, Dr. H. H. Beverage took issue with Mr. Norton's conclusions with respect to interference coming from without the United States as predicted from the curves of Fig. 2. He pointed out that:

"In order for Fig. 2 to serve a useful purpose one should know the location at which the measurements were made; this I understand cannot be discussed at the hearing."

Dr. Beverage then pointed out that the condition of the ionosphere within approximately 1,000 miles of the border of the United States would determine the question of whether interference entered the United States from stations in other parts of the world, and not the condition of the ionosphere at some unknown location if this location were beyond this boundary. (At the secret hearing this unknown location was revealed as being more than twice this distance from the United States.)




**NORTON FIG. 3 — EXHIBIT 380**

PERCENTAGE of the time and (parentheses) the number of hours during the period September 1943 through August 1944 for which the Sporadic E-layer skip distance was less than the values shown for particular frequencies. *Estimated from the National Bureau of Standards Ionosphere measurements at Washington, D. C.*

During the latter part of November, an informal conference was held in the office of Mr. Adair and attended by members of the Armed Forces, the Commission's staff, the Bureau of Standards, and industry.

On January 24th a new position on the subject of F2-layer interference was taken in a paper presented by Messrs. Norton and Allen at the annual convention of the Institute of Radio Engineers.

This paper in its final form was recently published by the Commission under the title "Very-High-Frequency and Ultra-High-Frequency Signal Ranges as Limited by Noise and Co-Channel Interference" by E. W. Allen, Jr., Mr. Norton having withdrawn his name as co-author in the meantime.

The paper contains much of the material of Exhibit 380, except that controversial Fig. 2 of that Exhibit, which

[2] As will appear hereinafter from the testimony in the closed hearing, Fig. 1 does apply to interference within the United States between our own stations.

showed F2 transmission at frequencies 100% higher than Washington, is missing, On page 6, referring to Fig. 4 of the paper. identical with Fig. 1 (derived from the Washington data) of Exhibit 380, appears the statement that "The best estimate which *we* are able to make is that the frequencies shown in Fig. 4 should be increased *by 15%* when considering conditions applicable to interference *throughout the United States.*"

This represented a repudiation as of a date of January 24th of the "facts" testified to by Mr. Norton in the October hearing about Fig. 2 (Exhibit 380) as regards interference coming from without the United States.[3]

The importance of this does not seem to have been recognized because of the continual reference to Mr. Norton's testimony as "factual data."

On January 15, 1945, the Commission issued its proposed allocations and on February 28th began its hearings of oral argument on its findings regarding FM.

At the oral argument there was presented on behalf of Panel Five a memorandum concerning F2 transmission prepared by Doctors Burrows, Beverage and Armstrong, and concured in by Doctors Stetson and Pickard and Mr. Stuart L. Bailey. The memorandum pointed out certain fundamental errors in Mr. Norton's conclusions. This memorandum was also presented by me as a part of my brief as filed and testified to without cross-examination or any attempt to overthrow any of its findings.

At the oral argument Mr. Norton declined cross-examination on the subject of his conclusions with respect to F2 layer interference, testifying (public record, p. 4870) as follows:

> "Unfortunately due to security considerations I will not be able to discuss in much more detail at this time the basis for the conclusions which I reached relative to the problem of F-layer interference. If the Commission feels that the facts in this regard are necessary before it can make a decision as to the proper place for FM in the radio spectrum, then I suggest that a closed session be held under the supervision of the military."

On page 4872 the following question was asked and answered:

> "Mr. Denny. I would like to ask one question. I do not know whether you would want to go this far on the record. I want to ask a question, but if there is any doubt about it, do not answer it.
>
> "It has been suggested in the course of these hearings when you presented your Exhibit 380 that the curves contained in that Exhibit indicated much greater F-2 layer reception than had heretofore been anticipated and the briefs and oral presentations that have been made have suggested you made certain fundamental errors in the computation of those exhibits. I would like to know whether, if such a closed session as has been suggested is held, you would expect to be in a position to substantiate the conclusions set forth in Exhibit 380.
>
> "Mr. Norton: Yes, I will certainly be able to substantiate those conclusions at such a session."

**The Closed Hearing** ★ The statements which have been quoted from Mr. Norton's testimony in this brief are those whose accuracy has been questioned in the memorandum filed on behalf of Panel Five and in my brief.

They are the principal "facts" on which the Commission proposed to move FM.

They are the "facts" which were repudiated at the secret hearing.

At this point it is in order to restate the questions in which we are interested:

(1) That Fig. 1 represents the conditions for F2 transmission between stations located within the United States for conditions of the last sunspot maximum.

(2) That what we are interested in with respect to interference entering the United States (or leaving it) is the condition of the ionsphere at a point approximately 1250 miles beyond our borders and not the condition of the ionosphere at the Equator or any similar distant part of the world.

(3) That Fig. 2 does not represent interference conditions which may be expected for the United States from foreign stations anywhere.

Point (1) will be treated first. No attempt whatever was made in Mr. Norton's testimony to substantiate the statements abstracted and reproduced on page 4 of this brief that the interference between stations located within the United States lay between the limits of Fig. 1 and Fig. 2, that is, occurred at frequencies higher than indicated by the Washington data. It was admitted by both Mr. Adair and Mr. Allen that Fig. 1 represents the condition within the United States. During the testimony of Dr. Newbern Smith, who is associated with Dr. Dellinger in the propagation studies carried out by the Bureau of Standards, he was questioned as follows (secret record p. 45):

> "Mr. Adair: If my memory is correct, I believe, referring to Mr. Norton's Fig. 1 (Exhibit 380), in that conference we held in my office some months back, you indicated that you felt that maybe those frequencies should be increased by about 15%. Would you correct me if I am wrong? How does that agree with Mr. Norton's Classified Exhibit No. 7 here?
>
> "Dr. Smith: I have not seen that Exhibit. I am afraid I can't answer that off-hand. I would have to study this.
>
> "Mr. Adair: Maybe you can tell us after lunch. I believe you did say they should be increased about 15%.
>
> "Dr. Smith: That is for transmissions coming into the continental United States from outside.
>
> "Mr. Adair: *Yes; that is right.*"

During Dr. Wells' examination Mr. Allen corrected the view expressed in Exhibit 593 in a statement as follows (secret record p. 226):

> "Mr. Denny: I think Mr. Allen has a question.
>
> "Mr. Allen: I have discussed it with Dr. Smith. It was my understanding that the 15% increase in frequency was due to the stations in the southern part of the United States interfering with each other. Dr. Smith said I was not correct on that. It was for interference coming into the United States from outside."

On page 23 of my brief, commenting on the statement in Mr. Allen's paper Exhibit 593, appears the following statement:

> "If by 'throughout the United States' is meant interference between our own stations it is believed to be still incorrect.
>
> "If it is understood that the critical frequencies as determined by the Washington measurements should be increased by 15% for certain parts of the United States for interference coming from without the country, then I think we shall have arrived at the facts with respect to Fig. 2 (Exhibit 380)."

*The accuracy of this statement is now admitted.*

With respect to point (2), Dr. Wells, who made the measurements on which Mr. Norton based the predictions of Fig. 2 of Exhibit 380, testified as follows (secret record p. 225):

> "Major Armstrong: Dr. Wells, do you agree that insofar as interference entering the United States from without the country is concerned, the thing that we are concerned with is a line roughly 1250 miles around the borders of the United States, and in the condition of the ionosphere at that point?
>
> "Dr. Wells: Yes, insofar as F2-layer interference is concerned."

[3] During the oral argument Mr. Allen's paper was offered in evidence as Exhibit 593 (p. 4851). Cross-examination about the change was refused on the ground of classified information at the oral argument as will also appear hereinafter (public record pp. 4875–4878). However, as will also appear hereinafter, even this 15% increase was withdrawn (secret record pp. 45 and 226).

Mr. Norton, on the same point, testified as follows (secret record p. 238):

"Major Armstrong: Everybody is already agreed, I take it, that for interference to enter the United States a line roughly 1,250 miles beyond our borders will determine whether or not interference gets into the country.

"Mr. Norton: Yes, that is correct.

"Major Armstrong: And unless the ionosphere 1,250 miles away supports transmission, then we need not worry about F2-layer interference.

"Mr. Norton: That is right."

This confirms the statement in the memorandum (my brief, p. 37):

"*What we are concerned with respecting transmissions entering the United States is the condition of the ionosphere at points lying within a line approximately 1200 miles beyond our borders.*"

A condition of the ionosphere having some high reflecting value over the Equator, or some other distant point, is not the controlling factor for interference entering the United States.

With respect to point (3), the difference between the testimony in the open and closed hearings is the most striking of all the conflicts.

Whereas Fig. 2 shows transmission up to a cutoff value of 120 megacycles, or 100% higher than the Washington data, the cutoff frequency now predicted by Mr. Norton for transmission over this path *for the same conditions* of sunspot maximum is 64 megacycles (Classified Exhibit 7) for the San Francisco-Honolulu path. This is less than 7% higher than the cutoff frequency shown in Fig. 1 of Exhibit 380 (Washington). The Miami-Lima, Peru, cutoff frequency is given as 62 megacycles, or approximately 3½% higher than Washington. These figures are for the highest hours of the highest month of a sunspot maximum having the intensity of the last cycle.

*This confirms the statement of the memorandum (my brief p. 37):*

"Experience gained by operation during past sunspot cycles indicates that the Washington data gives an accurate guide for transmission characteristics throughout the greater part of the United States. . . .

"There is some experimental evidence gained from amateur experience that transmission as it affects the south and southwest portion of the United States, may be expected to run 10 to 15 per cent higher than that indicated by the Washington data. The experimental results of the transmission appear to be highly sporadic and to have been observed on relatively few days."

**Analysis of the Norton Testimony in the Closed Hearing** ★ While under any ordinary circumstances the matter might be dropped at this point with the statement that Dr. Dellinger's appraisal of the situation as stated to Panel Five has now been confirmed, the repeated references to Mr. Norton's testimony as "factual data" warrants further examination of the record.

In his direct examination in the closed hearing Mr. Norton presented the "control point" theory of ionospheric propagation from a classified document known as the IRPL Radio Propagation Handbook (Classified Exhibit No. 1).

This Handbook contains the most modern theory of propagation as worked out by Dr. Dellinger's laboratory in cooperation with the corresponding British laboratory. Dr. Smith, who is largely responsible for it, testified as follows:

"Major Armstrong: Dr. Smith, as I understand it the theory which was presented here[4] was worked out by your Laboratory and the corresponding British Laboratory.

"Dr. Smith: That is right.

"Major Armstrong: I would like to agree with it also, Mr. Chairman. Our disagreement is not with what was said here today but what was said in the record last October."

To clear up on the record the difference between the predictions made by Mr. Norton about interference coming into the country on last October and his predictions during the closed hearing and the reason for it, I quoted from his previous testimony, where the reflection from only one point of the ionosphere was considered, and asked the following question (secret record pp. 30–31):

"Major Armstrong: There should have been two points taken into consideration there in accordance with the theory you have expressed today. Is that right?"

The following incomprehensible answer was given:

"Mr. Norton: No. The present theory I have expressed today would involve only one, namely, the point which would support *the highest* frequency transmission, and that point might be the one near the transmitter or the one near the receiver. I think that is shown quite well on Classified Exhibit No. 3. For example, if we take the path from Buenos Aires to Washington we find one control point 1,250 miles from New York that is marked Number One on this Exhibit, and we find another control point not at the Equator, to be sure, but about 1,250 miles from Buenos Aires. Now I have looked into the matter and I have found certain paths between South America and the Eastern part of the United States where the control point would be on the Equator, and it is quite obvious if you rearrange the geometry here a little you can find such a point.

"And in addition it turns out that the point in the ionosphere which controls these transmissions is this more southerly point around the Equator at certain seasons of the year and certain times of the day. So that the method is briefly this. You select on a long distance circuit two control points, each 1250 miles from transmitter and receiver. Then you investigate the ionosphere for these two points and you find the maximum usable frequency for each of these points in the ionosphere and the one which will support the ——, that is, the one at which the maximum usable frequencies *are closest* is the one to use in deciding the maximum usable frequency for that circuit."

The IRPL Handbook (Classified Exhibit No. 1) specifically states that it is the *lower* of the two control point frequencies which determines the maximum usable frequency between two places on the earth's surface.

As Step 9 in the process of making the determination of the frequency to use in communicating between two places the Handbook states (p. 52):

"9. Read the value of the m.u.f. (maximum usable frequency) at each control point. The *lower* of the two values is the m.u.f. for the path. . . ."

The first sentence in Mr. Norton's answer states the opposite. The final sentence does not make sense.

It is my understanding that Mr. Norton did not correct his testimony after it was transcribed. The question of whether there was a typographical error was taken up with the Engineering Department on April 7th which advised me that Mr. Norton was on the West Coast. On April 16th the Engineering Department advised me that it had not been able to get in touch with Mr. Norton but that the word *closest* was probably *lowest* as that was the only logical conclusion from the context of the sentence.

However, the first sentence of the answer states the *highest* frequency should be taken and is in conflict with the last sentence of the answer if it states that the *lowest* should be taken.

If Mr. Norton used only the highest frequency in his predictions of last October with respect to the effect of the Fig. 2 conditions on interference in the United States, then the error pointed out in the memorandum is admitted.

(CONCLUDED ON PAGE 64)

[4] By Mr. Norton.

Eimac TUBES

THE COUNTERSIGN OF DEPENDABILITY IN ANY ELECTRONIC EQUIPMENT

# Tests Prove Eimac Vacuum Condensers Far Superior in Operating Efficiency

Ability to handle high current at high frequencies is the true measure of the performance of a capacitor. A high peak voltage rating based on low frequency measurements does not tell the whole story.

The chart on this page shows the results of tests at 50 Mc. conducted on a standard Eimac VC50-32 Vacuum Capacitor and three other 50 mmfd. vacuum capacitors, designated on the chart by "A," "B" and "C." At just over 17 amps. (approximately 1525 peak volts across the capacitor) Unit "A" (rated at many times the applied voltage) became sufficiently heated to melt the solder on the end caps. Under this same test, the Eimac VC50-32 operates at less than 70°.

Eimac introduced the vacuum capacitor in 1938. It is interesting to note that the original Eimac capacitor design is still outperforming all comers. Such outstanding performance is typical of all Eimac products, which is one of the reasons why they are first choice of leading electronic engineers throughout the world.

1113

*Follow the leaders to*

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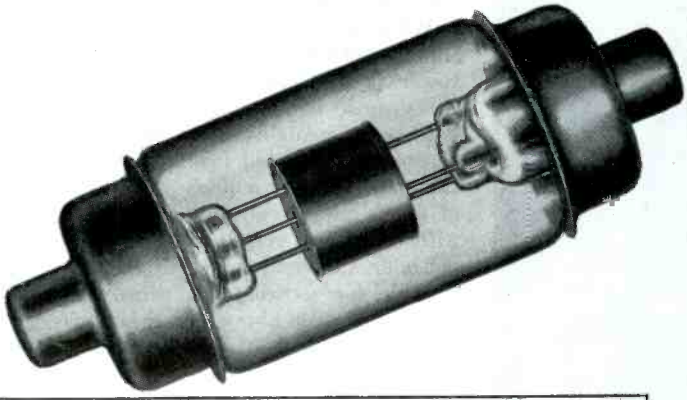

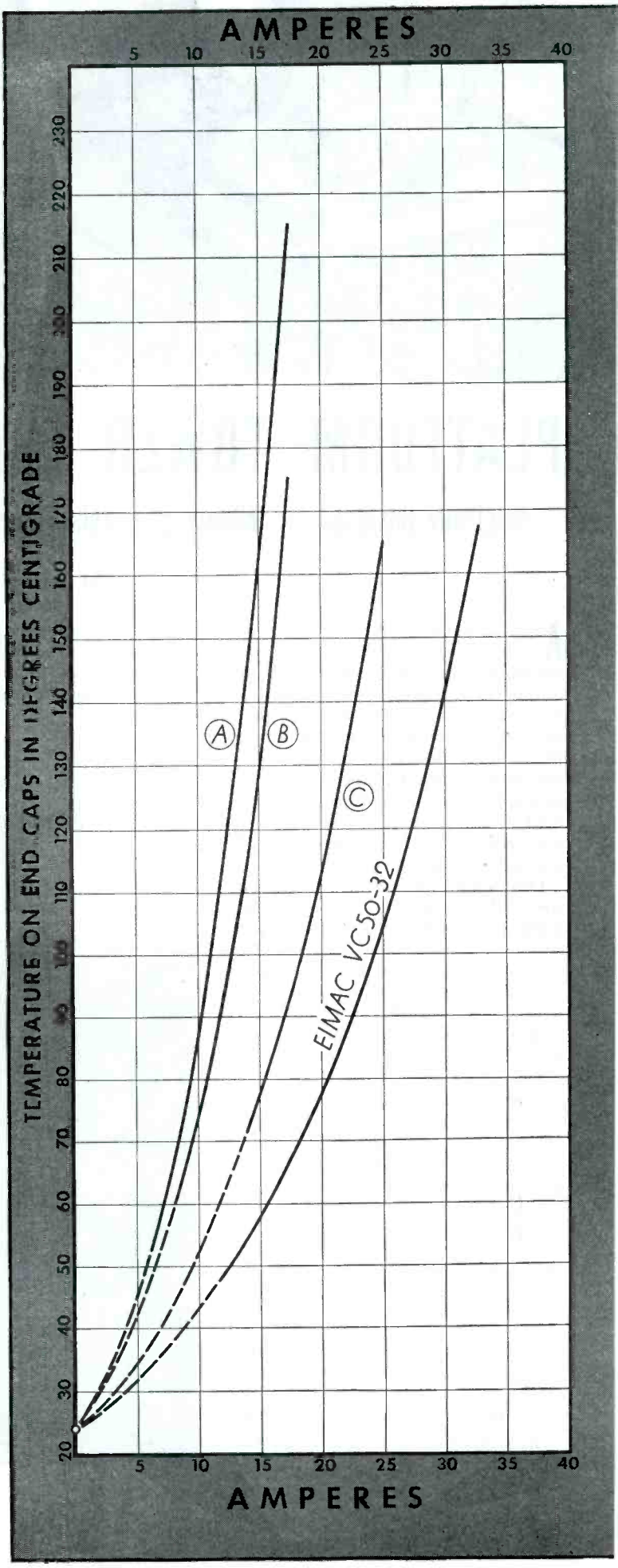


**EIMAC VACUUM CAPACITOR TYPE VC50-32**

**General Characteristics**

***Mechanical:***

Maximum Overall Dimensions

| | |
|---|---|
| Length | 6.531 inches |
| Diameter | 2.281 inches |

***Electrical:***

| | |
|---|---|
| Maximum Peak Voltage | 32,000 volts |
| Maximum RMS Current | 28 amps. |


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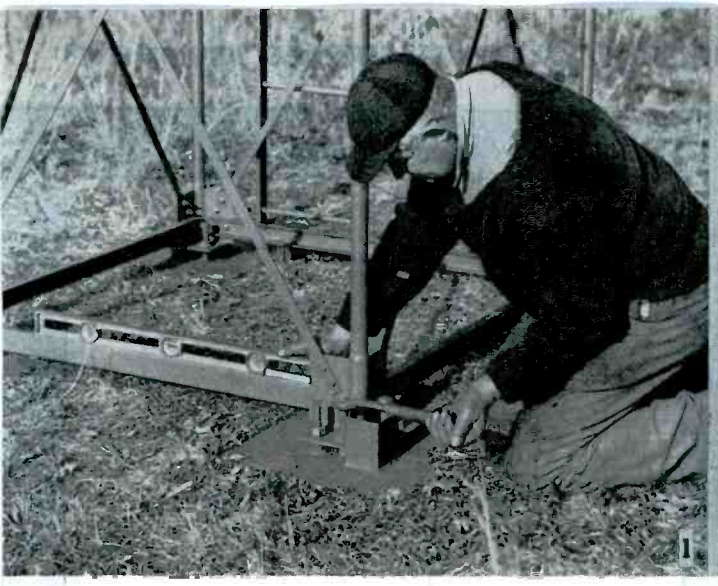

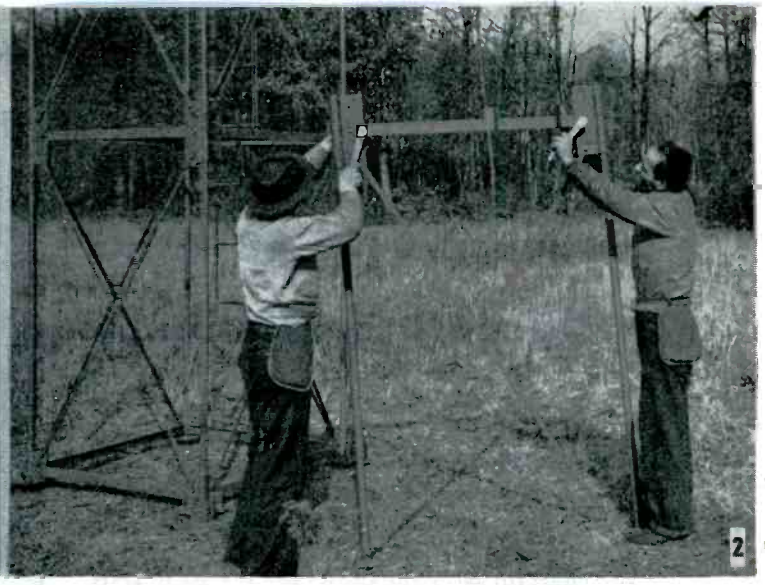

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## Originally Designed for Military Use, This Tower Is Ideal for Supporting Experimental Arrays

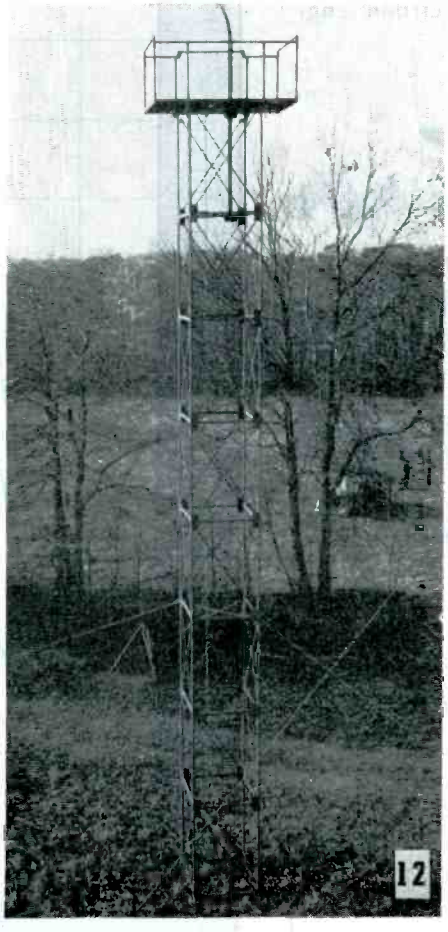
BY ZEH BOUCK*

AS restrictions are lifted on the publication of military radio information, photographs of many strange and interesting-looking towers are coming to light. Some, of course, are of such highly specialized types that they have little or no application to peacetime broadcasting or communications. Others, however, ingeniously designed and engineered for light weight and ease of erection, fit into new needs or those which were never filled adequately in prewar times.

One example of the latter is the Harco tower illustrated here both in course of construction and in the final stage of assembly. Available in various heights, it carries a platform on which all kinds of experimental arrays can be mounted and, if necessary, oriented by a motor drive controlled from the laboratory or operator's shack.

Fig. 1 shows the base of the tower, set into concrete blocks, and the simple method by which the bottom section can be adjusted so that succeeding sections will be exactly perpendicular. Only a level and a wrench are required.

In Fig. 2, workmen are assembling a part of one section so that, when they stand on a plank platform, Fig. 3, they can haul it up and drop it into place, as in Figs. 4 and 5. The plates which join the tubular uprights also hold the cross-braces. Since each part is delivered cut to size, with all holes located with great precision, no hand work or adjustments are required at the time of erection. Thus the only assembly tool needed is a good wrench. Nor is any wooden construction necessary, other than two planks to support the workmen, since a ladder is part of the tower construction, and it is extended as the tower assembly proceeds.



The assembly of each section involves the insertion of the lower ends of the vertical members of each side assembly into the steel fittings below, Fig. 6, connecting them with horizontal braces, Fig. 7, and putting on the cross-braces, Figs. 8 and 9. Finally, the ladder is extended by another section, as shown in Figs. 10 and 11.

When the last section has been bolted on, the platform is added, as in Fig. 12, and the tower is ready for whatever kind of an antenna or reflector may be required. The davit which is supplied for hauling up the antenna structure can be removed when it is not being used.

While the wind resistance offered by this type of construction is very small, the tower is not self-supporting, and guy wires must be employed. Three tower heights are available, of 30, 48, and 96 ft. Carrying their rated load of 500 lbs. on the platform, they require 1, 2, and 4 sets of guys, respectively, at each corner to withstand wind velocities up to 90 miles per hour. Conventional earth anchors are suitable for securing the wires. In the three sizes given above, the towers weigh 990, 1800, and 3750 lbs. completely assembled.

Fig. 1 shows concrete piers at the corners. However, many of these towers were erected for military purposes with only heavy planks for support. Nevertheless, concrete foundations are recommended for permanent installations. In dry, hard ground, about 1 cubic foot of concrete at each corner is sufficient for the 30- or 40-ft. tower, and about 3 cubic feet for the 96-ft. height.

*Harco Tower, Inc., 1180 East Broad Street, Elizabeth 4, N. J.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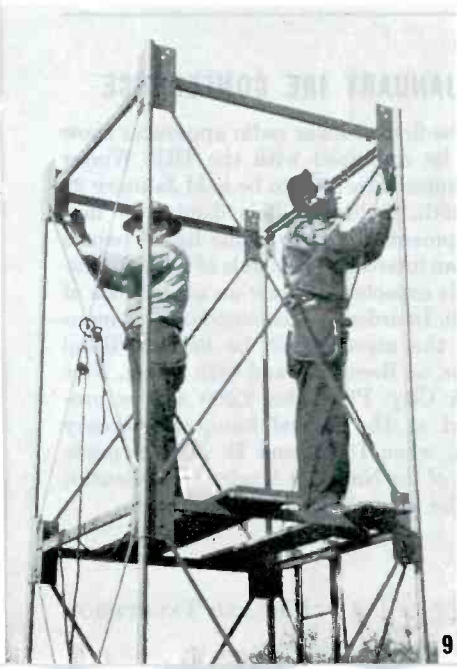
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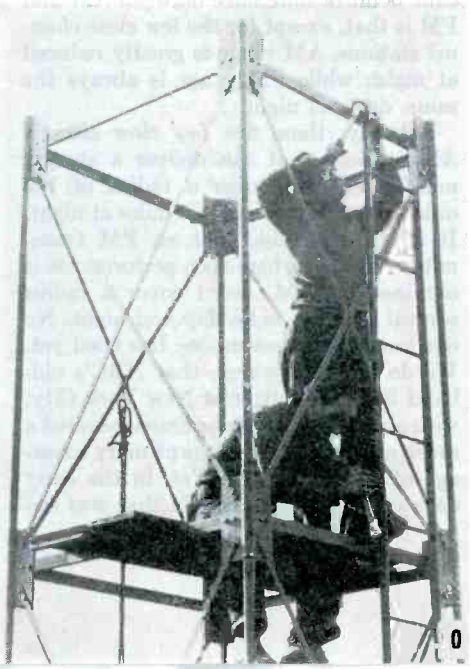
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# RMA INFORMATION ON FM

## Corrections of RMA's Explanation of AM-FM Differences

THE Radio Manufacturers Association has issued a series of questions and answers on Frequency Modulation, for those who "would benefit by a re-definition of FM and the difference between FM and AM." Most of the questions are well-chosen and the answers are informative, but some indicate an attitude of hedging on admitting the superiority of FM over AM as a service to listeners. For example:

"Q. What is FM? A. A new method of broadcasting that is normally operated in the higher portion of the radio spectrum, and which makes possible faithful and natural reproduction of all musical tones, from the deepest bass to the highest overtone."

Judging from some advertising of AM receivers, promising just that degree of faithful reproduction, it seems surprising that tone quality is the only feature of FM-AM difference to be mentioned. FM listeners generally refer to the absence on FM of the static, fading, squeals, and station interference which generally characterize AM reception.

Next in the RMA bulletin is this: "Q. What is the chief difference between AM and FM? A. An AM (standard) receiver responds to variations in amplitude, whereas an FM receiver responds to variation in frequency. Much electrical noise is not present in the higher frequencies used in FM."

The second part of that answer reflects the thinking of those who used to argue that, at FM frequencies, no electrical disturbances would be heard if AM were used. That opinion is still held by those who also say that they wouldn't be in favor of FM even if it was good.

If it were true, as stated by RMA, that "much electrical noise is not present in the higher frequencies used in FM," there would be no need for using FM limiter circuits, and FM sets would perform as well without limiters as with them. However, we know that there has been a universal complaint that those FM sets without limiters, sold before the war, were so noisy that their owners and the radio dealers characterized them as "phony" FM models.

Still, some engineers claim that, on AM, they have not experienced electrical noise above 100 mc. That can be due only to lack of sensitivity in the receivers they used. If any AM set has a sensitivity of 1 micro-volt-per-meter, comparable to the sensitivity of commercial FM receivers, the AM reception will be as noisy as at the lower frequencies.

Here is the next RMA question and answer: "Q. Are two different types of broadcasting methods necessary? A. Yes. Most AM stations, including all those now on the major networks, make use of ground waves which follow the curvature of the earth and which have a range of around 100 miles in the daytime and up to several hundred miles (for clear channel stations) at night. Most FM stations use direct ray broadcasting — the wave travels on a straight line from station to horizon. The maximum range, both day and night, is around 100 miles."

That is neither an answer to the question, nor is it the truth. It is difficult to understand how RMA could have released the statement that "Most AM stations, *including all those now on the major networks*, make use of ground waves — which have a range of around 100 miles in the daytime and up to several hundred miles (for cleared channel stations) at night."

The *truth* is that many stations on the major networks are rated at only 250 watts, and are lucky if they get out 20 miles in the daytime or more than 12 miles at night! Moreover, even with the reference to clear channel stations, the uninformed, for whom this RMA bulletin is intended, would infer that all AM network stations have a greater range at night than in the daytime, while FM stations lack that advantage.

It is not clear why, if it was necessary to bring up the point at all, reference was made to the exceptional case of the very few clear channel stations that are able to transmit further after dark. The significant point of difference between AM and FM is that, except for the few clear channel stations, AM range is greatly reduced at night, while FM range is always the same, day *and* night.

Actually, there are few *clear channel* AM stations that can deliver a steady, non-fading signal over a radius of 100 miles in the daytime or 600 miles at night. It is quite possible that an FM transmitter, located where such performance is obtained on AM, could cover a radius several hundred miles day and night. No one knows, because no one has tried yet. We do know, however, that NBC's old-band FM transmitter at New York City, with about 3 kw. in the antenna, covered a much greater area than the primary coverage of 50-kw. WEAF. Yet, in the early days of FM, engineers said that was impossible. Who can say, therefore, what will be the comparative AM-FM performance in such level areas of the country where an AM station can cover a radius of 100 miles in daylight hours?

By way of contrast with the RMA information, here is what the U. S. Department of Agriculture has to say about the difference between AM and FM in an 18-page bulletin released to farmers on October 19, 1945:

"For clear reception, an AM broadcast signal must be about 100 times as strong as any disturbance or interference, but an FM signal needs to be only about 2 to 10 times as strong. That's why FM is nearly 100% noiseless, while AM is constantly subject to static.

"A big AM station can reach out farther (how far depends on its power), but the farther out the waves go, the more they are subject to *fading*, *interference*, *static*, and other *noise*.

"What counts is not how far the broadcast goes, but how far it will give *good reception* — good enough so that the average person will want to listen to it. From this standpoint, a good FM station (say 10,000 watts) will serve an area at least comparable to the satisfactory coverage of a clear channel AM station as big as 50,000 watts. In general, suitable FM stations will give satisfactory service over *bigger* areas than local or regional AM stations." (The italics above are in the original text.)

Perhaps the writer of the RMA bulletin was himself one of the individuals who "are unfamiliar with FM" or was "too young to appreciate and remember the facts about FM widely disseminated before the war." It is difficult to escape the impression, however, that those answers were not written entirely for the purpose of presenting, fully and factually, the difference between AM and FM broadcast service to radio listeners.

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## JANUARY IRE CONFERENCE

The first postwar radio apparatus show will be combined with the IRE Winter Technical Meeting, to be held January 23 to 26th, inclusive. This display of new equipment, added to a fine list of papers and an interesting schedule of guest speakers, is expected to draw an attendance of 5,000. In order to accommodate this number, the meeting will be held at Hotel Astor, on Broadway and 44th Street, New York City. Places for 2,500 will be provided at the annual banquet, January 24th, when Dr. Frank B. Jewett, president of the National Academy of Sciences, will be the principal speaker.

FIG. 1. HAMMARLUND COMMUNICATIONS RECEIVER FOR .54 TO 31 MC.

# RADIO DESIGNER'S ITEMS

## Notes on Methods and Products of Importance to Design Engineers

**FM Dials:** In response to a request from NAB, the FCC has changed its original plan for numbering FM channels. Under the new system, the 107.9-mc. channel is No. 300. Lower channels will be numbered down from that point. This makes 48.1 the No. 1 channel.

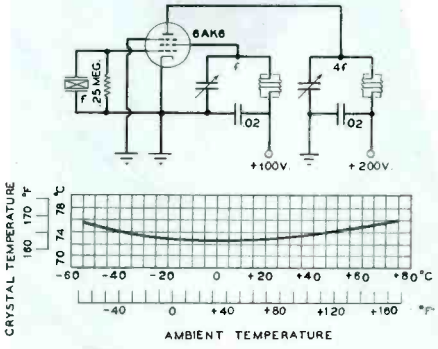


FIG. 2. BLILEY TEMPERATURE CONTROLLED CRYSTAL FOR MOBILE USE

**Receiver for .54 to 31 Mc.:** One of the first communications receivers incorporating wartime design features adapted to amateur service is offered by Hammarlund Mfg. Company, Inc., 460 W. 34th Street, New York 1. It is the HQ-129-X model, shown in Fig. 1, with 6 tuning bands and 4 bandspread ranges for ham bands. Three IF and 2 AF stages are provided in a circuit which includes numerous refinements from a compensated oscillator to reduce drift while the set is warming up to a series type automatic noise limiter which reduces many kinds of interference. The cabinet measures 19½ ins. long by 11 ins. high and 13 ins. deep. Speaker is mounted separately in a case 12½ by 12½ by 7¼ ins. deep.

**Crystals for Mobile Service:** A much-needed contribution to mobile radio equipment has been made by Bliley Electric Company, Erie, Pa. It is a plug-in type of temperature-controlled crystal, available for any frequency from 3,500 to 11,000 kc. The built-in heater operates on 6.3 volts at 1 amp., maintaining the overall frequency deviation at ± .005% or better, as shown in Fig. 2. Size of case above the standard 5-pin base is $2\frac{5}{32}$ in. high by $1\frac{3}{16}$ by $1\frac{9}{16}$ ins.

**Toroidal Coils:** New Band-pass filters from D-X Radio Products Company, 1200 N. Claremont Avenue, Chicago employ toroidal coils of exceptionally high *Q* to give greatly improved characteristics. Size of filters is reduced because there are no interlocking magnetic fields between toroidal coils when they are mounted close together.

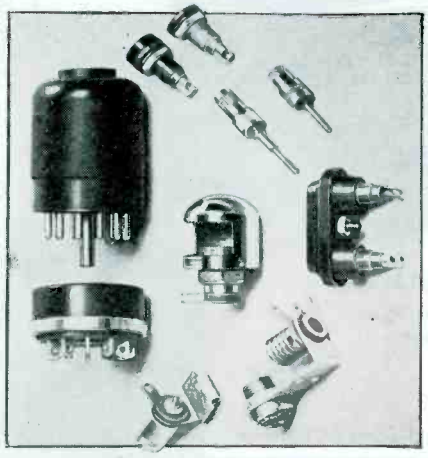

FIG. 3. NEW JOHNSON CONNECTORS

**Cathode-Ray Tubes:** A new bulletin on the characteristics of cathode-ray tubes has been issued by DuMont Laboratories, Inc., Passaic, N. J. Data is given on 5, 7, 10, 12, and 20-in. electrostatic and magnetic deflection types. Also, a new 15-in. magnetic deflection type is announced.

**Components:** E. F. Johnson, Waseca, Minn. has acquired the tools and manufacturing rights for cable connectors, pilot and dial light assemblies, and tip jacks and plugs which were formerly Mallory-Yaxley items. These are shown in Fig. 3.

**Speech Input Systems:** In an illustrated booklet on speech input equipment, Western Electric Company, 195 Broadway, New York 7, shows various layouts, with level diagrams, which can be employed in large and small studios. Valuable ideas are contained in the suggested arrangements.

**Heat Dissipating Unit:** The unit shown in Fig. 4, measuring only 16 by 7½ by 7½ ins., has been designed by Eastern Engineering Company, New Haven, Conn., to dissipate up to 1200 watts, irrespective of ambient temperature, maintaining temperature at a pre-adjusted value within 2° C. This view shows the side plates removed. Smaller models are available, also.

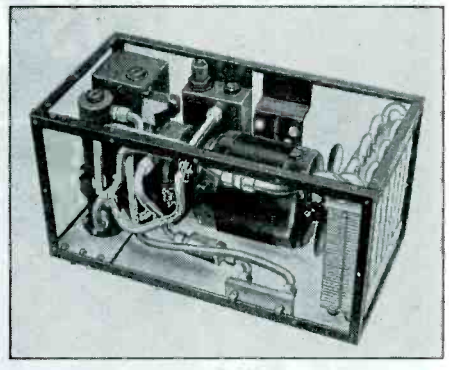

FIG. 4. HEAT DISSIPATING UNIT FOR COOLING POWER TUBE EQUIPMENT

**Transformer Design:** A comprehensive brochure of 88 pages has been issued by Standard Transformer Corporation, 3501 W. Addison Street, Chicago 18, on the various design factors of transformers and reactors. Intended for the use of applications engineers and purchasing agents, it covers both mechanical and electrical aspects from laminations to impregnation. In addition, a 40-page section is devoted to theory and engineering principles. Copies are available on request.

## DISCUSSION OF THE SECRET FM HEARING

(CONTINUED FROM PAGE 56)

However, a different explanation of the difference between the October predictions and the closed hearing testimony is given by Mr. Norton in subsequent cross-examination.

On page 238 (secret record) the subject was pursued further and the following questions asked and answers given:

"Major Armstrong: Now I refer to Exhibit 7, and I note you have modified your predictions of interference from South America and Australia of 80 megacycles for several hours a day, given on page 3767 (public record).

"Mr. Norton: Yes, that is correct.

"Major Armstrong: And I assume that that is because you have taken into account the condition of the ionosphere at the 1,250 mile points.

"Mr. Norton: No; that is not the case. I think perhaps you misunderstood my testimony.

"Major Armstrong: You state it then.

"Mr. Norton: Surely. The reason I changed my estimate was that I used a new method of correcting sunspot minimum to sunspot maximum conditions, taking into account the geomagnetic and geographic latitudes of the ionospheric reflecting points."

Now taking this answer at its face value, compare it with the testimony given in the October hearing on the subject of correcting sunspot minimum to sunspot maximum conditions (public record p. 3766):

"Upon considering all of the data from these other stations, it was found that the ionosphere over one of them supported higher frequency transmissions than the ionosphere over any of the others and this station was chosen for further analysis. Unfortunately, data are not available at this station prior to March of this year *so that it has been necessary to estimate sunspot cycle maximum conditions.*

"*Two independent methods were used for making these estimates and the resulting values obtained by these two methods agreed within a few per cent.*

"Fig. 2. shows the skip distances as a function of frequency for various percentages of the listening hours during the last sunspot cycle that the transmissions would have been expected over paths passing near this particular ionosphere station."

The attention of the Commission is now specifically directed to Mr. Norton's statement that Fig. 2 (Ex. 380) which showed F2 transmission up to a cutoff value of 120 megacycles and which was based on *two independent methods for making these estimates whose resulting values are supposed to have agreed within a few per cent,* has now been superseded by a new method of correcting sunspot minimum to sunspot maximum conditions which gives a cutoff value of the transmission of 64 megacycles, or 7% higher than the Washington data instead of 100% higher.

Hence it is now admitted in the secret hearing that the high F2-layer interference predicted last October, on the basis of the then newly declassified military information, has now by reason of the adoption of a new method of "estimates" been reduced to a frequency practically coincident with the long-known Washington measurements (7% higher).

Mr. Norton, whose F2-layer predictions have been withdrawn, now seeks to substitute as a basis for moving FM up a prediction with respect to maximum sunspot activity over the next 30 years which is not only at variance with the history of sunspot cycles during the past 200 years but was specifically challenged at the secret hearing by Dr. Harlan T. Stetson, an acknowledged expert in the field, a position which Mr. Norton does not claim for himself.

While the subject has now approached close to fantasy, if the Commission wishes to undertake a further study I understand Dr. Stetson will be glad to prepare a memorandum.

In closing, the attention of the Commission is called to the fact that evidence of long distance tropospheric transmission (500 to 1,000 miles) at frequencies in the vicinity of the proposed new FM band is accumulating. These transmissions are being observed from very low powered transmitters.

Respectfully submitted,
EDWIN H. ARMSTRONG

The foregoing facts have been assembled to assist the reader in drawing his own conclusions, taking into consideration all other factors that have been presented in the public record.

It is the writer's opinion that the reliability of the testimony of many witnesses concerning the advantages of the higher frequencies is seriously open to question.

However, the matter of the wisdom of the Commission's action in moving FM from its former band to 88 to 108 mc. will not be discussed in this memorandum, since its sole purpose is to present facts developed in the Secret Hearing insofar as they relate to F2 transmission.

*In succeeding issues, these propagation questions will be examined further.*

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## ENGINEERING SALES

(CONTINUED FROM PAGE 8)

graph sales in the middle western area. He will make his headquarters in Chicago, where he has been previously associated with both Lyon & Healy and Bissell-Weisert.

**Dallas:** Fred Cross, recently released from the AAF, is staff assistant at J. Y. Schoonmaker Company, manufacturers' representatives at 2320 Griffin Street.

**Motorola:** Mid-western regional manager is Murray Yeomans. He has been in the Motorola service and engineering products departments for 11 years. Now he will make his headquarters in St. Louis.

**Jackson, Miss.:** S. D. Camper, who resigned recently from the Crosley sales organization, has become president of Southern Wholesalers, Inc. This company will distribute the Crosley line in the Jackson area.

**Espey:** Has appointed Morham Exporting Company, 458 Broadway, New York City, as representatives for South and Central America and the West Indies.

**Raytheon:** Has launched an extensive promotion program behind the Raytheon Bonded Electronic Technian Program, under the direction of Arthur E. Akeroyd, distributor sales manager. Purpose is to help legitimate service men by assuring their customers of bonded protection against gyp practices such as were disclosed by the Reader's Digest of August 1941.

**Gates Radio:** Has opened a sales office at 40 Exchange Place, New York City. B. W. Lacher is in charge.

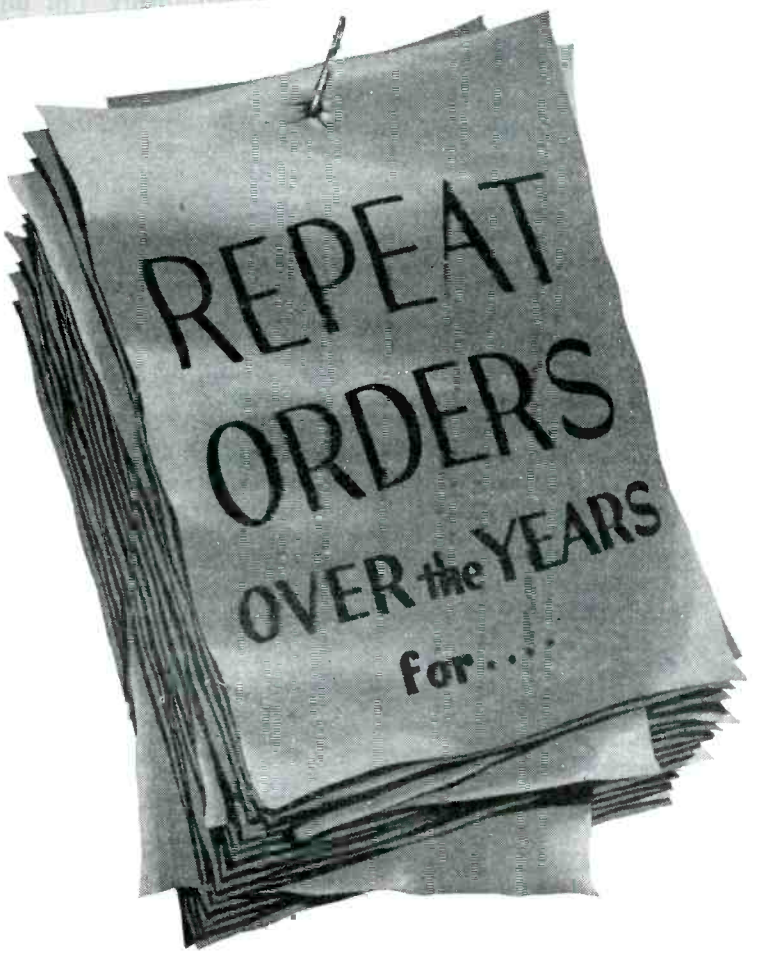
**Snyder:** About January 1st, Snyder Manufacturing Company, of Philadelphia, will open a Chicago sales office in the 333 Building, with Dwight Nelson and Leo Gibrich in charge as midwest representatives.

**Kaar:** Will expand emergency and marine radio telephone sales in New England through representative Irving I. Kahn & Company, 3324 Main Street, Hartford; in the middle Atlantic states through Jack Weber, 114 Liberty Street, New York; and in Kansas, western Iowa, Missouri, Nebraska, and Colorado through C. E. Moore, 3118 Linwood Boulevard, Kansas City, Mo.

**Stromberg-Carlson:** Callander-Lane Company, Columbus, Ohio, will distribute Stromberg radios in the central Ohio area. Partners in this concern are D. G. Callander and R. H. Lane.

**Crosley:** Newcomer is S. D. Mahan, appointed vice-president and general sales manager in charge of domestic and export sales, advertising, and service. For nearly three years he has been director of War Bond advertising and promotion for the U. S. Treasury, and previously served as general advertising manager for Westinghouse.

# TESTIMONIAL to PERFORMANCE!

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Amal Radio Tel Corp 475 Bdwy N Y 13
Amer Brass Co Waterbury Conn
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Amer Communications Corp 306 B'way N Y C
Amer Cond Co 4410 Ravenswood Av Chicago 40
I Menschik H C Kreinick
Amer Cyanamid Co 30 Rockefeller Plaza N Y
Amer Elec Heater Co 6110 Cass Av Detroit 2 Mich
E W Doherty
Amer Felt Co Glenville Conn
Amer Gas Accumulator Co Elizabeth N J
Amer Instr Co 8030 Ga Av Silver Springs Md W H Reynolds
Amer Insulator Corp New Freedom Pa
N E Gage B F Hantz
Amer Lava Corp Chattanooga Tenn
R S Bicknell G E Richter Jr
Amer Microphone Co 1915 S Western Av Los Angeles 7
F A Yarbrough H C Hornickel
Amer Molded Prods Co 1644 N Honore St Chicago
K A Bebington
Amer Phenolic Corp 1830 S 54 Av Chicago
A J Schmitt C Quackenbush
Amer Radio Hdwe Co Inc 152 MacQuesten Pkwy S Mt Vernon N Y
D T Mitchell I R Redland
Amer Radio Co 611 E Garfield Glendale 5 Cal
Jas Ruel Jas Ruel
Amer Steel & Wire Co Rockefeller Bldg Cleveland O
Amer Steel Package Co Defiance O
C F Behringer K A Duerk
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A Goffstein
Amer Time Prods 580 5th Av N Y C
Amer Transformer Co 178 Emmet Newark N J
S Marvin W Garlick
Amperex Electronic Prods 79 Washington St Brooklyn
Amperite Co 561 Broadway N Y C
Amplex Engineering Inc New Castle Ind
Amplifier Co of Amer 398 B'way N Y C
N M Haynes
Amy Aceves & King 11 W 42 St N Y C 18
E V Amy J G Aceves
Anaconda Wire & Cable Co 25 B'way N Y C
Andrea Radio Corp 43-20 34 St L I City 1 N Y
F A D Andrea H J Heindel
Andrew Co 363 E 75 St Chicago 19
V J Andrew C R Cox
Ansley Radio Corp 41 St Joes Av Trenton 9 N J
Ansonia Elec Co Ansonia Conn
W J Weaver A P Lunt
Arnessen Elec Co 116 Broad St N Y C
Arnold Eng Co 147 E Ontario St Chicago
Art Radio Corp 115 Liberty N Y C
Art Wire & Stamping Co 227 High St Newark N J
Astatic Corp Youngstown O
Atlas Condenser Prods Co 548 Westchester Av N Y C 55
S Pariser
Atlas Resistor Co 423 Broome St N Y C 13
W A Merrill E Merrill
Atlas Sound Corp 1443 39 St Brooklyn 18
C R Blumenthal R C Reinhard
Auburn Button Works 48 Canoga Auburn N Y
D Woodruff
Audak Co 500 5th Ave N Y C 18
Audio Development Co 2833 13 Av S Minneapolis 7 Minn
E W Swedien P H Hake
Audio Devices Inc 1600 Broadway N Y C
Autocall Co Shelby O
Auto Engraver Co 1776 B'way N Y C 19
M L Alexander
Automatic Electric Co 1033 Van Buren St Chicago
K W Graybill
Automatic Radio Mfg Co Inc 122 Brookline Av Boston Mass
A J Housman J S DeMetrick
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Automatic Winding Co Passaic Av E Newark
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Baer Co N S 9-11 Montgomery St Hillside N Y
Bakelite Corp 30 E 42 St N Y C 17
J E Brister, Wire & Cable Materials
T W Sharp, Sheet & Foil
C W Patton, Coatings & Adhesives
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R E Brannon, Molding Materials
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H C Mattes W L Dunn
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Britcher Corp 5087 Huntington Dr Los Angeles
Blake Radio Equip Co Great Barrington Mass
L S Thomas
Blaw-Knox Co Pittsburgh Pa
E J Staubitz
Bliley Electric Co Union Sta Bldg Erie Pa
G E Wright J M Wolfskill
Blum & Co Inc Julius 532 W 22 St N Y C
Bodine Electric Co 2254 W Ohio St Chicago
C A Rall
Boes Co, W W 3001 Salem Ave Dayton 10
W W Boes W S Young
Bogen Co Inc, David 663 B'way N Y C 12
J B Hersch B Kardon
Boonton Radio Corp Boonton N J
G A Downbrough L P Blakely
Boots Aircraft Nut Corp Ponus Ridge Rd New Canaan Conn
R W Johnson W Wootton
Borg-Gibbs Lab Delavan Wis
M E Brown
Boston Insulated Wire & Cable Co Boston
Brach Mfg Corp L S 55 Dickerson St Newark N J
W A Robinson
Bradley Labs Inc New Haven 10 Conn
Brainin Co C S 233 Spring St N Y C 13
C S Brainin
Brand & Co Wm 276 4th Ave N Y C
Brandywine Fibre Prods Co 14 & Walnut Sts Wilmington Del
E E Maneck T Breunich
Breeze Corps Inc 41 S 6th St Newark 7 N J
J T Masuch K G Strunk
Brilhart Co Arnold Great Neck N Y
Bristol Co Waterbury 91 Conn
L G Bean
Browning Labs Inc Winchester Mass
C H Day F A Spindell
Brush Development Co Cleveland O
A L Williams B Foulds
Bud Radio Inc 2118 E 55 St Cleveland 3
M L Haas A Sumerville
Bunnell & Co J H 81 Prospect St Brooklyn
J D McLellan R D Avery
Burgess Battery Co Freeport Ill
F J Kirkman J J Coleman
Burlington Inst Co Burlington Ia
F E Bulmahn W S Kramer
Burke Electric Co Erie Pa
E E Crompton C E Humble
Burndy Eng Co Inc 107 Bruckner Blvd N Y C 54
M Lee

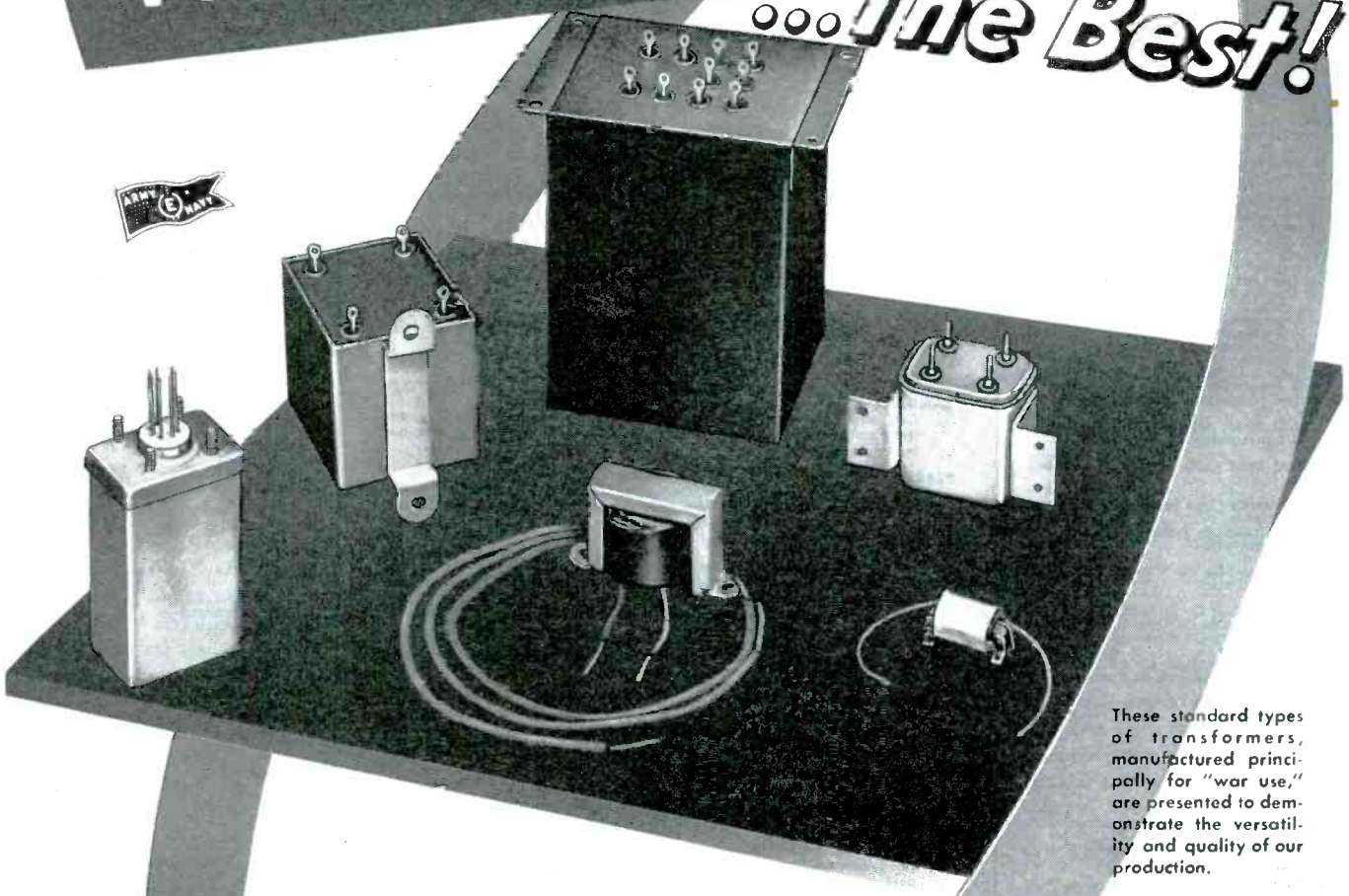
—C—

Callite Tungsten Corp 540 St Union City N J
R Lowit
Cambridge Inst Co 3732 Grand Central Term N Y C 17
R H Kruse V O Hutton
Cambridge Thermionic Corp 443 Concord Av Cambridge Mass
F Lyman Jr A L Quirk
Camloc Fastener Corp 420 Lex Av N Y C 17
J M Summers S W Hennessey Jr
Cannon Elec Dev Co 3209 Humboldt St Los Angeles
R J Cannon E Neifling
Capacitron Co 849 N Kedzie Av Chicago
Carbide & Carbon Chem Corp 30 E 42 St N Y C
Carborundum Co-Globar Div Niagra Falls N Y
K E Rogers B A Bovee
Cardwell Mfg Corp 81 Prospect St Bklyn
J A Benham R L Moorehouse
Carnegie-Illinois Steel Corp Pittsburgh
M M Chapman M W Reed
Carron Mfg Co 415 S Aberdeen St Chicago 7
F Raffles C S Linell
Carter Motor Co 1608 Milwaukee Av Chicago 47
R W Carter
Catalin Corp 1 Park Av N Y C
Celanese Plastics Corp 180 Madison Av N Y C
Centralab Div of Globe-Union Inc 900 E Keefe Av Milwaukee Wis
J D Wanvig J F Harper
Chace Co W M 1600 Beard Av Detroit Mich
C F Alban
Champion Radio Works Danvers Mass
Chatham Electr 475 Washington St Newark
A Scala W L Meier
Chicago Cond. Corp 3255 W Armitage Chicago 47
Chicago Molded Prods. Corp 1020 N Kolmar Chicago 51
E F Bachner F Swanson
Chicago Tel Sup Co W Beardsley Av Elkhart Ind
N C Schellenger
Chicago Transformer Div Essex Wire Corp 3501 Addison St Chicago 18
A Helgison D Schwennesen
Churchill Cabinet Co 2119 Churchill Av Chicago
Cinaudagraph Speakers Inc 3911 S Mich Av Chicago
R Adams M R Jones
Cinch Mfg Co 2335 W Van Buren St Chicago
C Wilson C L Knutson
Cincinnati Elec Pts Co Cincinnati 12
W C Sage
Cinema Eng Co 1508 W Verdugo Av Burbank Cal
A C Davis A C Davis
Clare & Co C P 4719 Sunnyside Av Chicago
C P Clare G F Weinreich
Clarostat Mfg Co Inc 130 Clinton St Brooklyn 2
G J Mucher
Cohn Sigmond 44 Gold St N Y C 7
Cole Steel Equip Co 349 B'way N Y C
Collins Radio Co Cedar Rapids Ia
A A Collins F M Davis
Collyer Ins Wire Co Pawtucket R I
Colonial Kolonite Co 2212 W Armitage Av Chicago
Colonial Radio Corp 254 Rano St Buffalo
A H Gardner H C Forbes
Columbia Wire & Supply Co 4106 N Pulaski Rd Chicago
Comar Elec Co 2701 Belmont Ave Chicago
Comm Equip & Eng Co 504 N Parkside Av Chicago
R A Clark Jr
Comm Measurements Labs 120 Greenwich St N Y C
D A Griffen
Comm Parts 1101 N Paulina St Chicago
R R Simons W R Wolfgram
Comm Products Co Jersey City N J
Comm Co Inc 300 Greco Av Coral Gables 34 Fla
G E Smith G A Leap
Comm Equip Corp 134 W Colorado St Pasadena 1 Calif
R Kimball R Kimball
Conant Elec Labs Lincoln Neb
Condenser Corp of Amer S Plainfield N J
Concord Radio Corp 901 N Jackson Ave Chicago
S W Berk H R Levinger
Condenser Prods Co 1375 N Branch St Chicago
M H Levenberg
Conn Tel & Elect Div Meriden Conn
F W Watts W R Curtis
Cons Diamond Saw Blade Corp Yonkers Av Yonkers 2 N Y
Cons Radio Prod Co 350 W Erie Chicago
E A Heppner
Continental Carbon Inc 13900 Lorain Av Cleveland O
Continental-Diamond Fibre Co Newark Del
Continental Elec Co Geneva Ill
H A McLivaine J H Hutchings
Continental Elec Co Newark N J
A W Peterson G E Peterson
Continental Radio & Telev. Corp 3800 W Cortland St Chicago
Cook Elec Co 2700 Southport Av Chicago
Cornell-Dubilier Elec Corp New Bedford Mass
W M Bailey
Corning Glass Works Corning N Y
W C Decker, Bulk & Tubing Div
C J Phillips, Electronic Dept
E F Ling, Product Engineering
T S Wood Jr, Lamp Dept
Cornish Wire Co Inc 15 Park Row N Y C 7
J Cook M T Mallard
Corry-Jamestown Mfg Corp Corry Pa
Cosmic Radio Corp 699 E 135 St N Y C 54
S Fishberg
Coto-Coil Co Providence R I
Cramer Co Centerbrook Conn
Creative Plastics Corp 963 Kent Av Bklyn
Crescent Ins Wire & Cable Co Trenton N J
Crosley Corp 1329 Arlington St Cincinnati
R C Cosgrove L M Clement
Crowname Inc 3701 Ravenswood Av Chicago
M M Lane A Leline
Crowley & Co Inc 1 Central Av W Orange N J
H I Danziger H L Crowley
Crystal Prod Co 1519 McGee St Kansas City Mo
L A Elbi
Crystal Research Labs 29 Allyn St Hartford 3 Conn
S T Ward S E Warner
Cutler-Hammer Inc Milwaukee Wis
P Ryan P B Hardwood

—D—

Dante Elec Mfg Co Bantam Conn
J J Dante
Daven Co 191 Central Av Newark N J
L Newman J P Smith
de Forest Labs Lee 5106 Wilshire Blvd Los Angeles
L deForest
Dejur-Amsco Corp 6 Bridge St Shelton Conn
H Blye
Delco Radio Div 303 N Bueckeye Kokomo Ind
B W Cooper B A Schwarz
Detrola Corp 1501 Beard Detroit Mich
R M Daugherty
Deutschmann Corp Tobe Canton Mass
De Vry Herman A 1111 W Center Chicago
DeWald Radio Corp 440 Lafayette St N Y C
M Glaser
Dial Light Co of Amer Inc 900 B'way N Y C
Dial Light & Signal Co 90 W St N Y C 6
Diamond Inst Co Wakefield Mass
Dictaphone Corp 375 Howard Av Bridgeport Conn
T H Beard
Diehl Mfg Co Somerville N J
P H Trickey
Dinion Coil Co Caledonia N Y
F S Eberts I W Armstrong
Dixon Crucible Co Jersey City N J
Dobeckman Co Cleveland O
H E Allen
Dolph John C 1060 Broad St Newark N J
Doolittle Radio Inc 7421 S Loomis Blvd Chicago
D Gray D Gray
Dow Chemical Co Midland Mich
W H Dow L J Richards

# "TYPICAL" TRANSFORMERS ... The Best!



These standard types of transformers, manufactured principally for "war use," are presented to demonstrate the versatility and quality of our production.

## and now, a look at the future

Our engineering and production departments will shortly announce a number of startling advancements, in the way of new constructions and new models. Our production facilities will be adequate to take care of most any unusual demand and will cover a wide range of applications. If you are in the market for any type of transformer, we urge you to contact us for suggestions.

Write for catalog.

**SNC**

# SWAIN NELSON COMPANY

GLENVIEW, ILLINOIS

## MANUFACTURERS, Continued

Drake Elec Works 3656 Lincoln Ave Chicago
G Petitt
Drake Mfg Co 1713 W Hubbard St Chicago 22
A J Foute H K Foute
Driver-Harris Co Harrison N J
F L Driver F E Bosh
Dumont Elec Co 34 Hubert St N Y C
J Katzman
DuMont Labs, Allen B Passaic N J
A B DuMont P S Christaldi
DuMont De Nemours & Co Arlington N J
Durez Plastics & Chemicals Inc North Tonawanda N Y
A W Hanmer E F Borro
DX Crystal Co 1200 Claremont Chicago
D-X Radio Prods Co 1200 N Claremont Av Chicago 22
M P McLean L J Patla

—E—

Eastern Air Devices 130 Flatbush Av Bklyn
H G Hamilton L C Pratt
Eastern Amp Corp 794 E 140th St N Y C 54
Eastern Electronics Corp 41 Chestnut St New Haven Conn
Eby Inc H H 18-A W Chelton Av Phila
H Holmstrom L R Wanner
Echophone Radio Co 540 N Mich Chicago 11
W J Halligan R E Samuelson
Eckstein Radio & Telev Co 1400 Harmon Pl Minneapolis 3 Minn
E A Eckstein E A Eckstein
Edwards Co W H 94 B'way Providence R I
E Gervais W H Edwards
Eicor Inc 1501 W Congress Chicago 7
Eisler Eng Co 751 S 13th St Newark N J
J Morick C Eisler
Eitel McCullough Inc San Bruno Calif
G F Wunderlich G Howes
Elastic Stop Nut Corp Of Amer Union N J
C E Heintz H Karlby
Elec Ind Inc 42 Summer Av Newark 4 N J
W H Fredericks
Electrical Insulation Co Inc 12 Vestry St N Y C 13
Electrical Prods Supply Co 1140 Venice Blvd Los Angeles 15
L A Rice
Electrical Prod Corp 950 30 St Oakland Calif
G W Thunen
Elec Reactance Corp Franklinville N Y
D N Wagner C E Krampt
Electrical Research Labs Inc 2020 Ridge Av Evanston Ill
O F Taylor W J Schnell
Electric Auto-Lite Co Wire & Cable Div Port Huron Mich
J A Minch F H Wetzel
Electric Indicator Co Stamford Conn
Elec Soldering Iron Co Deep River Conn
Electric Specialty Co Stamford Conn
D G Shepherd E W Borggrafe
Electric Storage Battery Co Phila Pa
Electrix Corp 140 Middle St Pawtucket RI
W P Herman J Carr
Electro Motive Mfg Co Willimantic Conn
J A Flanzer M Cohn
Electro Prod Labs 390 W Randolph Chicago
Electronic Comm Co 36 N W B'way Portland Ore
Electronic Corp of Amer 45 W 18 St N Y C 11
S J Novick F Lester
Electronic Eng Co 3225 W Armitage Chicago
Electronic Enterprises Inc 656 Av N Y C
Electronic Labs Inc 122 W New York St Indianapolis 4 Ind
W W Garstang R H Frye
Electronic Lab 1688½ Laural Canyon Blvd Los Angeles Calif
L C Barns
Electronic Mechanics Inc 70 Clifton Blvd Clifton N J
F B DuVall D E Replogle
Electronic Products Mfg Corp Dexter Mich
Electronic Specialty Co 3456 Glendale Blvd Los Angeles Calif
D A Marcus S K Babcock
Electronic Trans Co 207 W 25 St N Y C 1
A Cezar A Cezar
Electr Tube Corp 1200 E Mermaid Av Phila
Electronic Winding Co 5031 B'way Chgo Ill
Electro Tech Prod Inc Nutley N J
Electro-Voice Inc 1239 S Bend Av South Bend Ind
A R Kahn L R Burroughs
Emerson Radio & Phono Corp 111 8th Av N Y C
B Abrams D D Israel
Endurette Corp of America Cliffwood N J
Erco Radio Labs Inc 231 Main St Hempstead N Y
F Ruth E Ruth
Erie Resistor Corp 640 W 12 St Erie Pa
G R Fryling B B Minnium
Espey Mfg Co Inc 33 West 46 St N Y C 19
N Pinsley J Rosenbaum
Etched Prod Corp 39–01 Queens Blvd L I City N Y
A Nierenberg
Ever-Ready Label Corp 141 E 25 St N Y C

—F—

Fada Radio & Elec Co Inc 30–20 Thomson Av L I City N Y
E C Nicholides C E Honeywell
Fairchild Camera & Inst Corp 475 10th Av N Y 18 N Y
Fansteel Metallurgical Corp North Chicago
R J Atchison F L Hunter
Farnsworth Tele & Radio Corp 3701 Pontiac Fort Wayne Ind
B R Cummings J Ferguson
Fast & Co John E 3109 N Crawford Av Chicago
L Kopinski W S Franklin
Federal Elec Co 8700 S State St Chicago
Federal Eng Co 37 Murray St N Y C 18
M J Kirsch M J Kirsch
Federal Mfg & Eng Corp 199–217 Steuben St Bklyn 5
D H Engelson M Kaplowitz
Federal Recorder Co Elkhart Ind
Federal Tel & Radio Co 200 Mt Pleasant Newark 4 N J
E N Wendell E G Ports
W P Short
F X Rettenmeyer
Felker Mfg Co Torrance Calif
M N Felker M W Hinshaw
Ferranti Elec Inc 30 Rockefeller Plaza N Y C
W R Spittal
Ferris Inst Co Boonton N J
Ferrocart Corp of Amer Hastings on Hudson N Y
Finch Telecommunications Inc Passaic N J
Ford Radio & Mica Corp 538 63 St Bklyn
Formica Insulation Co Cincinnati Ohio
D J O'Connor G H Clark
Foster A P Co 719 Wyoming Av Lockland O
Franklin Mfg Corp 175 Varick St N Y C
A W Franklin
Freed Radio Corp 200 Hudson St N Y C
A Freed M Weinstein
Freed Transformer Co 72 Spring St N Y C
L Freed D Gurevics

—G—

Galvin Mfg Corp 4545 W Augusta Blvd Chicago
F J O'Brien D H Mitchell
Garden City Lab 2744 W 37 Pl Chicago Ill
Garner Co Fred E 43 E Ohio St Chicago
Garod Radio Corp 70 Washington St Bklyn
B S Trott
Gates Radio Co 123 Hampshire Quincy Ill
P S Gates FGrinwood
Gavitt Mfg Co Inc Brookfield Mass
Gear Specialties 2635 W Medill Av Chicago
E H Johnson C B Hale
Gen Armature Corp Lock Haven Pa
A C Potratz T Ramsey
Gen Cable Corp 420 Lex Av N Y C
J R McDonald I T Faucett
Gen Ceramics & Steatite Corp Keasbey N J
Gen Comm Co 530 Commonwealth Av Boston
T M Hastings Dr M C Bloom
Gen Control Co 1200 Soldiers Field Rd Boston 34 Mass
W J Kelleigh E B Farmer
Gen Electric Co Bridgeport Conn
Receiver Div
I J Karr C G Fick
Gen Electric Co Pittsfield Mass
Gen Electric Co Syracuse N Y
Transmitter Div
C A Priest J J Farrell
Gen Electric Co Owensboro Ky
Ken Rad Div
M J Lang
Gen Electr Inc 101 Hazel St Paterson N J
A C Mueller E J Oberle
Gen Industries Co Elyria Ohio
D L Boyd
Gen Inst Corp 829 Newark Av Elizabeth N J
B N Fisher
Gen Ins Wire Corp 53 Park Pl N Y C
Gen Radio Co 90 West St N Y 6 N Y
I G Easton
Gen Radio Co 275 Mass Av Cambridge 39 Mass
A G Thiessen
Gen Scientific Corp 4829 Kedzie Av Chicago
Gen Tele & Radio Corp 2701 Lehmann Ct Chicago 51
H R Rose W Kroening
Gen Trans Corp 1250 W Van Buren Chicago
L J Seelig C E DeHorn
Gen Winding Co 420 W 45 St N Y C
W A Barlow
Giannini & Co Inc 161 E Calif St Pasadena 5 Calif
Gibbs & Co Thos B Delavan Wisc
P Morrison P Wickham
Gilfillan Bros Inc 1815 Venice Blvd Los Angeles 6 Calif
S W Gilfillan F C Wolcott
Girard-Hopkins 1000 40 Av Oakland 1 Calif
J C Hopkins
A R Stack C Lasswell
Glts Molding Corp 4600 Huron St Chicago
G-M Labs Inc 4300 N Knox Av Chicago
A J McMaster A J McMaster
Glaser Lead Co Inc 31 Wyckoff Av Bklyn 27
Globar Div Carborundum Co Niagara Falls N Y
Goat Metal Stampings Inc 314 Dean St Bklyn
E M Haines
Gothard Mfg Co 2110 Clear Lake Av Springfield Ill
Goodrich Chem Co Rose Bldg Cleveland 15
Gould-Moody Co 395 B'way N Y C
Graybar Elec Co Inc 420 Lexington Av N Y C
C S Powell J W La Marque
Gray Mfg Co Hartford Conn
Gray Radio Co West Palm Beach Fla
G H DeShazo F E Gray
Green Elec Co Inc 130 Cedar St N Y C
Grenby Mfg Co Plainville Conn
C A Gray L H Whitney
Greenlee Tool Co 1929 Columbia Ave Rockford Ill
Groves Corp Cape Girardeau Mo
Guardian Elec Mfg Co 1400 W Wash Blvd Chicago
F F Rowell Jr M Nelsen
Guided Radio Corp 161 6th Av N Y C
F W Nickerson H C Dalrymple
Guthman & Co Edwin I 15 S Throop St Chicago

—H—

Halldorsen Co 4500 Ravenswood Av Chicago
Hallicrafters Co Chicago 16
C B Shapiro N W Turner
Hamilton Radio Corp 510 6 Av N Y C 11
A A Juviler J Raydin
Hammarlund Mfg Co Inc 460 W 34 St N Y C
L A Hammerlund E A Leach
Hanovia Chem & Mfg Co Newark 5 N J
Harco Steel Constr Co Inc 1180 E Broad Elizabeth N J
E Schaefer
Hardwick Hindle Inc Newark N J
Harris Prod Co Cleveland 4 Ohio
Hart Fdk & Co Inc 350 Madison Av N Y C
Harvey Radio Labs Inc 447 Concord Av Cambridge 38 Mass
F Lyman Jr A L Quirk
Harvey Wells Electr Inc Southbridge Mass
M T Harges C A Harvey
Hartman Corp of Amer 6417 Dale Av St Louis Mo
L H Matthey Jr
Harwood Co 540 N LaBrea Av Los Angeles 36 Calif
G J Levingston A C Pearson
Haydon Mfg Co Inc Forestville Conn
R A Conover C M Reed
Hazard Ins Wire Wks Wilkes-Barre Pa
Hazeltine Electronics Corp 58–25 Little Neck P'kway Little Neck N Y
D E Harnett
H-B Instr Co 2524 N Broad St Phila 32
W E Girard C G Roveran
Heinamann Circuit Breaker Co 137 Plum St
Trenton N J
B S Berlin N J Schwartz
Heintz & Kaufman Ltd So San Francisco
R H Andersen G Lebedeff
Herbach & Rademan Co 522 Market St Phila
M Rademan L Herbach
Hermaseal Co Rvside Dr Elkhart Ind
Hewlett-Packard Co 395 Page Mill Rd Palo Alto Calif
G Zieber B Bauer
Hexacon Elec Co 161 W Clay Av Roselle Park N J
A L Johnson A L Johnson
Hickok Electrical Inst Co 10514 Dupont Av Cleveland 8 Ohio
R D Hickok Jr W A Weiss
Hilo Varnish Co 42 Stewart Av Brooklyn
Hoffman Radio Corp 3330 S Hill St Los Angeles
H L Hoffman
Hollywood Electronics Service Dept 1223 Venice Blvd Los Angeles 6 Calif
J Gunter H Schaffer
Holyoke Wire & Cable Corp Holyoke Mass
Homelite Corp Port Chester N Y
Hopp Press Inc 460 W 34 St N Y C 1
P Hopp
Howard Pacific Corp 923 N Western Av Los Angeles
Howard Radio Co 1731 Belmont Av Chicago
J M Munlz W James
Hoyt Elec Inst Wks Boston Mass
H R S Prods 5707 W Lake St Chicago
H R Sleniers D Zmuda
Hudson American Corp 25 W 43 St N Y C
R Young A Haas
Hytron Radio & Electr Corp Salem Mass
B A Coffin C F Stromeyer

—I—

Illinois Cond Co 3243 Calif. Av Chicago
J J Kurland
Industrial & Com Electronics P O Box 296
Belmont Calif
R C Shermund D G Clifford
Ind Cond Corp 1725 W North Av Chicago
H L Sklar
Ind Timer Corp 115 Edison Pl Newark N J
Insl-X Co Inc 857 Meeker Av Brooklyn
Instr Resistors Co Little Falls N J
A H Mellek
Instr Specialties Co Inc 224 Bergen Blvd Little Falls N J
R W Carson F S Stickney
Insulation Mfgrs Corp 565 W Wash Blvd Chicago 6 Ill
A S Gray B F McNamara
Insuline Corp of Amer 36–02 35 Av Long Island City N Y
S J Spector A L Peterson
Interchemical Corp 350 5th Av N Y C 1
C J Roh J R Esposito
International Detrolo Corp Beard & Chatfield Sts Detroit 9 Mich
International Resistance 401 N Broad St Philadelphia 8 Pa. J Marsten
International Nickle Corp 67 Wall St N Y C
Irvington Varnish & Ins Co Irvington N J
J J Connors
Islip Radio Mfg Corp Islip L I
A E Theis A Weiner
Isolantite Inc Belleville N J
G W Hawkins

—J—

Jackson Electrical Inst Co Dayton Ohio
Janette Mfg Co 556 W Monroe Chicago Ill
A E Klunder J Kotchevar
J-B-T Instruments Inc 441 Chapel St New Haven 8 Conn
R M Bixler D E Andersen
Jefferson Elec Co Bellwood Ill
A E Tregenza L Maurer
Jefferson-Travis Corp 245 E 23 St N Y C
E E Ellnger Jr W B Wilkens
Jelliff Mfg Corp Southport Conn
Jennings Radio Mfg Co San Jose Calif
C K Townsend J E Jennings
Jensen Radio Mfg Co 6601 S Laramie Av Chicago
T A White H S Knowles
Johnson Co E F Waseca Minn
E F Johnson L W Olander
Jones Co Howard B 2460 W George St Chicago

—K—

Kaar Engineering Co 619 Emerson St Palo Alto Calif
J M Kaar N C Helwig
Karadio Corp 1400 Harmon Pl Minneapolis
Karp Metal Prods Co Inc 124 30th St Bklyn
Kato Engineering Co Mankato Minn
C H Jones C H Jones
Kellog Switchb'd & Supply Co 6650 Cicero Chicago
Kelnor Mfg Co Central Tower San Francisco
Kemlite Labs 1809 N Ashland Av Chicago
J V Daniels O H Floyd
Kenyon Trans Co Inc 840 Barry St N Y C
R B Shimer
Kester Solder Co 4209 Wrightwood Av Chicago 39 Ill
Keuffel & Esser Hoboken N J

## SCHEDULE OF DIRECTORIES FOR 1946

**JANUARY • Emergency Stations**
Call letters and names of radio supervisors of all municipal, county, and state police systems, and forestry, fire, public utility, railroad, trade, and bus radio systems.

**FEBRUARY • FM and Television Stations**
Both stations on the air and for which applications have been filed, together with their frequencies and call letters, and the names of the general managers and chief engineers.

**APRIL • Products Directory**
This is the most comprehensive Products Directory appearing in any radio publication. Items are indexed according to the requirements of purchasing agents and engineers, for quick reference, under more than 300 individual headings.

**MAY • Parts Jobbers and Factory Representatives**
Another exclusive directory, listing all accredited parts jobbers, and showing the lines handled by each factory representative.

**JULY • Emergency Stations**
Call letters and names of radio supervisors of all municipal, county, and state police systems, and forestry, fire, public utility, railroad, trade, and bus radio systems.

**AUGUST • FM and Television Stations**
Both stations on the air and for which applications have been filed, together with their frequencies and call letters, and the names of the general managers and chief engineers.

**OCTOBER • Products Directory**
This is the most comprehensive Products Directory appearing in any radio publication. Items are indexed according to the requirements of purchasing agents and engineers, for quick reference, under more than 300 individual headings.

**NOVEMBER • Manufacturers Directory**
Names and addresses of all companies manufacturing radio and associated equipment, tubes, materials, components, supplies, and insulating parts. Also will include names of sales managers, purchasing agents, and chief engineers.

## MANUFACTURERS, Continued

Keystone Carbon Co St Marys Pa
Kings Electr Co 372 Classon Av Bklyn
Knights Co James Sandwich Ill
L A Faber M A A Druesne
Kohler Co Kohler Wisconsin
Konkaljian Dani Eng Co 27 Wright St Newark N J
Kurman Elec Co 3030 Northern Blvd L I City N Y
Kurz Kasch Inc 1421 S B'way Dayton Ohio
C H Frantz L J Rawson
Kyle Corp South Milwaukee Wisconsin
R L Stebleton

—L—

Lake Radio Sales Co 615 Randolph St Chicago 6 Ill
J Aremka
Langevin Co 37 W 65 N Y C 23
Lapp Insulator Co Leroy N Y
Lavole Labs Morganville N J
S D Lavole A M Schmeling
Lawton Norman H 1775 B'way N Y C
Lear Inc 1480 Buchanan Av S W Grand Rapids Mich
E R Crane L G Woycke
Lectrohm Inc 5123 W 25 St Cicero 50 Ill
J J Cerny
Leeds & Northrup Co Philadelphia Pa
J C Hess J W Harsch
Leland Elec Co 1501 Webster St Dayton O
W F Lisman E B George
Lenz Elec Mfg Co 1751 N Western Av Chicago
R G Zender
Lepel Labs 39 W 60 St N Y C
S L Teitler H Peterson
Lewis Electronics Los Gatos California
M Shaw G W Lewis
Lewyt Corp 60 B'way Brooklyn N Y
R McGiffin A Wolf
Lifetime Sound Equipment Co 1101 Adams St Toledo Ohio
Lingo & Son John E Camden N J
J E Lingo W Thompson
Link Radio Corp 125 W 17 St N Y C 11
F M Link F T Budelman
Littlefuse Inc 4757 N Ravenswood Chicago 40
E V Sundt F Barta
Litton Eng Labs Redwood City Cal.
J P Gordon W C Wagener
Locke Insulator Corp P O Box 57 Baltimore Md
R G Bellezza R L McCoy
Lord Mfg Co Erie Pa
D L Dean
Louthan Mfg Co 2000 Harvey Av E Liverpool O
H S Russell C W Gerster
L-R Mfg Co Torrington Conn

—M—

Machlett Labs Inc Springdale Conn
Maas & Waldstein Co Newark N J
Macallen Co Boston Mass
Magnavox Co Fort Wayne 4 Indiana
L. E. Quinnell R. H. Dreisbach
Magnetic Windings Co Div of Essex Wire Corp 16 & Butler Sts Easton Pa
N R Donohoe W. H. Lowell
Majestic Radio & Telev Corp 2600 W 50 St Chicago
F Pachoike
Makepeace Co D E Attleboro Mass
Mallory & Co Inc, P R 3029 E Washington Indianapolis 6 Ind
J E Cain L Robbin
Mangold Radio Parts & Stamping Co 6300 Shelbourne St Phila 11
F Strobel
Marion Elec Inst Co Manchester N H
R A Ammon
Matchless Elec Co 564 W Randolph St Chicago
M B Mfg Co Inc 250 Dodge Av East Haven Conn
McClintock Co O B 139 N Lyndale Av Minneapolis Minn
L G Pattee E J Boucher
McElroy Mfg Corp 82 Brookline Av Boston
T R McElroy T R McElroy
Measurements Corp Boonton N J
H W Houck J B Minter
Mecanitron Corp 711 Boylston St Boston 16
Meck Industries John Plymouth Ind
J S Meck C Wexler
Meissner Mfg Div Maguire Ind Mt Carmel Ill
J Watson E J Stanmyre
Merit Coil & Trans Corp 4427 N Clark Chicago
J I Crocket C E H Jones
Metallic Arts Co 243 B'way Cambridge Mass
Metaplast Co 205 W 19 St New York
J Stein M A Prince
Metamold Radio Corp 1087 Flushing Av Brooklyn 6 N Y
F A Whiting A DiGiacomo
Micarta Fabricators Inc 5324 Ravenswood Av Chicago Ill
E Metzger
Micro Ferrocart Prods Div Maguire Ind 875 Fairfield Av Stamford Conn
H A Ford C C Neighbors
Micro Switch Div Freeport Ill
W W Gilmore P A Celander
Midwest Radio Corp 909 B'way Cincinnati 2
A G Hoffman P Smith
Millen Mfg Co Malden Mass
J Millen R W Caywood
Miller Co J W 5917 S Main St Los Angeles
P O'Connor
Mitchell Rand Ins Co 51 Murray N Y C 7
W B Stevens J J Finn
Monarch Mfg Co 2014 N Major Av Chicago
Monowatt Electric Corp 66 Bissell St Providence 7 R I
G B Behander
Monsanto Chemical Co Springfield Mass
Mossman Inc Donald P 612 N Mich Av Chicago
D P Mossman Sr C A Koerner
Mueller Elec Co 1583 E 31 St Cleveland
S Mueller E H DeConingh
Murdock Mfg Co Chelsea Mass
Muter Co 1255 S Mich Av Chicago 5 Ill
L F Muter K E Rollefson
Mycalex Corp of America Clifton N J
J Talshoff A J Monack

—N—

National Co Inc 61 Sherman St Malden Mass
W A Ready W J Larkin
Natl Carbon Co 30 E 42 St N Y
Natl Electr Mfg Co 22–78 Steinway L I City N Y
E Friedlander
Natl Tel Supply Co 5100 Superior Av Cleveland
Natl Union Radio Corp 15 Wash Newark N J
Dr L G Hector
Natl Varnished Prod Corp Woodbridge N J
Newark Transformer Co 17 Frelinghuysen Av Newark 5 N J
M J Herold O A Keefe
Newcomb Audio Prods Co 2815 So Hill St Los Angeles Calif
New York Transformer Co 26 Waverly N Y C 3
J C Hindle Z Burzycki
Noblitt Sparks Ind Inc 13th & Big 4 R R Columbus Ind
O G Noblitt A E Silva
Noma Electric Corp 55 W 13 St N Y C
W Marshall J E Funk
Northern Comm Mfg Co 210 E 40th St N Y C
H L Quick
No Amer Philips Co 100 E 42nd St N Y
Northern Labs Ltd 3–01 27 Av L I City N Y
J Zaleski
Norton Elec Inst Co Manchester Conn

—O—

Oak Mfg Co 1260 Clybourn Av Chicago 10
E Sandstrom E J Mastney
Ohio Carbon Co Cleveland Ohio
A K Moulton L L Stoffel
Ohmite Mfg Co 4835 W Flournoy St Chicago
J S Howe H Levy
Okonite Co Passaic N J
Onan & Sons, D W 2401 Royalston Av Minneapolis 5 Minn
C W Onan J C Holby
O'Neil-Irwin Mfg Co 321 8th Av So Minneapolis 15 Minn
Operadio Mfg Co St Charles Ill
G R Haase J F McCraigh
Owens-Corning Fiberglas Corp Toledo Ohio
R J Black
Oxford-Tartak Radio Corp 3911 S Mich Av Chicago
R Adams M R Jones

—P—

Packard Bell Co 1115 S Hope St Los Angeles
H D Thomas Jr R H Freck
Palnut Co 92 Cordlor St Irvington N J
J R Hotchkin E Hill
Pan-Electr Labs Inc 500 Spring St N W Atlanta
Panoramic Radio Corp 245 W 55 St N Y C
H L M Capron J I Heller
Parker-Kalon Co 198 Varick St N Y C
L Goldberg
Par-Metal Prod Corp L I City N Y
Patton-MacGuyer Co 17 Virginia Av Providence 5 R I
R C Patton T Steel
Peerless Electrical Prod Co 6920 McKinley Los Angeles
J Jaueh
Permo Prods Corp 6415 Ravenswood Chicago
Permoflux Corp 4900 W Grand Av Chicago
W E Gilman R C Bierman
Peterson Radio Council Bluffs Ia
Pheoll Mfg Co 5700 W Roosevelt Rd Chicago 50
E M Whiting F P Tisch
Philco Corp Tioga & C Sts Phila 34
J Ballantyne Radio P Craig
Telev F J Bingley
Philco Corp Storage Btry. Div Trenton 7 N J
Philharmonic Radio Corp 528 E 72 St N Y C
Z Soucek V Brociner
Philmore Mfg Co 113 Univ Pl N Y C 21
P Schwartz R Burke
Photobell Corp 116 Nassau St N Y C
A Edelman
Pierce-Roberts Co Trenton 6 N J
H W Roberts
Pilot Radio Corp 37–06 36 St L I City N Y
I Goldberg E Jahns
Pioneer Gen-E-Motor Corp 5841 W Dickens Av Chicago 39 Ill
Plaskon 2136 Sylvan Av Toledo Ohio
Plastic Wire & Cable Corp Norwich Conn
Plax Corp Hartford Conn
Polan Industries Huntington W Va
Polymet Condenser Co 701 E 135 St N Y C
S Fishberg
Precision Fabricators Inc E Rochester N Y
C W Major R L Pilon
Precision Tube Co 3824 Terrace St Phila
N H Jack E Turney
Premax Prods Div Inc Niagara Falls N Y
G O Benson
Premier Crystal Labs Inc 63 Park Row N Y C
A A Glass H M Bach
Premier Metal Etching Co 21–03 44 Av Long Island City N Y
Press Wireless Inc 1475 Broadway N Y C
A W Norton E E Eldredge
Presto Elec Co New York Av Union City N J
Presto Recording Corp 242 W 55 St N Y C 19
R C Powell G A Salaba
Price Bros Co Frederick Md
Printloid Inc 93 Mercer St N Y C 12
G Margolish
Production Engineering Corp 666 Van Houton Ave Clifton N Y
Pyroferric 175 Varick St N Y C

—Q—

Quaker City Gear Wks Inc N Front St Phila
Quam-Nichols Co 33 Pl Av Chicago 16 Ill
J P Quam H F Breit
Quartz Labs 1512 Oaks St Kansas City Kan
H Bowman O Jenkins

—R—

Racon Electric Co Inc 52 E 19 St N Y C 3
A I Abrahams A I Abrahams
Radell Corp Guilford Av Indianapolis Ind
Radex Corp 53 W Jackson Blvd Chicago
R R Cook H Stein
Radiart Corp W 62 St Cleveland Ohio
J N Schwerkert R Blauvelt
Radiation Prods Inc 1142 Wall St Los Angeles
R Lewis G M Urey
Radio City Prods Co 127 W 26 St N Y C
M Reiner F L Horman
Radio Condenser Co Camden N J
R E Cramer J S Robb
Radio Corp of Amer Camden N J
Radio Craftsmen 1341 S Mich Av Chicago
B L Friend E E Schultz
Radio Elec Serv Co of Pa N W Cor 7th & Arch Sts Phila 6
M Green A E Silva
Radio Engineering Labs Inc L I City N Y
W H Dietz M H Jennings
Radio Frequency Labs Boonton N J
R Corbin R W Seabury
Radio Inventions Inc 155 Perry St N Y C
R W Bristol J V L Hogan
Radio Mfg Engineers Inc 306 First Av Peoria 6 Ill
E G Shalkhauser R M Planck
Radiomarine Corp of Amer 75 Varick St N Y C
I F Byrnes
Radio Receptor Co Inc 251 W 19 St N Y C
H Cohn E D Gibbs
Radio Speakers Inc 221 E Cullerton Chicago
H C Forster G S Holly
Radio Supply & Eng Co Inc 129 Selden Av Detroit 1 Mich
Radio & Tel Ins Inc 480 Lexington Av N Y C
Radio Transceiver Labs 8717 117 St Richmond Hill N Y
F Jacobs F Jacobs
Radio Wire Telev Inc 100 6th Av N Y C 3
B Lehman L Marko
Radolek Co 601 W Randolph Chicago 6 Ill
Rauland Corp 4245 N Knox Av Chicago 41
E N Rauland J J O'Callaghan
Rawson Elec Inst Co 111 Potter St Cambridge Mass
Raytheon Mfg Co Foundry Av Waltham Mass
L K Marshall P L Spencer
Ray-O-Vac Co Madison 4 Wisconsin
Readrite Meter Works Bluffton Ohio
Rea Magnet Wire Co E Pontiac St Ft Wayne
R L Wheatley P M Bechtol
R E C Mfg Corp 1250 Highland St Hollis-ton Mass
R E Chick N F Huntley
Reeves Sound Labs 62 W 47 St N Y C
H E Reeves
Remler Co Ltd 2101 Bryant St San Francisco 10
E G Danielson H A Greene
Rice Bernard Sons Inc 325 5th Av N Y C 16
J A Despres
Richardson Co Melrose Park Ill
Richardson Allen Corp 15 W 20 St N Y C
E H Connelly
Rider Labs John F 404 4th Av N Y C
R Lorenzen
Ripley L-R Div 13 New Litchfield St Torrington Conn
Rockbestos Corp New Haven 4 Conn
B H Reeves H S Moore
Roebling's Sons Co John Trenton N J
C R Tyson C M Jones
Rogan Bros 2001 S Michigan Av Chicago
Rohn & Haas Co Wash Sq Philadelphia Pa
Rola Co Inc 2530 Superior Av Cleveland O
J Q Tiedje
Roller-Smith Div Bethlehem Pa
W S Gubelmann Jr A C Bates
Runzel Cord & Wire Co 4723 Montrose Av Chicago Ill
Russell Electric Co 366 W Huron Chicago 10

—S—

Sangamo Electric Co Springfield Ill
H L Kunz F C Holtz
Santay Corp 358 N Crawford Chicago Ill
Schott Co Walter L 9306 Santa Monica Blvd Beverly Hills Calif
W L Schott F Wilborn
Schauer Mach Co 2075 Reading Rd Cincinnati
G L Nord
Scientific Radio Prods Co 738 W B'way Council Bluffs Ia
L I Meyerson A Shidler
Scientific Radio Serv 4301 Sheridan St University Pk Hyattsville Md
H D Eisenhauer
Scott Radio Labs Inc 4450 Ravenswood Av Chicago Ill
E J Halter M Hobbs
Scovill Mfg Co 99 Mill St Waterbury Conn
N A Cornell
Seeburg Corp J P 1510 Dayton St Chicago
J L Barron M W Kenney
Selectar Mfg Corp 21–10 49 Av L I City N Y
C R deSyles J T Powers
Selenium Corp of Amer 1719 W Pico Blvd Los Angeles
M Burlin E Lidow
Sensitive Research Inst Co 9 Elm Av Mt Vernon N Y
D E Wolf V P Cronin
Sentinel Radio Corp Evanston Ill
Setchell Carlson Inc 2233 Univ Av St Paul
B T Setchell B T Setchell
Seymour Mfg Co Seymour Conn
Shakeproof Inc 2501 N Keeler Av Chicago
E W Fuller W M Hanneman
Shallcross Mfg Co Collingdale Pa
D H Shallcross F D V Mitchell
Shand Radio Specialties 203 W Kearsley St Flint 3 Mich
E H Shand
Sherman Mfg Co H B Battle Creek Mich
Sherron Electr Corp Flushing Av Bklyn
P H Sherron M V Barasch
Shur-Antenna-Mount Inc Sea Cliff N Y
Shure Bros 225 W Huron Chicago Ill
S N Shure B B Bauer
Sickles Co F W 165 Front St Chicopee Mass
M Cohen H J Benner
Signal Electric Mfg Menominee Mich
O H Henes R Winthers
Sigma Inst Inc 70 Ceylon St Boston 21
R T Fisher
Signal Indicator Corp 140 Cedar St N Y C
Simmons Fastener Corp 1750 N B'way Albany N Y
Simplex Wire & Cable Co 79 Sidney St Cambridge 39 Mass
E W Davis
Simpson Elec Co 5208 W Kinzie St Chicago
H A Bernreuter H A Bernreuter
Simpson Mfg Co Mark 186 W 4th St N Y C
Skydyne Inc Port Jervis N Y
Small Motors Inc 1308 Elston Av Chicago 22
A C Johnson G E Ditzler
Smith Mfg Co F A Inc 801 Davis St Rochester 2 N Y H M Sylvester
Snyder Mfg Co 22 & Ontario Sts Phila Pa
B L Snyder G Snyder
Sola Elec Co 2525 Clybourn Av Chicago 14
I G Sola M A Tennyson
Solar Mfg Corp 285 Madison Av N Y C 17
J I Cornell
Sonora Radio & Telev Corp 325 N Hoyne Av Chicago Ill
J Gerl D Fetterman
Sound Equipment Corp 3903 San Fernando Rd Glendale 4 Calif
D Wright D MacArthur
Southern Switch & Sig Co Shreveport La
Sparks Withington Co Jackson Mich
C J Kayko H V Nielsen
Spaulding Fibre Co Inc 233 B'way N Y C
C C Steck E A Russell
Speer Resistor Corp St Marys Pa
G G Herrick H N Veley
Speer Carbon Co St Marys Pa
Spencer Thermostat Co Attleboro Mass
V G Vaughan J D Bolesky
Spencer Wire Co West Brookfield Mass
Sperry Gyroscope Co Inc Garden City N Y
P R Bassett E C Sparling
Sperti Inc Norwood Station Cincinnati O
R A Lostro H Rinehardt
Sprague Electric Co North Adams Mass
Stackpole Carbon Co St Marys Pa
J H Stackpole H Dressel
Standard Piezo Co Carlisle Pa
F E Reader W E Richmond
Standard Radio Parts Co 1244 State St Racine Wis
J Swanson J A Swanson
Standard Trans Corp 1500 N Halsted Chicago
H H Krefft
Standard Winding Co Newburgh N Y
F A Catanzariti
Stanwyck Winding Co Newburgh N Y
Steward Mfg Corp 4311 Ravenswood Av Chicago
O C Koch J M Hrouda
Stewart Stamping Co 621 E 216 St Bronx N Y
Stewart-Warner Corp 1826 Diversey Pkway Chicago
Sticht Co Inc H H 27 Park Pl N Y C
A H Volker
Stille-Young Corp 2300 N Ashland Av Chicago
E F Schneider
Stoelting Co C H 424-K N Homan Ave Chicago
Stromberg-Carlson Co Rochester 3 N Y
R H Manson F C Young
Struthers-Dunn Inc 1321 Cherry St Phila
Stupakoff Ceramic & Mfg Co Latrobe Pa
S H Stupakoff R E Stark
Sullivan Varnish Co 410 N Hart St Chicago
M Sullivan
Superior Inst Co 227 Fulton St N Y 7 N Y
Superior Tube Co Norristown Pa
S L Gabel E W Miller
Supreme Inst Co Greenwood Miss
E G Perkins R Soward
Surprenant Elec Insulation Co 84 Purchase Boston 10 Mass
E M Quill G E Forsberg
Sylvania Electric Prods Inc Emporium Pa
C W Shaw W R Jones
Synthane Corp Oaks Pa
R R Titus

—T—

Taylor Fibre Co Norristown Pa
Taylor Tubes Inc 2341 Wabansia Chicago
Tech App Corp 4106 DeLong St Flushing N Y
H H Brown T Lundahl
Tech Labs 337 Central Av Jersey City N J
Tech Radio Co 275 9th St San Francisco
Telegraph App Co 412 Green St Chicago
J E Goode
Telephonics Corps 350 W 31 St N Y C
J F Stengel W T Weidenman
Teleradio Eng Corp 99 Wall St N Y C
Televiso Prods Inc 7466 Irving Pk Rd Chicago 34
Templetone Radio Mfg Co New London Conn
O Dane Dr D Pollack
Thermador Electrical Mfg Co 5119 Riverside Los Angeles 22
W E Cranston Jr J Wardell
Thomas & Betts Co 36 Butler St Elizabeth N J
C A Badeau

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ON PAGE 6 OF THIS ISSUE




## MANUFACTURERS, Continued

Thomas & Skinner Steel Prod Co Indianapolis Ind
J R Thomas H P Rockwell
Thompson Corp Geo S 5240 Huntington Dr Los Angeles
Thordarson Elec Mfg Co 500 W Huron Chicago
Times Telephoto Equip Inc 229 W 43rd N Y C
Tobe Deutchmann Corp Canton Mass
Transmitter Equipment Mfg Co Inc 345 Hudson St N Y C 14
M B Kahn S L Sack
Trav-Ler Karenola Radio & Telev Corp 571 W Jackson Blvd Chicago 6
J Friedman R J O'Brien
Trimm Inc 1770 W Berteau Chicago
P A Bottoptt
Triplett Elec Instrument Co Blunton O
R L Triplett F J Lingel
Tungsol Lamp Works Inc 95 8 Av Newark N J
A K Wright
Turner Co 909 17 St N E Cedar Rapids Ia
R P Evans Dr L D Weld

—U—

Ucinite Co Newtonville Mass
G V Sweetnam C A Woodward
Ungar Inc, Harry 615 Ducommun St Los Angeles
S D Ungar
United Cinephone Corp Torrington Conn
L B Cornwell J M Miller Jr
United Electr Co 42 Spring St Newark N J
B F Steiger
United Scientific Labs 440 Lafayette N Y C
L Weiss M Glaser
United Transformer Co 150 Varick N Y C
Universal Microphone Co 424 Warren Av Inglewood Calif
L Willyard
University Labs 225 Varick St N Y C
A Blumenthal S Levy
U S Industrial Chem 33 W 42nd N Y C
U S Rubber Co 1230 6 Av N Y C
Utah Radio Prods Co 820 Orleans Chicago 10
W A Ellmore M S Danisch

—V—

Vaco Prods Co 305 E Ontario St Chicago
Valpey Crystal Corp Holliston Mass
T S Valpey D MacDougall
Vibration Spec Co 1536 Winter St Phila
Viewtone Co 203 E 18th St N Y C 3
Vulcan Elec Co Lynn Mass

—W—

Wallace Mfg Co Madison & Chili Peru Ind
W T Wallace
Ward Leonard Elec Co 31 S St Mt Vernon N Y
A A Bernard W W Miller
Ward Prods Corp 1523 E 45 Cleveland O
Warren Telechron Co Ashland Mass
Warwick Mfg Corp 4640 W Harrison Chicago
J S Holmes H A Gates
Waterproof Elec Co 70 E Verdugo Burbank Calif
Webster Products 5610 Bloomingdale Ave Chicago
D MacGregor N L Conrad
Webster Elec Co Racine Wis
Weller Mfg Co Easton Pa
Western Electric Co Inc 120 B'way N Y C 5
F R Lack S P Taylor
Westinghouse Elec Corp 2519 Wilkens Baltimore 3
C J Burnside R N Harmon
Westinghouse Elec Corp E Pittsburgh Pa
Westinghouse Lamp Div Bloomfield N J
R C Stewart
Weston Elec Inst Corp 427 N Broad St Elizabeth N J
Wheelco Insts Co 847 Harrison Chicago
C L Saunders E Schneider
Whitaker Cable Corp 1311 Burlington St Kansas City 16 Mo
White S S Indust Div 10 E 40th N Y C
Wholesale Radio Labs 744 W B'way Council Bluffs Ia
Wilcox Electric Co Inc 1400 Chestnut St Kansas City 1 Mo
J V Wilcox A P Stuhrman
Wilcox Gay Corp Charlotte Mich
W L Hasemeier D Martin
Willor Mfg Corp 794 E 140 St N Y C
Wilmington Fibre Spec Co Wilmington Del
J W Morris
Wilson Co H A 105 Chestnut Newark N J
Wincharger Corp Sioux City 6 Ia
M M Lasensky
Winslow Co Inc 9 Liberty St Newark N J
R R Knapp
Wirt Co 5221 Greene St Philadelphia 44
P H Stuckey
Workshop Assoc 66 Needham St Newton Highlands Mass
Worner Electronic Devices 609 W Lake St Chicago 6
L L Worner A E Eldam

—Z—

Zenith Radio Corp 6001 Dickens Av Chicago
E F McDonald Jr G E Gustafson
Zierick Mfg Co 385 Girard Av Bronx N Y
Zophar Mills Inc 112–130 26 St Brooklyn
A Saunders

## GENERAL MANAGERS

— A —

Abrahams AI Racon Electric Co Inc
Abrams B Emerson Radio & Phono Corp
Adams R Cinaudagraph Speakers Inc
Adams R Oxford Tartak Radio Co
Aitchison RJ Fansteel Metallurgical Corp
Alden M Alden Prods Co
Alexander ML Auto Engraver
Allen HE Dobeckum Co
Ammon RA Marion Elec Instr
Amy EV Amy Aceves & King
Andersen RH Heintz & Kaufman Ltd
Andrea FAD Andrea Radio Corp
Andrew FJ Andrew Co
Avery RS Avery Adhesives

— B —

Bachner EF Chicago Molded Prods Corp
Ballantyne J Philco Corp
Barron JL JP Seeburg Corp
Bassett PR Spery Gyroscope Co
Bassett RE Bassett Inc Rex
Beard TH Dictaphone Corp
Behringer GF American Steel Package
Bellezza RG Locke Insulator Corp
Benham JA Allen D Cardwell Mfg Corp
Benson GO Premax Prods Div Chisholm-Ryder Co
Berard AA Ward Leonard Elec Co
Berk SW Concord Radio
Bernreuter HA Simpson Electric Co
Bicknell RS American Lava Corp
Birnbach N Birnbach Radio Co
Black RJ Owens-Corning Fibre Glass Corp
Billey FD Billey Electric Co
Blumenthal A University Labs
Blumenthal CR Atlas Sound Corp
Boes WW Boes Co WW
Bowen PE Hudson American Corp
Bowman H Quartz Labs
Brannan RE Bakelite Corp
Brister JE Bakelite Corp
Bristol RW Radio Inventions Inc
Bromberg E Heineman Circuit
Brown HH Technical Appliance Corp
Bunch CH Acme Elec & Mfg Co
Burlin M Selenium Corp of America
Burnside CJ Westinghouse Elec & Mfg

— C —

Cain JE Mallory & Co Inc
Cannon RJ Cannon Mfg Corp
Capron HLM Panoramic Radio Corp
Carlson H Bakelite Corp
Carson RW Instrument Specialties Co
Carter RW Carter Motor Co
Cerny JJ Lectrohm Inc
Cezar A Electronic Transformer Co
Chapman MM Carnegie-Ill Steel Corp
Chick RE R E C Mfg Corp
Clare CP Clare & Co C P
Coffin BA Hytron Corp
Cohen M Sickles Co F W
Cohn H Radio Receptor Co Inc
Cole SI Aerovox Corp
Collins AA Collins Radio Co
Collman CC Billey Elec Co
Connelly EH Allen Richardson Corp
Connors JJ Irvington Varnish & Insulating Corp
Conover RA Haydon Mfg Co Inc
Cook J Cornish Wire Co Inc
Cook RR Radex Corp
Cooper BW Delco Radio Div
Corbin R Radio Frequency Labs Inc
Cornwell LB United Cinephone Corp
Cosgrove RC Crosley Corp
Courteol HC Mercold Corp
Craigmile CS Belden Mfg Co
Cramer RE Radio Condenser Co
Crane ER Lear Inc
Cranston WE Thermador Electrical Mfg
Crockett SM Merit Coil & Trans Corp
Crompton EE Burke Electric Co
Cummings BR Farnsworth Telev & Radio

— D —

Dane O Templetone Radio Mfg Co
Daniels JV Kemilite Labs
Danielson EG Remler Co Ltd
Danziger HI Crowley & Co Inc
Davis AC Cinema Eng Co
Davis AD Allied Radio Corp
Day CH Browning Labs Inc
Dean DL Lord Mfg Co
Decker WC Corning Glass Works
DeShazo GH Gray Radio Co
de Syles CR Selectar Mfg Corp
Diehl WF Airplane & Marine Inst Inc
Dietz WH Radio Eng Labs Inc
Doherty EW American Elec Heater Co
Donohoe NR Magnetic Windings Co
Dow WH Dow Chemical Co
Downsbrough GA Boonton Radio Corp
Doyle RF Alliance Mfg Co
Driver FL Driver-Harris Co
DuMont AB DuMont Labs Inc
DuVall FB Electronic Mechanics Inc

— E —

Eberts FS Dinion Coil Co Inc
Eckstein EA Eckstein Radio & Telev Co
Eisler C Eisler Eng Co
Eisenhauer HD Scientific Radio Serv
Ellinger EE Jefferson-Travis Radio Mfg
Ellmore WA Utah Radio Prods Co
Engle KD Industrial Condenser Corp
Engelson DH Federal Mfg & Eng Corp
Evans RP Turner Co

— F —

Falck FW Advance Elec Co
Favor LA Knights Co James
Felker MN Felker Mfg Co
Fitzsimmons JL Electro Tech Prod Inc
Flanzer JA Electro Motive Mfg Co
Forster HC Radio Speakers
Foulds B Brush Developments Co
Franklin AW Franklin Mfg Corp
Franz CH Kurz Kasch Inc
Fredericks WH Electrical Industries
Freed A Freed Radio Corp
Freed L Freed Transformer Co
Friedlander E Ntl Electronic Mfg Co
Friedman J Trav-Ler Karenola Radio Telev Corp
Friend BL The Radio Craftsmen
Fryling GR Erie Resistor Corp
Fuller EW Shakeproof Inc

— G —

Gabel SL Superior Tube Co
Gage NE American Insulator Corp
Gardner AH Colonial Radio Corp

**GENERAL MANAGERS, Continued**

Garstand WW Electronic Labs Inc
Gates PS Gates Radio Co
Gerl J Sonora Radio & Telev Corp
Gervais E Edwards Co W H
Glfillan SW Glfillan Bros Inc
Gilman WE Permuflux Corp
Gilmore W Micro Switch Div
Girard WE H B Instr Co
Glass AA Premier Crystal Labs Inc
Goffstein A American Telev & Radio Co
Goldberg I Pilot Radio Corp
Goode JE Telegraph Apparatus Co
Gordon J P Litton Engineering Labs
Gothard RW Gothard Mfg Co
Gray AS Insulation Mfgrs Corp
Gray CA Grenby Mfg Co
Gray D Doolittle Radio Inc
Green M Radio Elec Serv Co of Pa
Griffin DA Communication Measurements Lab
Gross EH Bakelite Corp
Gubelman WS Roller-Smith Div
Gunter J Hollywood Electronics

— H —

Haase GR Operadio Mfg Co
Haas ML Bud Radio Inc
Halligan WJ Echophone Radio Co
Halter EJ Scott Radio Labs
Hamilton HG Eastern Air Devices
Hanmer AW Durez Plastics
Harges MT Harvey Wells Electr Inc
Harnett DE Hazeltine Electronics Corp
Hasemeier WL Wilcox-Gay Corp
Hastings TM Gen Comm Co
Hawkins GM Isolantite Inc
Helgeson A Chicago Transformer Corp
Henes OH Signal Electric Mfg
Herold MJ Newark Transformer Co
Herrick GG Speer Resistor Corp
Hersch JB Bogen Co Inc
Hess JC Leeds & Northrup
Hickok RD Hickok Electrical Inst Co
Hilliard WP Bendix Radio Div
Hindle JC N Y Transformer Co
Hoffman AG Midwest Radio Corp
Homes JS Warwick Mfg Corp
Holmstrom F H H Eby Inc
Hopkins JC Girard-Hopkins
Horman FL Radio City Prods Inc
Hotchkin JR Palnut Co
Houch HW Measurements Corp
Houseman AJ Automatic Radio Mfg Co
Howe JS Ohmite Mfg Co
Hoyt AE Herb E Zobrist Co
Hull Dr LM Aircraft Radio Inc

— J —

Jack NH Precision Tube Co
Jacobs F Radio Transceiver Labs
Johnson AC Small Motors Inc
Johnson AL Hexacon Electric Co
Johnson EF Johnson Co E F
Johnson EH Gear Specialties
Johnson RW Boots Aircraft Nut Corp
Jones CH Kato Engineering Co
Jones GM Ace Mfg Corp
Juviler J Hamilton Radio Corp

— K —

Kaar JM Kaar Engineering Co
Kahn AR Electro-Voice Corp
Kahn MB Transmitter Equip Mfg Co
Karr IJ General Electric Co
Kayko CJ Sparks Withington Co
Kelleigh WJ General Control Co
Kimball R Communications Equip Corp
Kirkland HR Kirkland Co H R
Kirkman FJ Burgess Battery Co
Kirsch MJ Federal Engineering Co
Klunder AE Janette Mfg Co
Knapp RR Winslow Co
Koch OC Steward Mfg Corp
Kopinski L Fast & Co John E
Kramer WS Burlington Instr Co
Krampf CE Electrical Reactance Corp
Kruse RH Cambridge Inst Co
Kunz HL Sangamo Electric Co

— L —

Lack FR Western Electric Co Inc
Lane MM Croname Inc
Lang MJ Gen Elect Co Ken Rad Div
Lansensky MM Windcharger Corp
Lavoie SD Lavoie Laboratories
Lee M Burndy Engineering Co Inc
Lehman B Radio Wire Telev Inc
Levingston GL Harwood Co
Lewis R Radiation Prods Inc
Lieberman JP Air King Prod
Ling EF Corning Glass Works
Lingo JE John E Lingo & Son
Link FM Link Radio Corp
Lippert WE Teleradio Engineering Corp
Lisman WF Leland Electric Co
Lorenzen R John F Rider Labs
Lostor RA Sperti Inc
Loveless PF Stallman of Ithaca
Lyman F Cambridge Thermionic Corp

— M —

MacArthur D Sound Equip Corp
MacGregor D Webster Products
Major C W Precision Fab Inc
Maneck EE Brandywine Fibre Prods Co
Manson RH Stromberg-Carlson Co
Marcus DA Electronic Specialty Co
Marshall LK Raytheon Mfg Co
Marshall W Noma Electric Corp
Marvin S American Transformer Co
Mascuch JT Breeze Corps Inc
Mattes HC Belmont Radio Corp
McDonald EF Zenith Radio Corp
McElroy TR McElroy Mfg Corp
McEwen LI Gates Radio Co
McGiffin R Lewyt Corp
McIlvaine HA Continental Elec Co
McLean MP D-X Radio Prods Corp
McLellan JD Bunnell & Co
McMaster AJ G-M Laboratories Inc
Meck JS Meck Industries
Menschik I American Condenser
Merrill WA Atlas Resistor Co
Metzger E Micarta Fabricators Inc
Meyerson LI Scientific Radio Serv
Millen J Millen Mfg Co
Minch JA Electric Auto-Lite Co
Mitchell DT American Radio Hdwre Co
Moeller AC Gen Elec Co
Morris JW Wilmington Fibre Specialty Co
Morrison P Gibbs & Co Thomas B
Mossman DP Donald P Mossman Inc
Moulton AK Ohio Carbon Co
Muter LF Muter Co
Mueller S Mueller Electric Co
Muniz JM Howard Radio Co

— N —

Nee TG Acme Wire Co
Newman L Daven Co
Nickerson FW Guided Radio Corp
Nicholides EC Fada Radio & Elec Co
Nierenberg A Etched Prod Corp
Novick SJ Electronic Corp of America
Noblitt QG Noblitt Sparks Inc
Norton AW Press Wireless Inc

— O —

O'Brien FJ Galvin Mfg Corp Motorola Radio
O'Connor DJ Formica Ins Co
Onan CW Onan & Sons

— P —

Pariser S Atlas Condenser Prods
Parkins EG Supreme Instruments
Pattee LG McClintock Co
Patton CW Bakelite Corp
Patton RC Patton-MacGuyer Co
Peterson AW Continental Elec Co
Petitt G Drake Elec Works
Phillips CJ Corning Glass Works
Piercy ER Thomas & Skinner Steel Prod Co
Pinsley N Espey Mfg Co
Pode HA Bendix Aviation Corp
Potratz AC Gen Armature Corp
Powell CS Graybar Electric Co Inc
Powell RC Presto Recording Corp
Price JR Bakelite Corp
Priest CA General Electric

— Q —

Quam JP Quam-Nichols Co
Quick HL Northern Comm Mfg
Quill EM Suprenant Elec Insulation Co
Quinnell LE Magnavox Co

— R —

Rademan M Herbach & Rademan Co
Raffles F Carron Mfg Co
Rauland EN Rauland Corp
Reader FE Standard Piezo Co
Ready WA National Co Inc
Reed LM Air Communications Inc
Reeves BH Rockbestos Corp
Reid CE Air Associates Inc
Reiner M Radio City Prods Co
Roberts HW Pierce-Roberts Co
Robinson WA Brach Mfg Corp
Rodgers JL Bakelite Corp
Rogers KE Carborundum Co
Rose HR Gen Telev & Radio Corp
Roveran CG H-B Instrument Co
Rowell FF Guardian Elec Mfg Co
Rude R Barker & Williamson
Russell HS Louthan Mfg Co
Ruth F Aero Communications Inc
Ruth F Erco Radio Labs Inc
Ryan P Cutler-Hammer Inc

— S —

Sage Wm C Cincinnati Elec Parts Co
Sandstrom E Oak Mfg Co
Saunders CL Wheelco Instrs
Scala A Chatham Electronics
Schaffer H Hollywood Electronics
Schmitt AJ American Phenolic Corp
Schott WL Schott Co Walter L
Schwartz P Philmore Mfg Co
Schwerkert JN Radiat Corp
Seelig LJ General Transformer Co
Setchell BT Setchell Carlson Inc
Shallcross DH Shallcross Mfg Co
Shand EH Shand Radio Specialties
Shapiro CB Hallicrafters Co
Sharp TW Bakelite Corp
Shaw CW Sylvania Elec Prods Inc
Shaw G Bakelite Corp
Shaw M Lewis Electronics
Shepherd DG Electric Specialty Co
Shermund RC Induction Heating Corp
Sherron PH Sherron Metallic Corp
Siemers HR H R S Prods
Shure SN Shure Bros
Simmons RR Communications Parts
Smith GE Communications Co Inc
Smith H Bakelite Corp
Snyder BL Snyder Mfg Co
Sola IG Sola Elect Co
Soucek Z Philharmonic Radio Corp
Spector SJ Insuline Corp
Spittal WR Ferranti Elec Inc
Stack AR Girard-Hopkins
Stackpole JH Stackpole Carbon Co
Stafford S Adams & Westlake Co
Stebleton RL Kyle Corp
Steck CC Spaulding Fibre Co Inc
Stein H Radex Corp
Stein J Metaplast Co
Stengel JF Telephonics Corp
Stevens WB Mitchell Rand Insul Co
Strobel F Mangold Radio Parts & Stpg
Stuart RC Westinghouse Elec Corp
Stuckey PH Wirt Co
Stupakoff SH Stupakoff Ceramic & Mfg
Sullivan JE Airadio Inc
Summers JM Canloc Fastener Corp
Sundt EV Littelfuse Inc
Swanson JA Standard Radio Parts Co
Swedlen EW Audio Development Co
Sweetnam GV Ucinite Co

— T —

Taishoff J Mycalex Corp of Amer
Taylor OF Electrical Research Labs Inc
Taylor SP Western Elec Co
Teitler SL Lepel Labs
Thels AE Islip Radio Mfg Corp
Thiessen AC General Radio Co
Thomas HD Packard Bell Co
Townsend CK Jennings Radio Mfg Co

## GENERAL MANAGERS, Continued

Tregenza AE Jefferson Elec Co
Triplett RL Triplett Elec Instrument
Tyson CR John Roebling's Sons Co

— U —

Ungar SD Ungar Inc Harry

— V —

Valpey TS Valpey Crystal Corp
Vaughan VG Spencer Thermostat Co
Volker AH Sticht Co Inc

— W —

Walker RC Aireon Mfg Corp
Wallace WT Wallace Mfg Co Wm T
Wanvig JD Centralab Div of Globe-Union
Ward AA Altec Lansing Corp
Ward SI Crystal Research Labs
Watson J Meissner Mfg Div
Watts FW Connecticut Tel & Elec Div
Wayman EL Hudson American Corp
Weaver WJ Ansonia Elec Co
Weiss L United Scientific Labs
Wendell EN Federal Tel & Radio Corp
Whearley RL Rea Magnet Wire Co
White TA Jensen Radio Mfg Co
Whiting EM Pheoll Mfg Co
Whiting FA Micamold Radio Corp
Wilcox JV Wilcox Electric Co Inc
Wilson C Cinch Mfg Co
Wolf DE Sensitive Research Inst Co
Wood TS Corning Glass Works
Woodruff D Auburn Button Wks
Worner LL Worner Electronic Devices
Wrape HJ Benwood-Linze Co
Wright D Sound Equip Corp
Wright GE Billey Elec Co
Wunderlich GF Eitel-McCollough Inc
Wunderlich NE Federal Tel & Radio Corp

— Y —

Yarbrough FA American Microphone Co
Young R Hudson American Corp

— Z —

Zachariah VN Zach Radio Supply
Zayac FR Ballantine Labs Inc
Zieber G Hewlett-Packard Co
Zimmer HW Sylvania Elect Prods
Zimmerman AS Bakelite Corp

## CHIEF ENGINEERS

— A —

Abrahams AI Racon Electric Co Inc
Aceves JG Amy Aceves & King
Alban CF WM Chace Co
Andersen DE J-B-T Instruments Inc
Applegate ID Ideal Com Dresser Co
Aremka J Lake Radio Sales Co
Armstrong IW Dinion Coil Co Inc
Avery RD Bunnell & Co

— B —

Babcock SK Electronic Specialty Co
Bach HM Premier Crystal Labs Inc
Badeau CA Thomas & Betts Co
Bailey WM Cornell-Dubilier Elec Corp
Barasch MV Sherron Electronics Corp
Barlow WA General Winding Co
Barta F Littlefuse Inc
Basim DS Airadio Inc
Bates AC Roller-Smith Div Realty & Industrial Corp
Bauer B Hewlett-Packard Co
Bauer BB Shure Bros
Bausch CL Bausch & Lomb Optical Co
Bash FE Driver-Harris Co
Bean LG Bristol Co
Bechtol PM Rea Magnet Wire Co
Benander GB Monowatt Elec Corp
Benner HJ Sickles Co FW
Bernreuter HA Simpson Electric Co
Bevington KA American Molded Prods Co
Bierman RC Permaflux Corp
Black KC Aircraft Radio Corp
Bingley FJ Philco Corp
Blakely LP Boonton Radio Corp
Blauvelt R Radiart Corp
Blye H DeJur Amsco Corp
Bohlen WI Rex Bassett Inc
Bolesky JD Spencer Thermostat Co
Borggrafe EW Electrical Specialty Co
Borro EF Durez Plastics & Chem Inc
Bortorff PA Trimm Inc
Boucher EJ McClintock Co
Bovee BA Carborundum Co — Globar Div
Boyd DL General Industries Co
Brainin CS Brainin Co
Brelt HF Quam-Nichols Co
Breunich T Brandywine Fibre Prods Co
Brociner V Philharmonic Radio Corp
Brown ME Borg-Gibbs Lab
Budelman FT Link Radio Corp
Bulmahn FE Burlington Instr Co
Burke R Philmore Mfg Co Inc
Burroughs LR Electro-Voice Corp
Burzycki CZ New York Transformer Co
Byrnes IF Radiomarine Corp of America

— C —

Caldwell ER Air Communications Inc
Carlson VE Aircraft-Marine Prods Inc
Caywood RW Millen Mfg Inc James
Cezar A Electronic Transformer Co
Catanzariti FA Standard Winding Co
Celander PA Micro Switch Div
Christaldi PS Du Mont Labs, Allen B
Clark G H Formica Insulation Co
Clark RA Comm Equip & Eng Co
Clement LM Crosley Corp
Clifford DG Industrial & Comm Electronics
Cohn M Electro Motive Mfg Co
Coleman JJ Burgess Battery Co
Conrad NL Webster Products
Cox CR Andrew Co
Cornell JI Solar Mfg Corp
Cornell NA Scovill Mfg Co
Craig P Philco Corp
Cronin FP Sensitive Research Inst Co
Crowley HL Crowley & Co Inc Henry L
Cullin JF General Armature Corp
Curtiss WR Connecticut Tel & Elec

— D —

Dalyrmple HC Guided Radio Corp
Danisch MS Utah Radio Prods Co
Dante JJ Dante Elec Mfg Co
Daugherty RM Detrola Corp
Davis AC Cinema Eng Co
Davis EW Simplex Wire & Cable Co
Davis FM Collins Radio Co
DeConingh EH Mueller Electric Co
de Forest L Lee de Forest Labs
DeHorn CE General Transformer Co
DeMetrick JS Auto Radio Mfg Co Inc
Dezettel LM Allied Radio Corp
DiGiacomo A Micamold Radio Corp
Ditzler GE Small Motors Inc
Donaldson WR Celanese Corp
Dreisbach RH Magnavox Co
Dressel H Stackpole Carbon Co
Druesne MAA James Knights Co
Duerk KA American Steel Package Co
Dunn WL Belmont Radio Corp

— E —

Easton DG General Radio Co
Eckstein EA Eckstein Radio & Telev Co
Edelman A Photobell Corp
Edwards WH Edwards Co
Eisler Chas jr Eisler Eng Co
Elbi LA Crystal Prod Co
Eldam AE Worner Electronic Devices
Eldredge EE Press Wireless Inc
Enfing E Cannon Mfg Corp

— F —

Farmer EB General Control Co
Farrell JJ General Electric Co
Faucett IT Gen Cable Corp
Ferguson J Farnsworth Telev & Radio
Fetterman D Sonora Radio & Telev Corp
Fick CG Gen Elec Co
Fligate JT Jefferson-Travis Corp
Finn JJ Mitchell Rand Insulation Co
Fishberg S Polymet Condenser Co
Fishberg S Cosmic Radio Corp
Fisher BN Gen Inst Corp
Fisher RT Sigma Inst Inc
Floyd OH Kemlite Labs
Forbes HC Colonial Radio Corp
Forsberg GE Suprenant Elec Insul Co
Franklin WS Fast & Co John E
Freck RH Packard Bell Co
Frost GW Gothard Mfg Co
Frye RH Electronic Labs Inc
Funk JE Noma Electric Corp

— G —

Garlick W American Transformer Co
Gates HA Warwick Mfg Corp
George EB Leland Electric Co
Gerster CW Louthan Mfg Co
Gibbs ED Radio Receptor Co Inc
Girard WE H-B Instrument Co
Glaser M DeWald Radio Corp
Glaser M United Scientific Labs
Graves ED Avery Adhesives
Gray D Doolittle Radio Inc
Gray FE Gray Radio Co
Graybill KW Automatic Elec Co
Greene HA Remler Co Ltd
Grimwood F Gates Radio Co
Gruber MM Presto Recording Corp
Gurevics D Freed Transformer Co
Gustafson GE Zenith Radio Corp

— H —

Haas A Hudson American Corp
Hake PH Audio Development Co
Haines EM Goat Metal Stampings Inc
Hale CB Gear Specialties
Hanneman WM Shakeproof Inc
Hantz BF American Insulator Corp
Harmon RN Westinghouse Lamp Div
Harnett DE Hazeltine Elec Corp
Harper JF Centralab
Harsch JW Leeds & Northrup Co
Harvey CA Harvey Wells Electronics Inc
Harwood PB Cutler Hammer Inc
Hausmann EO Cont Diamond Fibre Co
Haynes NM Amplifier Co of America
Hector Dr LG Ntl Union Radio Corp
Heindel HJ Andrea Radio Corp
Heller JI Panoramic Radio Corp
Helwig NC Kaar Eng Co
Hennessey SW Camloc Fastener Corp
Heppner EA Cons Radio Prod Co
Herman WP Electrix Corp
Hill E Palnut Co
Hilliard JK Altec Lansing Corp
Hinners F Air King Prod
Hinshaw MW Felker Mfg Co
Hobbs M Scott Radio Labs
Hoeflich EC Ace Mfg Corp
Hoffman HL Hoffman Radio Corp
Hogan JVL Radio Inventions Inc
Holby JC Onan & Sons D W
Holly GS Radio Speakers Inc
Holtz FC Sangamo Electric Co
Honeywell CE Fada Radio Elec Co
Hopp P Hopp Press Co
Horman FL Radio City Prods Inc
Hornickel HC American Microphone Co
Howes G Eitel-McCollough Inc
Hrouda JM Steward Mfg Corp
Huckabee VC Advance Elec Co
Humble CE Burke Electric Co
Hunter FL Fansteel Metallurgical
Huntley NF R E C Mfg Corp
Hutchings JH Continental Elec Co
Hutton VO Cambridge Inst Co

— I —

Israel DD Emerson Radio & Phono Corp

— J —

Jacobs F Radio Transceiver Labs
Jahns E Pilot Radio Corp
James W Howard Radio Co
Jauch J Peerless Electrical Prod Co
Jenkins O Quartz Labs
Jennings JE Jennings Radio Mfg Co

**CHIEF ENGINEERS, Continued**

Jennings MH Radio Eng Labs Inc
Johnson AL Hexacon Electric Co
Jones CH Kato Engineering Co
Jones CM John Roebling's Sons
Jones CEH Merit Coil & Transformer Corp
Jones MR Cinaudagraph Speakers Inc
Jones MR Oxford Tartak Radio Corp
Jones WR Sylvania Elec Prods Inc

— K —

Kahn L Aerovox Corp
Kalb RM Kellogg Switchb'd & Supply
Kaplowitz M Federal Mfg & Eng Corp
Karolon B Bogen Co Inc
Karlby H Elastic Stop Nut Corp of Amer
Katzman J Dumont Elec Co
Keefe OA Newark Transformer Co
Kenney MW Seeburg Corp J P
Kimball C Alreon Mfg Corp
Kimball R Communications Equip Corp
Kirsch MJ Federal Engineering Co
Knowles HS Jensen Radio Mfg Co
Knutson CL Cinch Mfg Co
Koerner CA Donald Mossman Inc
Kotchevar J Janette Mfg Co
Krefft HH Standard Transformer Corp
Kreinick HC American Condenser Co
Kreis JG Acme Wire Co
Kroening W Gen Telev & Radio Corp
Kurland JJ Illinois Condenser Co

— L —

LaMargue JW Graybar Elec Co Inc
Larkin WJ National Co Inc
Lasswell C Girard-Hopkins
Leach EA Hammerlund Mfg Co
Leap GA Communications Co Inc
Lebedeff G Heintz & Kaufman Ltd
Leline A Croname Inc
Lester F Electronic Corp of America
Levenberg MH Condenser Prods Co
Levinger HR Concord Radio Corp
Levy H Ohmite Mfg Co
Levy S University Labs
Lewis GW Lewis Electronics
Lidow E Selenium Corp of America
Lindgerg CA Air Way Elec Appl Corp
Linell CS Carron Mfg Co
Lingel FJ Triplett Elec Instr Co
Litton CV Litton Eng Labs
Lorenzen R Rider Labs
Lowell WH Magnetic Windings Co
Lowit R Callite Tungsten Corp
Lundahl T Technical Appliance Corp
Lunt AP Ansonia Elec Co

— M —

MacArthur G Sound Equipment Corp
MacDougall D Valpey Crystal Corp
Mallard MT Cornish Wire Co Inc
Margolish G Printoid Inc
Marko L Radio Wire Telev Inc
Martin D Wilcox Gay Corp
Marsten J International Resistance
Mastney EJ Oak Mfg Co
Matthey LH Hartman Corp of America
Maurer L Jefferson Elec Co
Mazzola JR Automatic Mfg Corp
McCabe IE Mercoid Corp
McCoy RL Locke Insulator Corp
McCraigh JF Operadio Mfg Co
McElroy TR McElroy Mfg Corp
McMaster AJ G-M Laboratories Inc
McNamara BF Insulation Mfgrs Corp
Meier WL Chatham Electronics
Melick AH Instr Resistors Co
Merrill E Atlas Resistor Co
Miller EA Acme Elec & Mfg Co
Miller EW Superior Tube Co
Miller JM United Cinephone Corp
Miller WW Ward Leonard Elec Co
Minnium BB Erie Resistor Corp
Minter JB Measurements Corp
Mitchell FDV Shallcross Mfg Co
Mitchell DH Galvin Mfg Corp
Monack AJ Mycalex Corp of America
Moore F Dejur-Amsco Corp
Moore H S Rockbestos Corp
Moorehouse RL Cardwell Mfg Co
Mucher GJ Clarostat Mfg Co Inc

— N —

Nelsen M Guardian Elec Mfg Co
Nielsen HV Sparks Withington Co
Nord GL Schauer Machine Co

— O —

Oberle EJ Gen Electronic Inc
O'Brien RJ Trav-Ler Karenola Radio & Tc'ev Co
O'Callaghan JJ Rauland Corp
O'Connor P Miller Co J W
Olander LW Johnson Co E F
Osterland E Ballantine Labs Inc

— P —

Pacholke F Majestic Radio & Telev Corp
Patla LJ D-X Radio Prods Co
Pearson AC Harwood Co
Peters CE Benwood Linze Co
Peterson GE Continental Elec Co
Peterson AL Insuline Corp
Peterson H Lepel Labs
Pilon RL Precision Fabricators Inc
Planck RM Radio Mfg Engineers Inc
Pollack Dr D Templetone Radio Mfg Co
Ports EG Federal Telephone & Radio Co
Powers JT Selectar Mfg Corp
Pratt LC Eastern Air Devices
Pray GE Airplane & Marine Inst Inc
Prince MA Metaplast Co

— Q —

Quackenbush C American Phenolic Corp
Quirk AL Cambridge Thermionic Corp

— R —

Rall CA Bodine Electric Co
Ramsey T Gen Armature Corp
Ravdin J Hamilton Radio Corp
Rawson LJ Kurz Kasch Inc
Redland IR Amer Radio Hdware
Reed CM Haydon Mfg Co Inc
Reed WM Carnegie Ill Steel Corp
Reinhardt RC Atlas Sound Corp
Replogle DE Electronic Mechanics Inc
Rettenmeyer FX Federal Tel & Radio Corp
Reynolds EG Air Associates Inc
Reynolds WH American Inst Co
Rice LA Electrical Prods Supply Co
Richards LJ Dow Chemical Co
Richmond WE Standard Piezo Co
Rinehart H Sperti Inc
Robb JS Radio Condenser Co
Robbin L Mallory & Co P R
Rockwell HP Thomas & Skinner Steel Prod Co
Rollefson KE Muter Co
Rosenbaum J Espey Mfg Co Inc
Roveran CG H B Instr Co
Russell EA Spaulding Fibre Co Inc
Ruth E Erco Radio Labs Inc
Ruth E Aero Communications Inc

— S —

Sack SL Transmitter Equip Mfg Co Inc
Saliba GJ Presto Recording Corp
Samuelson RE Echophone Radio Co
Saunders A Zophar Mills Inc
Schaefer E Harco Steel Constr Co Inc
Schellenger NC Chicago Tel Supply
Schmeling AM Lavole Laboratories
Schneider E Wheelco Instr
Schneider EF Stille-Young Corp
Schneider EV Alliance Mfg Co
Schnell WJ Electrical Research Labs Inc
Schultz EE Radio Craftsmen
Schutz FC Ace Mfg Corp
Schwartz BA Delco Radio Div
Schwartz NJ Heineman Circuit Breaker Co
Schwennesen D Chicago Trans Corp
Seabury RW Radio Frequency Labs
Setchell HT Setchell Carlson Inc
Shidler A Scientific Radio Prods Co
Shimer RB Kenyon Transformer Co Inc
Short WP Federal Tel & Radio Corp
Silva AE Noblitt Sparks Inc
Skiar HL Industrial Condenser Corp
Smith JP Daven Co
Smith P Midwest Radio Corp
Snyder G Snyder Mfg Co
Soward R Supreme Instr Corp
Sparling CE Sperry Gyroscope Co
Spencer PL Raytheon Mfg Co
Spindell FA Browning Labs Inc
Stanmyre EJ Meissner Mfg Co
Stark RE Stupakoff Ceramic & Mfg Co
Staubitz EJ Blaw-Knox Co
Steele T Patton-MacGuyer Co
Steiger BF United Electronics Co
Stein H Radex Corp
Stevens FJ American Lava Corp
Stickney FS Instrument Specialties Co
Stoffel LL Ohio Chemical Co
Stromeyer CF Hytron Radio & Electr Corp
Strunk KG Breeze Corps Inc
Stuhrman AP Wilcox Electric Co
Sullivan M Sullivan Varnish Co
Summerville A Bud Radio Inc
Swanson F Chicago Molded Prods Corp
Swanson JA Standard Radio Parts Co
Sylvester HM Smith Mfg Co

— T —

Taylor SP Western Elec Co
Tennyson MA Sola Elec Co
Thiessen AG Gen Radio Co
Thomas LS Blake Radio Equip Co
Thompson W John Elingo & Son
Thunen GW Electrical Prod Corp
Tish FP Pheoll Mfg Co
Titus RR Synthane Corp
Toepel WA Parker Kalon Co
Townsend CS Bendix Radio Div
Trickey PH Diehl Mfg Co
Trott BS Garod Radio Corp
Turner NW Hallicrafters Co
Turney E Precision Tube Co

— U —

Urey GM Radiation Prods Inc

— V —

Veley HN Speer Resistor Corp

— W —

Wagner DW Elec Reactance Corp
Wagner WC Litton Eng Labs
Wanner LR H H Eby Inc
Wardell J Thermador Electrical Mfg
Warner SE Crystal Research Labs
Warren RS Adams & Westlake Co
Webb WL Bendix Radio Div
Weidenman WT Telephonics Corp
Weiner WA Islip Radio Mfg Corp
Weinreich GF Clare & Co C P
Weinstein M Freed Radio Corp
Weise RC Barker & Williamson
Weisman RJ Okonite Co
Weiss WA Hickok Electrical Inst Co
Weld Dr LD Turner Co
Wermine HH Belden Mfg Co
Wetzel FH Electric Auto-Lite Co
Wexler C Meck Industries John
Whitney LH Grenby Mfg Co
Wickham P Gibbs & Co Thomas B
Wilborn F Schott Co Walter L
Wilkens WB Jefferson-Travis Radio Mfg
Williams AL Brush Development Co
Willyard L Universal Microphone Co
Winthers R Signal Electric Mfg
Wolcott CF Griffian Bros Inc
Wolf A Lewyt Corp
Wolfgram WR Communications Parts
Wolfskill JM Bliley Electric Co
Woodward CA Ucinite Co
Wootton W Boots Aircraft Nut Corp
Woycke LG Lear Inc
Wright JA Tungsol Lamp Works Inc

— Y —

Young FC Stromberg-Carlson Co
Young WS W W Boes Co

— Z —

Zaleski J Northern Labs Ltd
Zender RG Lenz Elec Mfg Co
Zmuda D H R S Products
Zobrist HE Herb E Zobrist Co


With a proven background of honorable service on far-flung battlefronts around the world, Amphenol components—greatly improved by wartime experience and augmented in number, style and type—are now available to normal markets. Simplifying both buying and selling, this wider selection of high quality, tested items can be procured from one manufacturer. To know these popular Amphenol products better—write today for the new Condensed Catalog No. 72.

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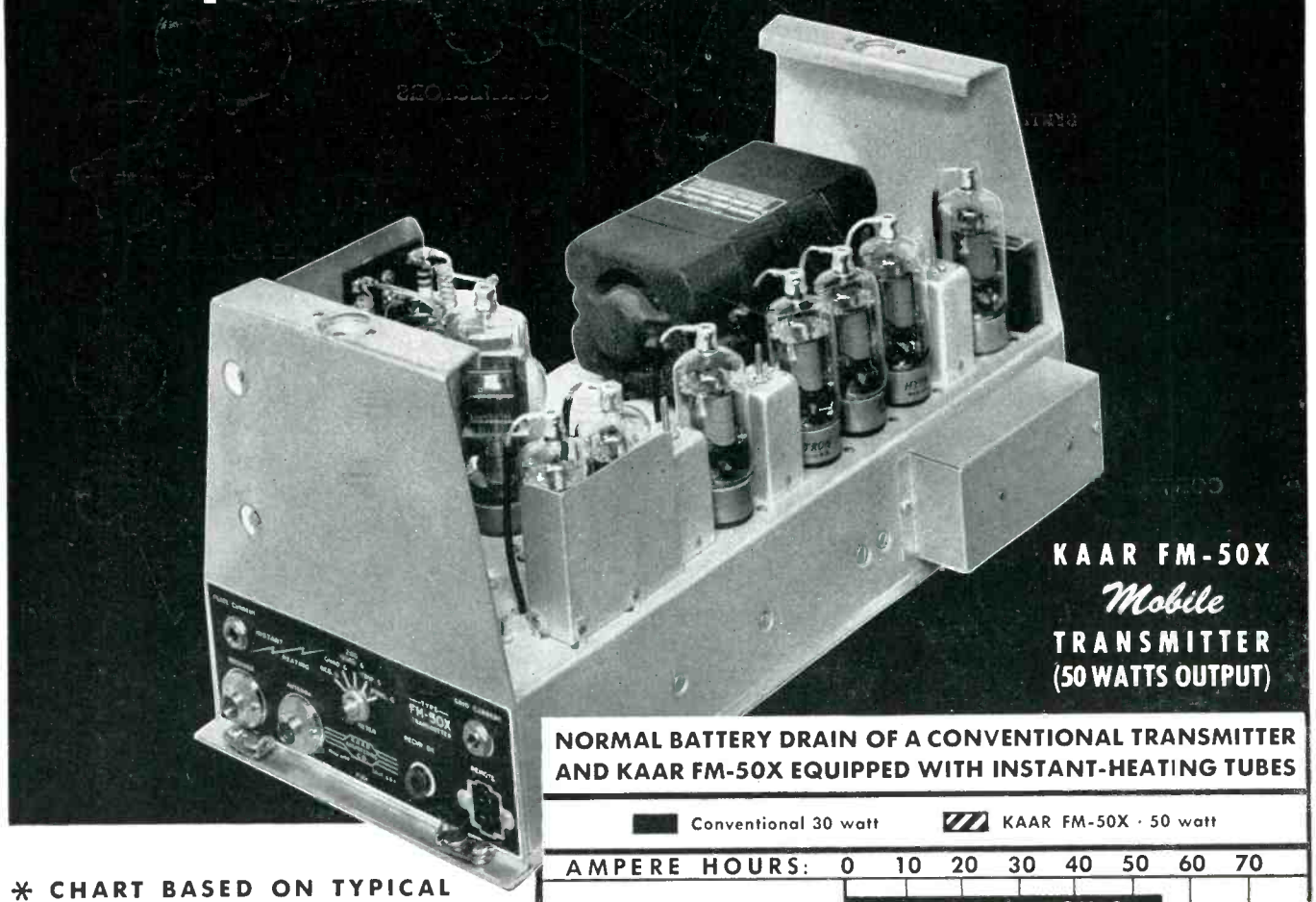
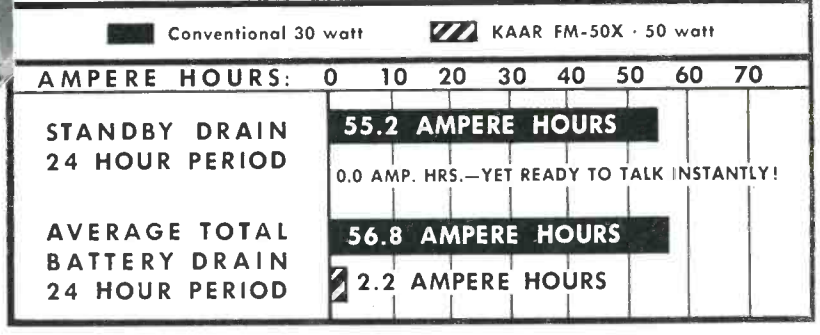
# Compare the actual battery drain!*




**NORMAL BATTERY DRAIN OF A CONVENTIONAL TRANSMITTER AND KAAR FM-50X EQUIPPED WITH INSTANT-HEATING TUBES**




* **CHART BASED ON TYPICAL METROPOLITAN POLICE USE**

*(140 Radiotelephone-equipped cars operating three shifts in city of 600,000 population.)*

| | |
|---|---|
| MESSAGES ORIGINATED BY CARS | 904 |
| MESSAGES ACKNOWLEDGED BY CARS | 932 |
| TOTAL TRANSMISSIONS PER CAR | 13 |
| AVE. LENGTH OF TRANSMISSION | 15 sec. |
| AVE. TRANSMITTING TIME 24 HOURS | 3 min. 15 sec. |

# KAAR mobile FM-50X transmitter gives you 20 watts more output with only 1/25th usual battery drain!

KAAR engineers—who pioneered the instant-heating AM radiotelephone—have now, through the use of instant-heating tubes, made 50 and 100 watt *mobile* FM transmitters practical! Thus you gain greater power and range—along with a tremendous reduction in battery drain!

With instant-heating KAAR equipment standby-current is zero—yet the moment you press the button microphone you are on the air. Contrast this with conventional emergency transmitters, over 90% of which operate with the filaments "hot" during stand-by. Since sturdy instant-heating tubes eliminate this great waste of energy without slowing the handling of messages, KAAR 50 and 100 watt transmitters can be operated from the standard ignition battery!

## 100 WATT MOBILE FM!

The KAAR FM-100X is identical to the FM-50X, except for the final amplifier. It puts 100 watts into a standard 34 ohm non-inductive load and is ideal for county and state police use. It requires no special batteries, wiring, or generator changes.

## ADDITIONAL FEATURES

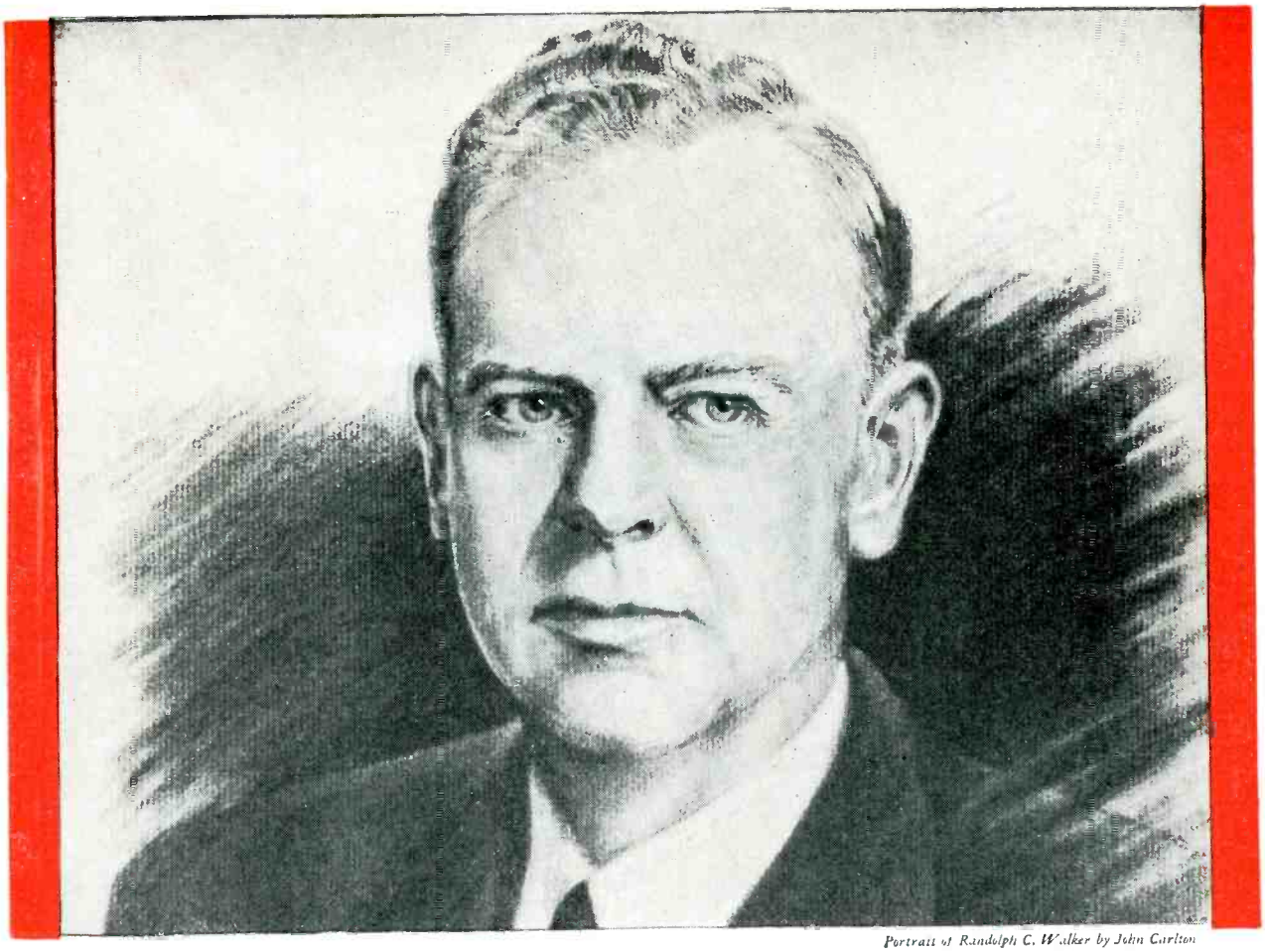
A new system of modulating the phase modulator tubes in KAAR FM transmitters provides excellent voice quality. Note that the equipment is highly accessible, and only two types of tubes are used. Frequency range: 30 to 44 megacycles.

Write today for free bulletin describing KAAR FM transmitters in detail. It's ready now!

# KAAR ENGINEERING CO.

PALO ALTO CALIFORNIA

*Export Agents:* FRAZAR AND HANSEN · 301 Clay St · San Francisco, Calif.



*Portrait of Randolph C. Walker by John Carlton*

# Engineers of Victory

## NOW SERVE MEN AT PEACE

The creative engineering which armed our fighting men for Victory has no less a responsibility in the years of peace ahead. Now that the war is won, we have the job of making this a better world.

AIREON produced huge quantities of communications and radar equipment and other machinery for waging war. Its achievements were equal to its heavy responsibilities, and its workers established an outstanding record of performance.

AIREON enters peacetime production with a notable engineering organization, highly skilled personnel and great confidence in the future. We have developed many products which will contribute to better living, for the manufacture of which all 15 AIREON plants will continue in production.

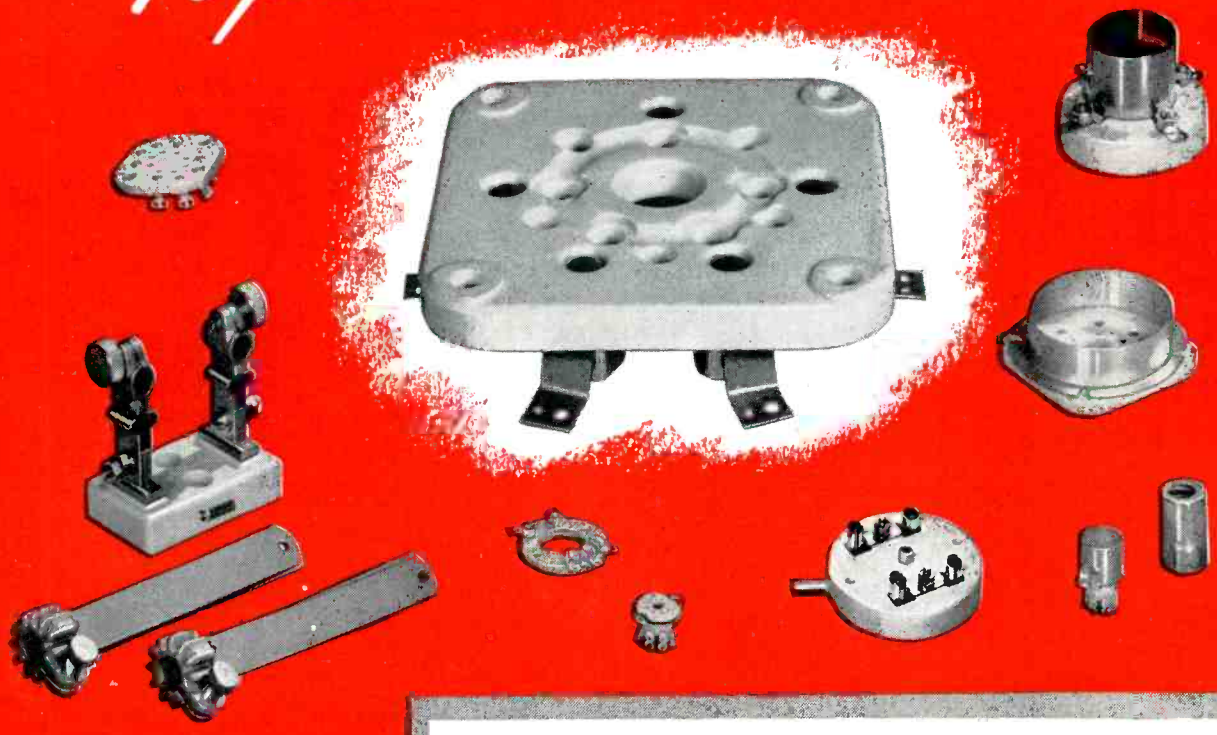
In order to extend our usefulness we recently established an experimental laboratory in Greenwich. AIREON's creative engineering in radio communications, electronics, musonics and hydraulics will team with production proficiency in contributing devices for future service.

In peace, as in war, AIREON will stand for quality and performance.

Randolph C. Walker
PRESIDENT

**Cinaudagraph Speakers**
**A DIVISION OF Aireon**
**3911 SOUTH MICHIGAN AVENUE, CHICAGO**

# Tops in the Field



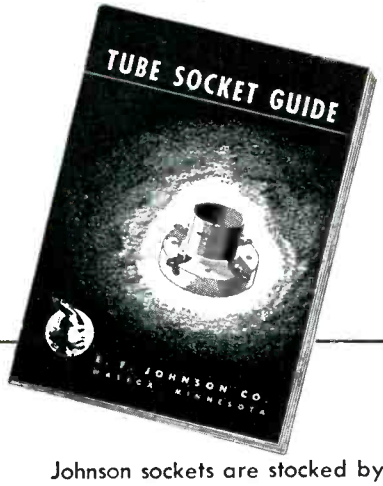
The latest addition to the famous line of Johnson tube sockets is the 275, Giant Five Pin tube socket with all the oustanding features which have made other Johnson sockets superior. A special feature of the 275 is the provision that has been made to allow forced ventilation from below the chassis, as required for the recently announced Eimac 4-125A and 4-250A. This socket may also be used for other Giant Five Pin tubes when a wafer type socket is desired.

Johnson sockets are engineered to meet the most exacting requirements of industrial, commercial broadcast and "ham" applications. For more than 20 years Johnson engineers have designed, and Johnson production lines have produced, transmitting components known throughout the industry as tops in the field. With this background and the close association with tube manufacturers, Johnson is continually leading the way with tube sockets designed to meet the rigid requirements of present day electronic circuits and equipment.

If you have a special tube socket problem, write Johnson, today.

*Write for*

**TUBE SOCKET GUIDE**



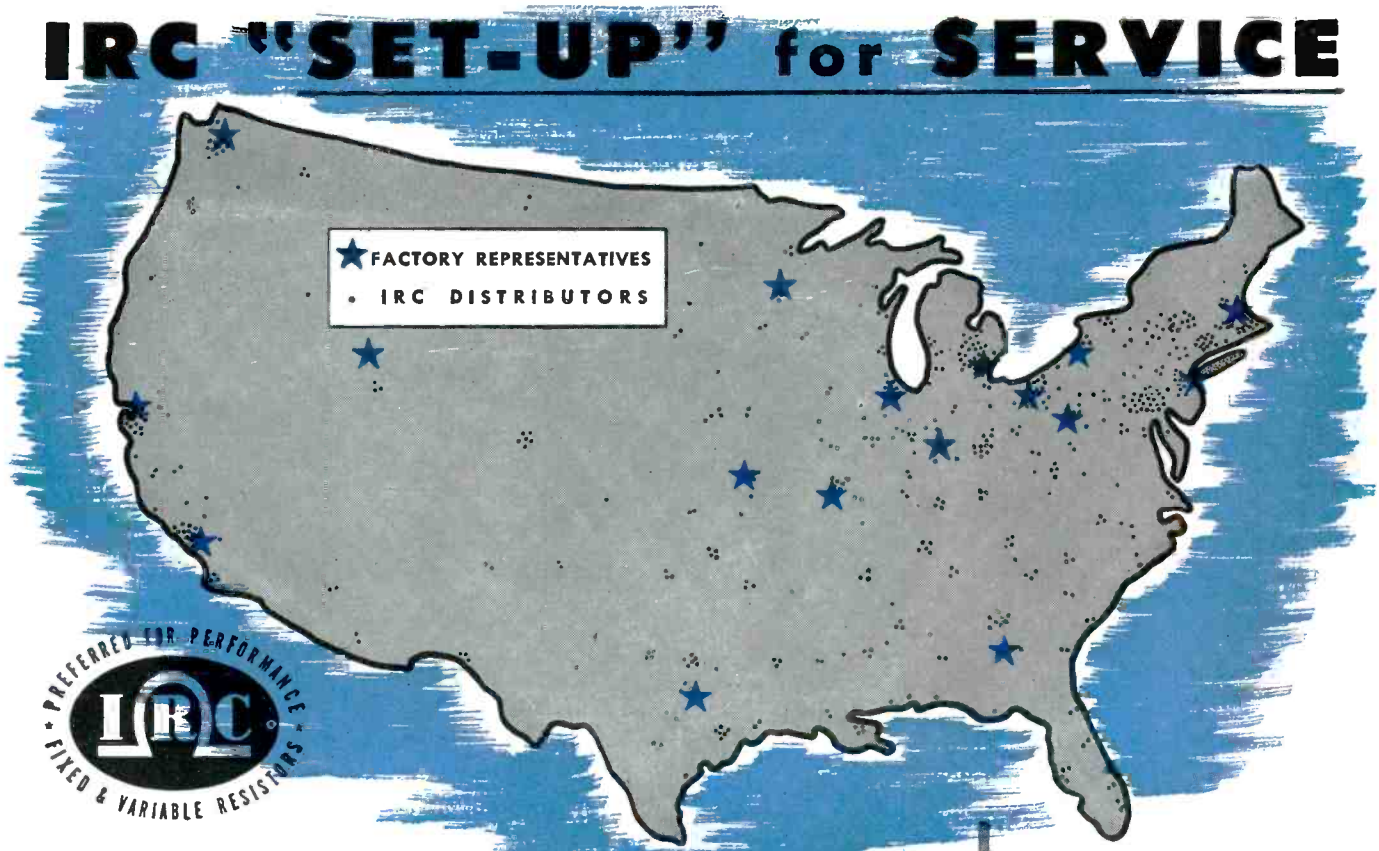

Johnson sockets are stocked by leading radio-electronic parts jobbers.

**JOHNSON**

*a famous name in Radio*

**E. F. JOHNSON COMPANY • WASECA • MINNESOTA**

# IRC "SET-UP" for SERVICE




## IRC RESISTORS ARE "ON LOCATION"

## *Everywhere!*

From coast to coast and border to border you'll find IRC "specialists" ready to help you with your resistor problems. These alert and capable organizations are ready to assist you in determining the precise resistors for your specific applications. IRC can render this unbiased technical service because it is the largest exclusive producer of resistance devices, making more types of resistors in more shapes, for more applications than any other manufacturer in the world.

Because of volume production combined with specialized engineering skill, orders in any quantity can be filled promptly. Your inquiries will be given immediate and efficient attention. Names and addresses of your nearest IRC Distributors will be furnished on request.

## INTERNATIONAL RESISTANCE CO.

DEPT. 9-K

401 NORTH BROAD STREET • PHILADELPHIA 8, PA.

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**BUFFALO**
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**CHICAGO**
S. B. Darmstader
308 W. Washington St.

**CLEVELAND**
Fred Bell 1400 W. 25th St.

**DALLAS**
George E. Anderson Santa Fe Bldg.

**DETROIT**
Koehler-Pasmore
8316 Woodward Ave.

**INDIANAPOLIS**
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**KANSAS CITY, MO.**
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**LOGAN, UTAH**
Ronald G. Bowen 83 E. First St.

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672 S. Lafayette Park Place

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George O. Tanner 508 Grant St.

**SAN FRANCISCO**
James P. Hermans 1278 Mission St.

**SEATTLE**
Dave M. Lee 2626 Second Ave.

**ST. LOUIS**
Norman W. Kathrinus 1218 Olive St.

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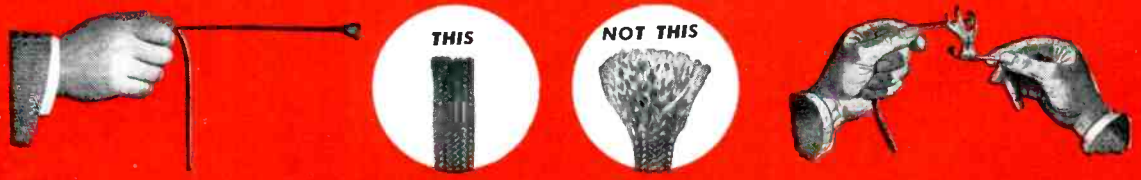


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## OBSERVATIONS OF AN AM LISTENER

(CONTINUED FROM PAGE 27)

prospects for our FM reception. From all we can find out, we aren't sure of hearing the FCC-Kesten version of FM broadcasting when it's on the air. We hoped that Chairman Porter would let the stations continue on the lower frequencies, with power enough to get out to our Radio Hill, but he says he's going to shut down the old transmitters, if necessary, to discourage manufacturers from building two-band FM sets. He says it will save the public from unnecessary expense.

We wish he hadn't brought that up. It reminds us to wonder how much we are going to pay for that 100-ft. tower et al with which we *hope* to hear some of the FM stations on their reduced power at the new frequencies.

One thing is sure. We don't propose to continue listening to the miserable AM sets which RMA president Cosgrove says will comprise the "vast majority" to be built by radio manufacturers.

That isn't because we are nuts about formal music and high-hat programs. It's just that, after nearly two years of listening to FM exclusively, we have suddenly come to realize to what miserable AM broadcast service the vast majority of listeners have become accustomed.

You can see why we weren't the least bit impressed when the broadcast executives sounded off that the demand for standby musicians on AM-FM transmission would retard and discourage interest in FM. If that's the best answer they can give, we say that broadcasting needs some new executives!

While these comments are observations on our own experience with AM reception at one particular location, they reflect the sentiments of the many millions of listeners in all parts of the country, both urban and rural, who do not have an opportunity to express themselves in print. To anyone who takes exception to this statement, we can only say: "If you'll travel the country as we have, and check reception everywhere you go, as we have, you'll hold the same opinion of AM service as we do."

That's why we get so hot about the long-haired slip-stick pushers who have turned FM inside out because they want to improve it by 2½%, when we lose 40% of an AM program by having to tune back and forth between fading stations on the same network to keep it coming in.

We can remember the time when we hooked up a dozen headsets and charged 24 people a quarter each to hear the Dempsey-Carpenter fight broadcast over WOR. And they said: "Isn't radio wonderful!" In the next three or four months, a great number of people will buy little AM sets, and they'll say: "Isn't it grand to have a radio!"

(CONTINUED ON PAGE 89)

## OBSERVATIONS OF AN AM LISTENER

(CONTINUED FROM PAGE 88)

About that time, FM sets will be moving in and out of radio stores in substantial quantities, and they, along with listeners who are still using prewar models, will hear the new reception. Then, Mrs. Jones will ask Mrs. Smith: "I hear you bought a radio set. Do you get the FM programs?" And Mrs. Smith will look embarrassed and say: "Oh, I wish we could, but John was so impatient. He rushed out and bought one of those little stinkers, and all we can hear is a terrible racket. I wish he'd waited to get an FM set like the new one the Browns just got."

Retard FM? Discourage interest in it? Why, if the broadcasters have to pay ten standby orchestras they'll still have to give American listeners FM transmission. Ten thousand Petrillos won't be able to stop FM when sets are put on sale again. He may be able to bluff the broadcasters, but no one can keep this better quality of radio reception from our radio listeners, even if AM has to go off the air completely.

As for the Cosgrove statement that sets without FM won't be obsolete because more than half the industry's volume will be on sets selling below $60. That's very limited thinking. It's limited to AM thinking, and doesn't take into account that, to an FM listener, the improvement over AM is well worth the increased cost.

But will people who live outside the metropolitan areas have to put up 100-ft. towers to pick up the "improved" FM transmission, as we have done? Yes, they will, at least right now. However, that condition should be corrected before the supply of FM receivers can catch up with the demand.

The Commission's report on allocations from 44 to 108 mc., dated July 27, 1945, stated: "This Commission, however, is under a statutory duty to make available to *all* people of the United States an efficient nationwide radio service. The Commission's duty is not fulfilled if its provision for FM service is such as to make it impossible for rural areas to enjoy satisfactory FM service."

And in spite of the way the Commissioners have been misled by some of their theoreticians, we believe they mean what they said, and that the present conditions will be corrected when they realize that the present FM broadcast setup is totally inadequate to serve listeners outside the metropolitan areas.

## NEWS PICTURE

(CONTINUED FROM PAGE 37)

experience in the manufacture, installation, and testing of radio-radar equipment during two years at the Naval Aircraft Factory. After a tour of duty at NOATC,

(CONCLUDED ON PAGE 92)

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## Answer Everyday Sound Problems

### *Maximum Intelligibility Under Extreme Noise*

Hand-Held, close-talking single button carbon *DIFFERENTIAL microphone for all speech transmission in any noisy, windy, wet or extremely hot or cold locations. Cancels out background noise. Articulation is at least 97% under quiet conditions, and 88% under a 115 db noise field.

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Model 725—Cardak I. List. . . . $55
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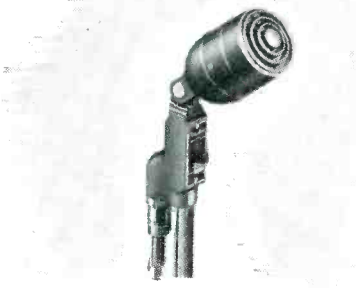

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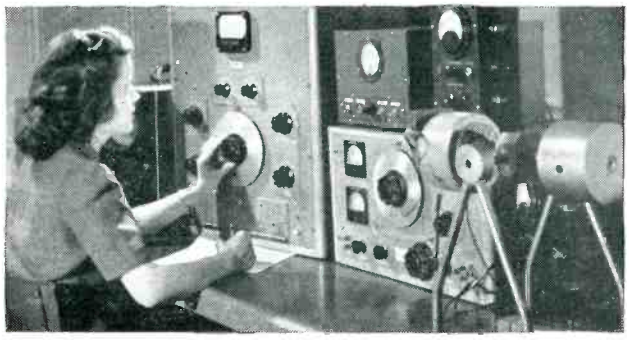

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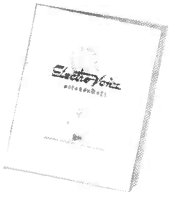

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## NEWS PICTURE

(CONTINUED FROM PAGE 89)

Corpus Christi, he spent a year as airborne electronics officer on the staff of NOATC, Jacksonville.

Your editor recalls a discussion at the Naval Aircraft Factory, some three years ago, not long after Arnold Nygren had left WFIL and had received his commission. He was asked the question: "From your experience with both AM and FM broadcasting, if you were going to put up a commercial station of your own, would it be AM or FM?"

He answered promptly: "FM, by all means. FM gives solid coverage over an area so much larger than it's possible to deliver in AM!" And then he proceeded to back up that statement with facts drawn from his own experience.

We believe our readers will join us in welcoming him to the staff at *FM* AND TELEVISION because his knowledge of FM is not read from a slip-stick, but from first hand experience in the dual rôle of chief engineering AM and FM broadcast stations.

## FMBI MERGED WITH NAB

AT A meeting held in Washington on October 31st and November 1st, representatives appointed by the FMBI and NAB boards met to perfect the final details under which FMBI activities would be transferred to the newly created NAB FM Department. Attending on behalf of FMBI were Walter Damm, president, Wayne Coy, Gordon Gray and John Shepard 3rd. NAB was represented by Paul W. Morency and Dr. Frank Stanton. Leslie Johnson, the other member named by NAB, was prevented by other business from attending. Also present were NAB president Justin Miller, executive vice president A. D. Willard and C. E. Arney, Jr., secretary-treasurer.

The purposes and objectives of the FM Department of NAB were set forth by the executive committee as follows:

1. To seek to secure the assignment of sufficient additional channels for FM so that broadcasting may develop in the public interest to its fullest potentialities without the artificial barriers, restraints, and regulation now imposed upon it.
2. Issuance of three-year licenses to FM licensees.
3. Revision of the numbering of FM channels to begin with the highest frequency instead of the lowest, in order that the numbering will be consecutive when the band is extended downward.
4. Use of joint program logs during the period of duplicate operation.
5. Use of joint call letters during the duplicate operation.
6. Revision of the six-hour minimum rule to eliminate requirement of three hours before 6:00 p.m. and three hours after 6:00 p.m.

## WHAT'S NEW THIS MONTH

(CONTINUED FROM PAGE 4)

transmitter extends far beyond that afforded by an AM transmitter of the same power. If, therefore, network affiliates shift from AM to FM, fewer stations would be required per network to cover the same listeners.

This was pointed out[1] by Dr. Frank Stanton of CBS when, discussing the merits of the CBS Single-Market FM Plan, he said: "Our development of this Single Market Plan was, in part, the result of inquiries from our affiliates, particularly those whose AM service areas could be swallowed up by giant multi-market FM stations. They were concerned, naturally enough, with how they were going to fit into the network coverage pattern of the future. . . . Translated into future station network economics, this meant that in some 31 areas our present AM affiliates would not be necessary to the operation of the network and, as some of them have put it, they would wither on the vine to the extent that FM multi-market stations developed and took over their audiences." And that, Dr. Stanton further explained, was a reason for the CBS proposal, the principles of which the FCC has adopted.

In other words, the FCC has adopted the principle that the power of an FM station is not to be fixed by the requirements of adequate service to radio listeners, but is to be limited to such minimum value as to keep all network affiliates in business even though more people could be better served by fewer FM stations on higher power.

Before proceeding further with this discussion, let us define *adequate service to radio listeners*. This term is not used here to indicate merely the reception of a station. It is intended to indicate day-and-night reception which provides constant amplitude (i.e., without fading) and reception free from inter-station interference. This, surely, is a minimum requirement for *adequate service* to radio listeners. In claiming listener coverage, AM stations do not so define reception of their stations, and in surveys made by telephone *they* are satisfied with the answer, "Yes, I am tuned to WXXX." If the surveys took into account the number of listeners who are not getting *adequate service*, the results would show how far from true such statements from AM broadcasters are as the following, quoted from Paul Kesten:[2] "(I am talking now about the conscientious broadcaster, the majority of the industry, the man who is seriously investing in pub-

[1] See page 27, "The Transition from AM to FM Broadcasting," by Paul W. Kesten and Dr. Frank Stanton, published by Columbia Broadcasting System, Inc., 485 Madison Ave., New York 22, N. Y. This pamphlet contains statements before the FCC on July 30, 1945.

[2] See page 11, "The Transition from AM to FM Broadcasting."

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## WHAT'S NEW THIS MONTH

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lic service, who is a respected force in his community.) . . . He, *with other* AM broadcasters in his area, is serving all the homes with radios within that area, and those homes represent *almost all* the homes there are. That particular fact is well worth emphasis — there is no sizable additional audience to be reached by FM. 95 out of every 100 homes in most markets have radios today — you can't add much to that."

From the broadcasters' point of view, this is the truth. But it gives no consideration to the listeners. Broadcasters have shunned such a determination, but the well-informed opinion of this observer is that not 20% of the listeners in any area have the adequate AM service, as defined here, to which radio progress now entitles them.

Bearing in mind the inferior quality of signals provided in a large part of what AM broadcasters lay claim to as their service areas, let us continue the examination of the Single-Market Plan and the economics of FM broadcasting.

CBS, despite official protestations, is not particularly concerned with limiting FM to single-market coverage because 31 of their affiliates might, otherwise, be eliminated. Nor is that a consideration to any other network. As far as revenue is concerned, it would simply mean that the remaining stations would be charged higher rates since FM would increase their coverage.

What does worry network officials is an entirely different matter. They are worried because the stations thus displaced *would not* go out of business. Instead, they would *continue* to operate, and the total number of stations displaced from the five major nets would be sufficient to support a new network. And that would be very bad, because it would constitute added competition for listeners' time!

There, in brief, is the thinking behind the Single-Market FM Plan, on the basis of which the FCC is limiting the power of FM stations, and limiting the power of each station to such an extent that it really doesn't matter whether transmission is better on the old band than the new band, or not.

Let's see what this means to the listeners. It is known from experience that a 50-kw. FM transmitter with a good antenna at a favorable location can give adequate service on the old band over a radius of 75 miles, or an area of 17,600 square miles. This is a very conservative figure. But, the FCC will not permit any one station so much coverage because, except in certain rural areas, that radius would include two or more metropolitan areas.

Now, to compare the *possible* FM service with the *actual* service *permitted* by the FCC, draw a circle, and another circle of the same size, just touching the first. Consider that the centers are 75 miles apart, and that the circles represent the service areas of two metropolitan FM stations on the same network. With a radius of 37.5 miles, each station will cover about 4,400 square miles. Now, draw a single circle around the other two. Its radius will represent 75 miles, and its area, about 17,600 square miles.

As your diagram will then show, one FM station located between two cities 75 miles apart could deliver perfect signals to all listeners in an area of 17,600 square miles. But the FCC won't permit it. Instead, the FCC says: "Oh, no, in such a case there must be a low-power station in each city, and each station must be limited in coverage to an area of 4,400 miles, so they won't overlap."

Look again at these figures and you will realize that the two low-power stations will cover only one-half the area served by the single, high-power station. What about the people living in that other 8,800 square miles? Yes, what about them?

Oh, the FCC has an answer to that. Their plan allows for the erection of still lower-power community stations, each to cover a radius of 20 miles, or an area of 125 square miles. That sounds all right, but is it? The area remaining to be served is 8,800 square miles. *But it would take 70 community stations to provide signals to all listeners in that area!*

In other words, under the present FCC plan, based on the original CBS proposal, unless the 2 metropolitan stations are supplemented by 70 community stations, there will not be the service to listeners that could be provided by one FM station such as the Yankee station at Paxton, or Major Armstrong's station at Alpine. And, mind you, those are only 50-kw. transmitters.

That is where the problem of economics comes in. Obviously, it would be impossible to operate any number of community stations outside the areas covered by the metropolitan stations because the number of people in most, or possibly all the subdivisions of 125 square miles would be too small to support even one broadcast station.

Therefore, the FCC provides no FM service except to people who live within the area of a metropolitan FM station, or in towns with sufficient population density to support community stations. In some sections of the United States, the FCC-CBS plan may exclude 25% of the population from FM service that could be provided by one 50-kw. FM station.

What makes this doubly serious is that such people do not have adequate AM service, either. To be sure, they may get something on AM, but nothing that remotely resembles *adequate reception*. If the situation set forth here represents an overstatement of actual conditions in some sections of the Country, it is an understatement of conditions in other sections,

(CONTINUED FROM PAGE 94)

depending upon variations in the relative distances between population centers and the density of population.

The principle of single-market coverage certainly does not serve public interest, as shown by the three-circle diagram and simple arithmetic. The FCC says that even under the single-market plan there are not enough frequencies in some cities to meet the initial demand, even though the stations are limited as to power and coverage. The primary obligation of the FCC is to assure listeners of adequate reception. If the obligations of public interest, convenience, and necessity could be met on the new FM band, we could forget the old one. But since, according to the FCC, the new band is too narrow to accommodate an adequate number of stations, either the FCC-CBS allocations plan must be abandoned eventually, or the old band must be retained.

Probably the present FM allocations setup will be abandoned in any case, because it subordinates public service to the protection of present networks against future competitors. Allocations of power must assume nation-wide FM coverage by *several*[3] networks, and must allow each station a *potential* audience sufficient to make it a reasonably sound commercial venture.

To be sure, this is the basis that RTPB and FMBI should have used in setting up their proposals last year. However, the Commissioners were only willing to accept technical testimony, and the FM allocations hearings finally degenerated into an engineering wrangle in which the economics of broadcasting were not considered. That, however, does not relieve the Commission of its statutory responsibility to take such further steps as are necessary to assure FM service for at least the 95% of our population which AM broadcasters claim to serve, and particularly that percentage of listeners, reasonably estimated at 80%, who have never had adequate AM reception.

**2.** Under heading "Control of Broadcasting Is *Top Priority* Issue", a pamphlet has been widely circulated by CIO's National Citizens Political Action Committee. The purpose of the pamphlet is summarized on the first page: "There is grave danger that the invaluable rights to use publicly-owned radio channels will be

[3] The CBS maps and data presented in "The Single Market Plan for FM Radio" by Paul Kesten show that a network of 200 stations can cover 88.7% of the U. S. population, including 83.6% of the people living in villages and 76.6% of those living on farms. Only apparent after the closest scrutiny of the data is the fact that the effect of the plan is to limit the population served by each station in such a way as to make it economically impractical to give listeners service from more than one network in many areas. Only by setting up a smaller number of stations with wider coverage can 95% of all listeners be assured of adequate FM service from several stations.

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## WHAT'S NEW THIS MONTH

(CONTINUED FROM PAGE 95)

gobbled up by the insiders who now control standard (AM) broadcasting, and the many licenses will go to the Hearsts, Pattersons, McCormicks, Gannetts, and others who already control a high percentage of the nation's newspaper circulation and numerous radio stations. . . . You must act now to prevent control of FM from falling into these hands or the fight on other issues which interest you today and which will interest you in the months and years ahead will be harder to win."

Copies of this pamphlet can be obtained from the NCPAC, 205 E. 42nd Street, New York 17, N. Y. Despite the fact that the text is written in characteristic CIO rabble-rousing style, containing the usual barbs directed at NAM, the reactionaries, and various large corporations, the wide distribution of the pamphlet may arouse some of our legislators to the point of taking an interest in the actions of the FCC.

As an example of the "back-door" approach to Government control of radio, the 6-point petition contained in the pamphlet also deserves study for, if the proposals should be adopted, the CIO would be in absolute control of radio broadcast facilities and program material in this country. Here are the six points which the public is asked to urge upon our legislators:

1. "To grant no more than one-quarter of available FM channels to licensees of existing standard (AM) broadcasting stations and to newspapers, and that such applicants be granted licenses only upon proof of exceptional public service in their present operations and guarantees that they will perform a wholly new and different program service on their FM stations."

The CIO might be willing to determine what constitutes proof of exceptional public service, but their measure would, in all probability, be comformity to CIO and PAC thinking. However, no agency of democratic government would accept or should be given such responsibility. It would be extremely dangerous to change the present regulations under which stations are presumed to serve public interest, convenience, and necessity unless it can be shown that they have failed to meet this public obligation.

As for guaranteeing to perform a wholly new and different service — who will decide in what respect the service should be new and different? Here again the CIO-PAC calls for Government regulation, presumably by officials whom the CIO could influence by political pressure.

2. "To prescribe, in terms of hours and expenditures, standards of public service programming for all broadcast stations, which standards an applicant must agree to meet before receiving a license, and

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## WHAT'S NEW THIS MONTH

(CONTINUED FROM PAGE 96)

which all licensees must demonstrate that they have met before being granted renewal of licenses."

This is a restatement of the CIO-PAC plan for Government control of broadcasting, which the CIO could attempt to influence through minority-group pressure politics.

3. "To grant three-quarters of the FM broadcast channels to newcomers, under rules and regulations which will insure fair consideration for veterans, small businessmen, farm, labor, cooperative, and citizens groups and others who, to date, have not enjoyed broadcasting opportunities."

Such opportunities are now available to the groups enumerated. Of course, the Government cannot guarantee the success of stations operated by these groups. They will succeed or fail according to their success in competing for listeners' attention, but at least there are FM frequencies available for those who have the personal qualifications required, and funds to assure the continued operation of a broadcast station.

4. "To prohibit the granting of an FM license to any standard (AM) licensee without a public hearing."

It is not clear that this would serve public interest, convenience, or necessity. Actually, how many listeners would ask to have an FM license refused to any AM station? Radio listeners have been trained as letter-writers, and if any station offends a significant number of listeners, the FCC hears about it very quickly.

The only purpose to be served by a public hearing would be to give the CIO-PAC the opportunity of opposing stations which had not conformed with CIO-PAC ideas — in the opinion of CIO-PAC officials.

5. "To prohibit the renewing of any broadcast license until the application for renewal has been advertised in a local newspaper of general circulation and all persons in the community, so desiring, have been afforded the opportunity to apply competitively for the same license or to submit evidence why such license should not be renewed."

What is meant by "the opportunity to apply competitively for the same license"? The opportunity to compete on what basis? No price is put on a station license. Would the competition be based on promises that have to do with programs? Who would decide between the competitors? What guarantees would be given? How would the listeners be protected? This proposal involves a potential change in station ownership and the transfer of property. The whole idea is impractical.

6. "To arrange, whenever and wherever possible, for local hearings to be held in communities which applicants intend to serve."

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## WHAT'S NEW THIS MONTH

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Under such an arrangement, it would be easier for local CIO-PAC groups to exert pressure at the hearings in the vociferous style they have been urged to adopt, but it does not appear that public interest would be better served than when hearings are held at Washington. The idea is entirely impractical, for it would be physically impossible for the Commissioners to carry out such a plan.

Altogether, the 6-point petition urged by CIO-PAC is purely a bid for a minority pressure-politics control of broadcasting under the guise of new Government regulations. It fails to serve public interest because it is motivated by the special interests of a group that is seeking political power.

Whatever may be said in criticism of the Commissioners and engineers of the FCC, it is still true that radio has a better chance to survive as an instrument of public service to a free and democratic people under the present laws and regulations than if it is exposed to direct or back-door control by the officials of the CIO-PAC.

At the same time, the circulation of this pamphlet will serve a useful purpose if it encourages radio listeners to respond to Chairman Porter's public pleas for their expressions of opinion.


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

Of *FM* AND TELEVISION, published monthly at Great Barrington, Massachusetts, for October 1, 1945

State of Massachusetts } ss.
County of Berkshire }

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

1. That the names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, Milton B. Sleeper, Great Barrington, Massachusetts; Editor, Milton B. Sleeper, Great Barrington, Massachusetts; Managing Editor, none; Business Manager, Andrew Glier, Sheffield, Massachusetts.

2. That the owner is: Milton B. Sleeper, db/a FM Company, Great Barrington, Massachusetts.

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

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

(*Signed*) ANDREW GLIER, *Business Manager*

Sworn to and subscribed before me this Second day of October, 1945.

[Seal] ELIZABETH G. DONAHUE, *Notary Public*

Commission expires March 31, 1950.

## SPOT NEWS NOTES

(CONTINUED FROM PAGE 36)

Roebuck warehouses, and to reduce transportation costs.

**Nationwide FM Relays:** Tests are under way on relays between New York and Philadelphia, the first links in a system to be built by RCA for Western Union. Operating in the 3,900- to 4,450-mc. band, the present system employs a channel width of 150 kc., capable of handling an estimated 270 multiplex or 1080 single telegraph circuits. Used for FM programs, the present equipment could possibly handle 8 channels. Next links, for which FCC applications have been filed, will be New York to Pittsburgh, Pittsburgh to Washington, Washington to New York. Only 2 repeaters are used between New York and Philadelphia.

**Nelson P. Case:** New chief engineer of receiver division for Hallicrafters. An AB in physics and an EE from Stanford '24, he was an assistant physicist at the Bureau of Standards until 1929. From 1930 until 1943 he was with Hazeltine Electronics, during the latter part of that time in charge of the Hazeltine license laboratory in New York.

**New York City:** Technical Appliance Corporation has consolidated its wartime plants at 41-06 De Long Street, Flushing, N. Y. Company offices will be located at the Flushing plant.

**New York City:** Jefferson-Travis Corporation has acquired all outstanding stock in Musicraft Corporation and affiliated companies of New York and Los Angeles. Musicraft operates a modern record-pressing plant in Los Angeles, and is erecting another in Ossining, N. Y. Jefferson-Travis plans a wide expansion of its production of popular and classical recordings.

**E. A. Leach:** After 17 years with General Electric has joined Hammerlund as executive engineer. Equipped BS and MS degrees in electrical engineering, he entered the G.E. test department in 1929. His subsequent course was most unusual. He moved on into the design of ground and aircraft radio and radar equipment, then became assistant superintendent of the manufacturing department, and finally, a year ago, was made sales manager for G.E. emergency communications equipment. Now, at Hammerlund, he will be responsible for the industrial accounts, handling the engineering details of manufacturing contracts. He will also have a hand in the new line of transmitters and receivers.

# GOOD NEWS FOR BROADCASTERS

## REL 88-108 Megacycle Band

# FM

## Broadcasting Equipment in Assembly

**PLACE YOUR ORDER NOW**

This REL broadcasting equipment can now be ordered . . . to meet or exceed present FCC requirements.* Entirely new . . . with important design advancements.

### Transmitters

With the new Armstrong Modulator . . . providing simple, stable . . . even more efficient performance than ever before!

| Power Output | Cat. No. |
|---|---|
| 250 watt | 549A-DL |
| 1000 watt | 518A-DL |
| 3000 watt | 519A-DL |
| 10,000 watt | 520A-DL |

### Speech Equipment

Cat.
603—Studio Speech Console, Table type, 6 Position
604—Station Speech Console, Table type, combined with Cat. 600 Monitor and transmitter desk control

### Monitoring Equipment

Cat.
600—FM Station Frequency and Modulation Monitor

Wire or write today for technical data, prices and delivery . . . or better yet . . . do as other broadcasters have already done—send your order, subject to later confirmation, thus assuring early delivery.

*REL FM equipment guaranteed to meet or better the FCC standards of good engineering practice for FM Broadcast stations.

REL

*Sales Representatives*

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| Detroit, Mich. | Chicago, Ill. | Hollywood 46, Calif. |

PIONEER MANUFACTURERS OF FM TRANSMITTERS EMPLOYING ARMSTRONG PHASE-SHIFT MODULATION

# RADIO ENGINEERING LABS., INC.

*Long Island City, N.Y.*

# Link

# EMERGENCY RADIO

LINK engineering skill has long been recognized by the U. S. Government and this organization has worked in close cooperation and secrecy with many government agencies on numerous vital developments.

In an address to the I.R.E. on September 15, 1945, Major General Roger B. Colton, A.A.F. Headquarters, named Link as one of the 15 pioneer contributors to the success of military radar.

## FIRST IN WAR

Such skill and knowledge is reflected by Link in its thousands of Emergency Radio installations being used by State, County, Township, Borough, City, Utility, Commercial, Forestry, Park, Highway, Railway and other Emergency Services.

Seconding Commissioner Hickey's commendation of Connecticut's Link FM system, Frank Bramley, Supervisor of Radio Maintenance, said, "The use of rugged, trouble-free equipment was the clincher without which planning and foresight would have been useless."

A finer recommendation for emergency radio is impossible, considering these statements from the undisputed pioneers in 2-way statewide FM operation.

## FIRST IN PEACE

OCT 25 A M.

RADIATION LABORATORY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE 39, MASSACHUSETTS

OPERATING UNDER THE SUPERVISION OF THE NATIONAL DEFENSE RESEARCH COMMITTEE

IN REPLY REFER TO:
51-LAD/HDD-102445
REFERRING TO YOUR REFERENCE:

October 24, 1945

Mr. F. M. Link
F. M. Link Company
125 West 17th Street
New York 11, New York

Dear Mr. Link:

The Radiation Laboratory owes a great deal of its success to the various manufacturers who have so thoroughly backed up its microwave radar program. In your field you have been one of the major contributors to the laboratory's work.

Your able design and development engineers were instrumental in the early production of high power radar modulators and other equipment for laboratory use and for some of the laboratory's rush programs on building small quantities of new and special purpose equipment. Both of these production programs have aided in the race to get good equipment out fighting.

As the laboratory is terminating its work, I wish to take this opportunity to express my full appreciation for your efforts.

Very truly yours,

L. A. DuBridge, Director

LAD/HDD:SB

EDWARD J. HICKEY
Commissioner

STATE OF CONNECTICUT
DEPARTMENT OF STATE POLICE
100 WASHINGTON STREET
HARTFORD 1, CONN.

NOV 5 A M

November 3, 1945

Mr. Fred M. Link
Consulting Radio Engineer
125 West 17th Street
New York 11, N. Y.

Dear Mr. Link:

Once again I want to express to you our appreciation of the excellent service we have received from your organization in the maintenance of our radio system, especially during the war crisis.

The Connecticut State Police radio system was taxed to the utmost during this period. Frankly, its performance exceeded our expectations.

Frank Bramley's article in the September-October 1945 issue of the MUNICIPAL SIGNAL ENGINEER reminds me of the trying days in 1939 when our department was faced with the problem of statewide installations. Professor Daniel E. Noble, then of the University of Connecticut, had been engaged in experimental research on frequency modulation. In the summer of 1939 he was retained as our consulting radio engineer and designed our radio system and its equipment.

At the time there was no suitable FM equipment on the market. Professor Noble's specifications were submitted to several manufacturers with a request for quotations. Your company not only met the requirements but was the only one able to furnish the complete equipment, thereby obtaining the contract. Since then we have had constant and efficient radio service.

Naturally we were proud to be the first state police department to have FM state-wide coverage and to share with you the honors in this achievement.

Yours very truly,

Edward J. Hickey
COMMISSIONER OF STATE POLICE

EJH/CVC

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