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FM AND TELEVISION

FEB. 1947

CHAMPION OF "FREE RADIO"

(SEE PAGES 3 AND 28)

ARTICLES for

★ ★ Edited by Milton B. Sleeper ★ ★

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Heating

Communications
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Police
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Here's a new Eimac tetrode—the power step-up you have been asking to have added to the Eimac line.

Capable of 2-kw power output at 4000 plate volts, with less than 15 watts of grid drive, the 4-750A opens a new field of possibilities to designers of electronic equipment. A pair of these tetrodes, driven by low cost, low-power tubes, will supply more than 4-kw output.

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EIMAC 4-750A POWER TETRODE
Electrical Characteristics

Filament: Thoriated tungsten	
Voltage	7.5 volt
Current	20 amp
Direct Interelectrode capacitances (av.)	
Grid-plate	.24 μμf
Input	26.85 μμf
Output	7.78 μμf
Maximum Ratings	
D-C Plate Voltage	6000 max. volts
D-C Plate Current	700 max. ma.
Plate Dissipation	750 max. watts

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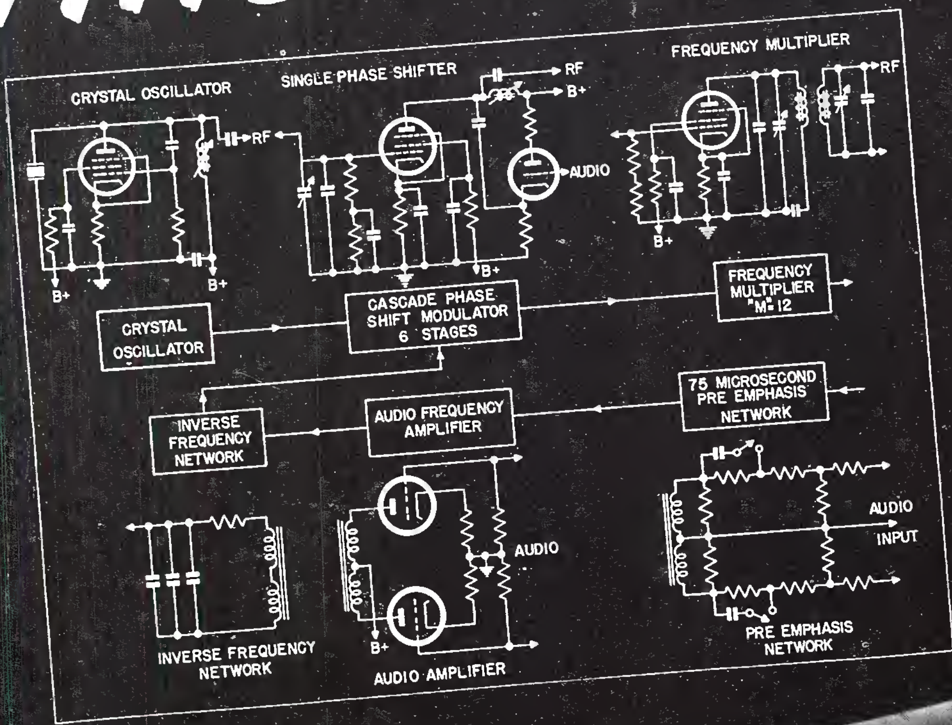

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FM AND TELEVISION

FORMERLY, FM MAGAZINE and FM RADIO-ELECTRONICS

VOL. 7 — FEBRUARY, 1947 — NO. 2

CONTENTS

★ ★ ★ ★ ★ ★

MILTON B. SLEEPER, *Editor and Publisher*

William T. Mohrman, *Advertising Manager*

Stella Duggan, *Production Manager*

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THIS MONTH'S COVER

C. M. Jansky, Jr., whose picture appears on this month's cover, has consistently championed the use of FM as a means of making radio as free a field of enterprise as any other kind of American business. He contends that anyone who has the capital to erect a broadcasting station should be privileged to go on the air, just as anyone who can equip a printing plant or stock a store is free to publish a newspaper or to enter the hardware business. In his article on page 28, be explains why the Government bas had to regulate AM broadcasting, and why FM eliminates the need for such limitation. This is not a matter of ideology, but of established engineering principles.

Entered as second-class matter, August 22, 1945, at the Post Office, Great Barrington, Mass., under the Act of March 3, 1879. Additional entry at the Post Office, Concord, N. H. Printed in the U. S. A.

MEMBER, AUDIT BUREAU OF CIRCULATIONS

WHAT'S NEW THIS MONTH

1. Facts of Life

2. Nathan Report

1. The article "Facts of Life about FM" in our January issue brought the greatest number of comments ever received in the seven years that this Magazine has been published.

We thought our remarks about the need for antennas might bring some complaints from manufacturers. To our surprise, those who wrote us agreed emphatically.

Now that we have reviewed the letters, representing a cross-section of the manufacturers, broadcasters, and dealers, we are preparing a supplementary article, "More Facts about FM," for publication in the March issue. We have some more, and perhaps more important matters to put before the three groups concerned.

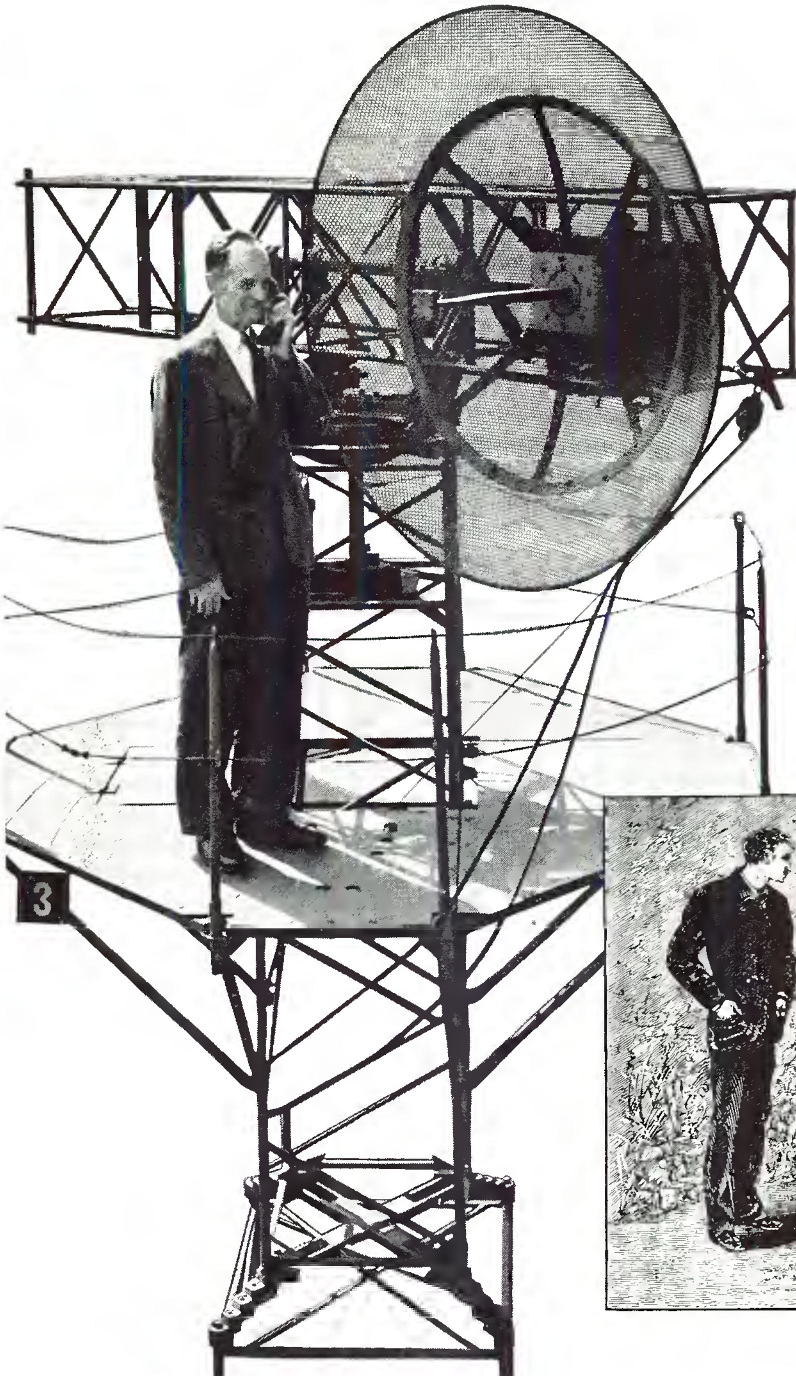
We received just one complaint. It was from John J. Harrison, Manager of W. & J. Sloane's radio department, and formerly sales engineer at the Scott offices in New York City. We went up to see him and, before we left, we were happy to withdraw the criticism of his department that appeared in these pages last month. Since the occasion of our previous visit, when we dropped in with Capt. Finch to hear his station WGHF, John Harrison has done a very fine job of setting up a handsome display of FM sets. Moreover, he told us that last fall he had cancelled all orders for sets that did not provide FM tuning. Now, he does not have a single straight AM model in his stock.

As for antennas, his problem is that manufacturers require him, under the Feld-Crawford Act, to charge for antenna installations. And, believe it or not, people who pay $675 to $1,050 for receivers won't spend a few dollars extra for antennas. The result is that many of these fine sets are delivering much less than the performance of which they are capable, yet Sloane's would be glad to install antennas for these expensive models without charge, if the manufacturers would allow it.

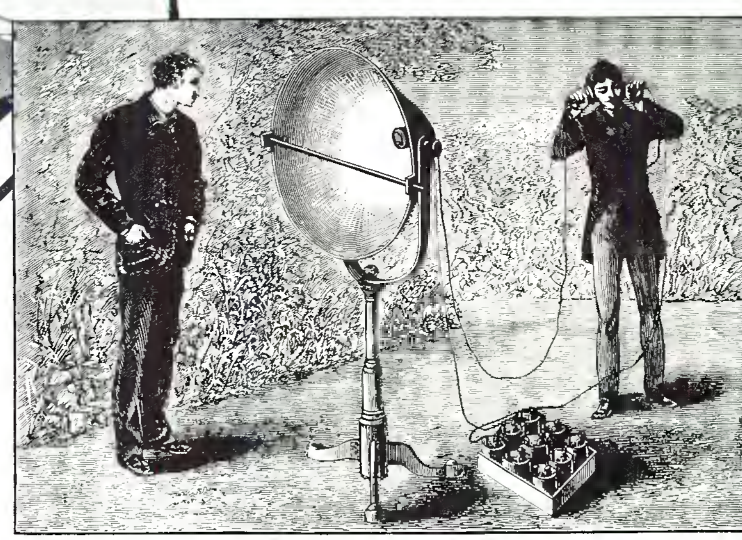
2. A factual discussion of the Nathan report, published by the First National Bank of Boston contains this comment:

"The Nathan report endeavors to show that profits are excessive because they reveal a greater percentage gain since 1936–39 than have wage payments during

(CONTINUED ON PAGE 42)



Words that rode on a beam of light



If Alexander Graham Bell could look at the microwave antenna in the illustration, how quickly his mind would go back to his own experiments, 67 years ago!

For in 1880 the inventor of the telephone had another new idea. Speech could be carried by electric wires, as Bell had demonstrated to the world. Could it be carried also by a *light beam?*

He got together apparatus—a telephone transmitter, a parabolic reflector, a selenium cell connected to handphones—and "threw" a voice across several hundred yards by waves of visible light, electromagnetic waves of high frequency.

Bell's early experiment with the parabolic antenna and the use of light beams as carriers was for many years only a scientific novelty. His *idea* was far ahead of its time.

Sixty years later communication by means of a beam of radiation was achieved in a new form—beamed microwave radio. It was developed by Bell Telephone Laboratories for military communication and found important use in the European theater. In the Bell System it is giving service between places on the mainland and nearby islands and soon such beams will be put to work in the radio relay.

In retrospect, Bell's experiment illustrates once again the inquiring spirit of the Bell System.

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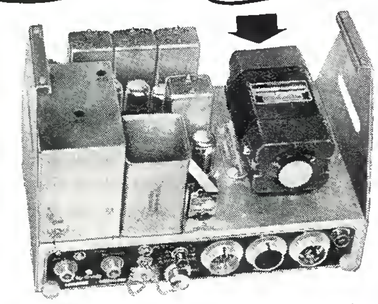
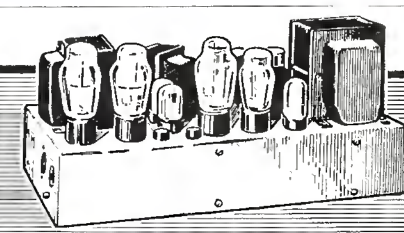
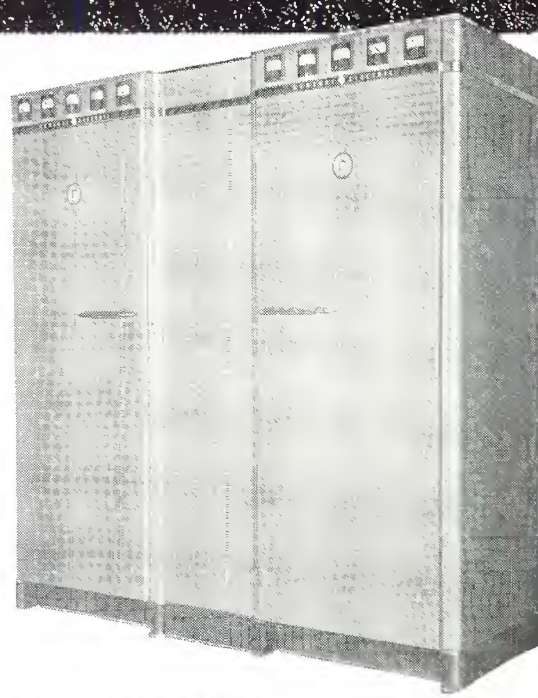




ADVERTISERS INDEX

100 FM TRANSMITTERS *shipped!*



HERE is the one hundredth FM broadcast transmitter produced by G. E. It was shipped on January 10th. Nearly 150 more, on order, are now being built.

This 3 KW transmitter incorporates the famous Phasitron circuit plus many other technical advances by General Electric. It is one of the units in the complete General Electric line of transmitters which range in power from 250 W to 50 KW.

These FM transmitters have proved their efficiency and economy in stations throughout the country.

For complete information on these transmitters, designed and built to assure you lower costs per hour of operation, write or call your nearest General Electric broadcast sales engineer, or the *Electronics Department, General Electric Company, Syracuse 1, New York.*

FIRST AND GREATEST NAME IN ELECTRONICS

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160-FI-6914

ENGINEERING SALES

Collins: Thomas B. Moseley, formerly chief engineer for International Electronics Corporation, has been appointed broadcast sales engineer for Collins Radio Company, in the southwestern area. He will make his headquarters at Dallas, Texas.

Chicago: Concord Radio Corporation, planning an extension of its business in foreign markets, has named Jack E. Snyder as manager of its export division. Snyder has been with the Company for 16 years.

Philco: William MacMurtrie, who joined the Philco purchasing department in 1935, has been appointed general purchasing agent. Raymond A. Boyce, who held this post previously, has been advanced to the position of director of purchases.

Admiral: New northwestern sales manager of all Admiral Corporation products is Harold D. Conklin. He will make his headquarters in San Francisco.

New York City: Marvin Taub has resigned as advertising manager of Radio Receptor, and has joined Shaw Associates, an advertising agency at 112 E. 19th Street, New York, as vice president in charge of new business.

Weston: Curtis H. Stout is now representing Weston Electrical Instrument Corporation in Arkansas, western Tennessee, northern Mississippi, and northern Louisiana. His home office is at 1808 Beechwood Road, Little Rock, Ark.

Eitel-McCullough: Dave M. Lee Company, Seattle, has been appointed regional sales representative for Eimac tubes in Washington, Oregon, western Montana, and western Idaho. James F. Johnson (W7VP) will be in direct charge of the line.

G. E.: First General Electric FM-AM sets shipped to distributors from the Bridgeport plant are earmarked for sale to FM broadcast stations, where they will be used for public demonstrations. This is part of a plan of coöperation with the FM stations.

Air King: Washington Distributors, 115 Madison Street, Seattle, have been appointed distributors for Air King radios in Oregon, Washington, Idaho, Montana, and Alaska.

SYLVANIA NEWS
CIRCUIT ENGINEERING EDITION

FEB. *Prepared by* SYLVANIA ELECTRIC PRODUCTS INC., Emporium, Pa. 1947

"ATTENTION TO DETAIL!" KEYNOTE OF SYLVANIA ELECTRIC RADIO TUBE PRODUCTION

WELDING CONNECTIONS. All connections in the Lock-In Tube are welded for greater durability. Short, direct connections result in fewer joints and lower loss.

GLASS HEADERS. Small cylindrical cups of glass and metal pins are pressed into the low-loss glass base to which is joined the small glass exhaust tubing.

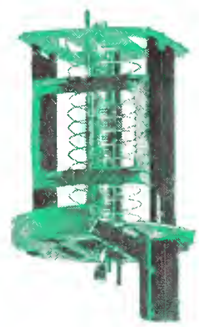
"Lock-In" Tube Manufacture Typical Of Plant Operation

Each Sylvania tube receives minute attention in every phase of production. Laboratory research achievements in developing and putting into production new alloys, new compounds, new engineering techniques, contribute fundamentally to the quality operation of Sylvania tubes.

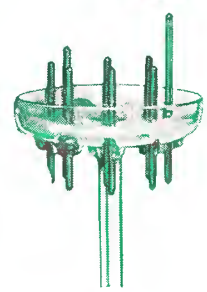
An outstanding example of this controlled production is the famous Lock-In Tube. Note accompanying photographs.

LOCK-IN MOUNT AND GLASS HEADER

IMPROVED MOUNT . . . elements are ruggedly supported on all sides. Meticulous accuracy is required to fit and weld each part to the others to become the finished mount. There are few welded joints and no soldered joints — the elements can't warp or weave.



ALL-GLASS HEADER . . . through which element leads are directly brought — low-loss and better spacing of lead wires. These leads become the sturdy socket pins — effecting a much desired reduction in lead inductance and inter-element capacity.



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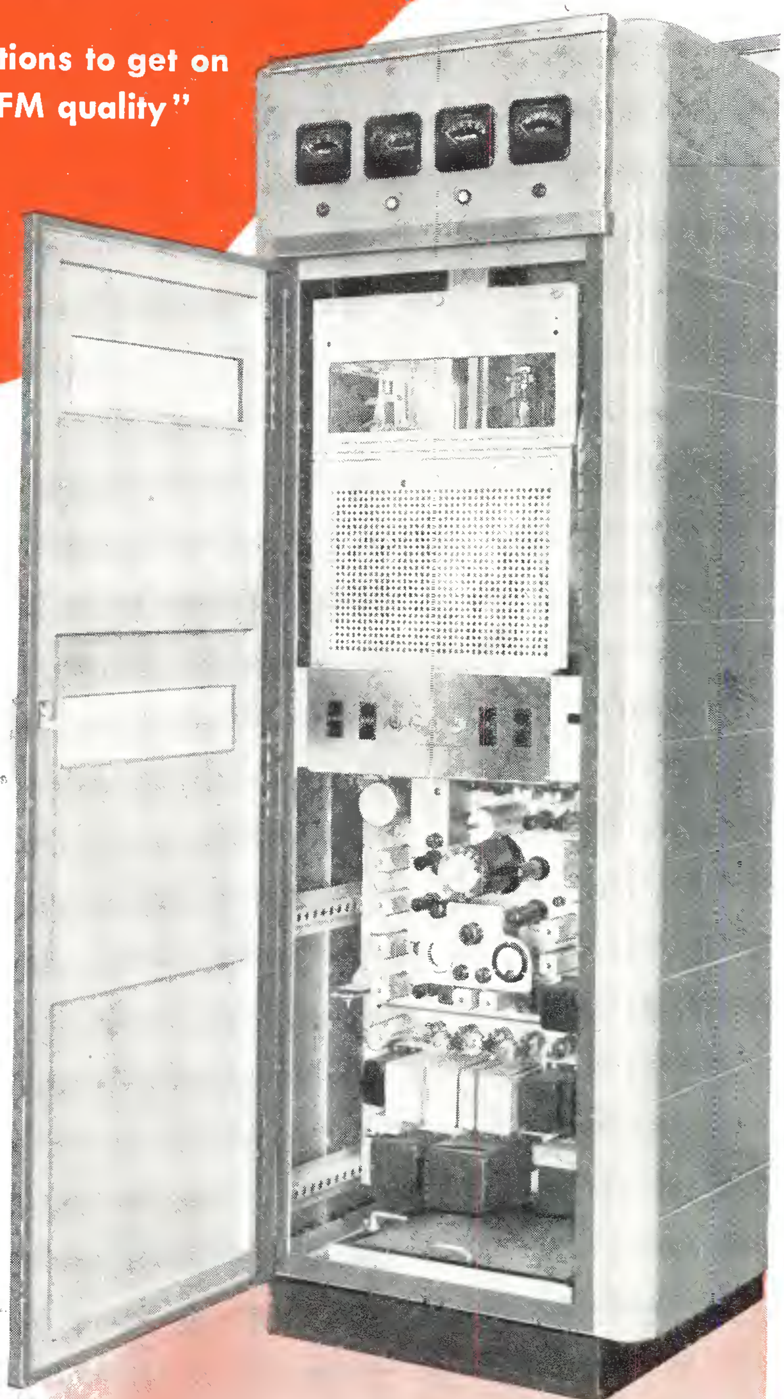
No Waiting for this pace-setting

- Delivery can now be made from stock
- A quick way for low-power stations to get on the air immediately with true "FM quality"
- A simple, low-cost way for high-power stations to meet standby requirements



RCA's popular "Direct FM" 250-watt transmitter has just about everything you might want: record-breaking performance, operating convenience and economy, and attractive styling. RCA FM transmitters are now being used or installed by more than 200 stations across the country—either separately or to drive a higher power RCA FM transmitter.

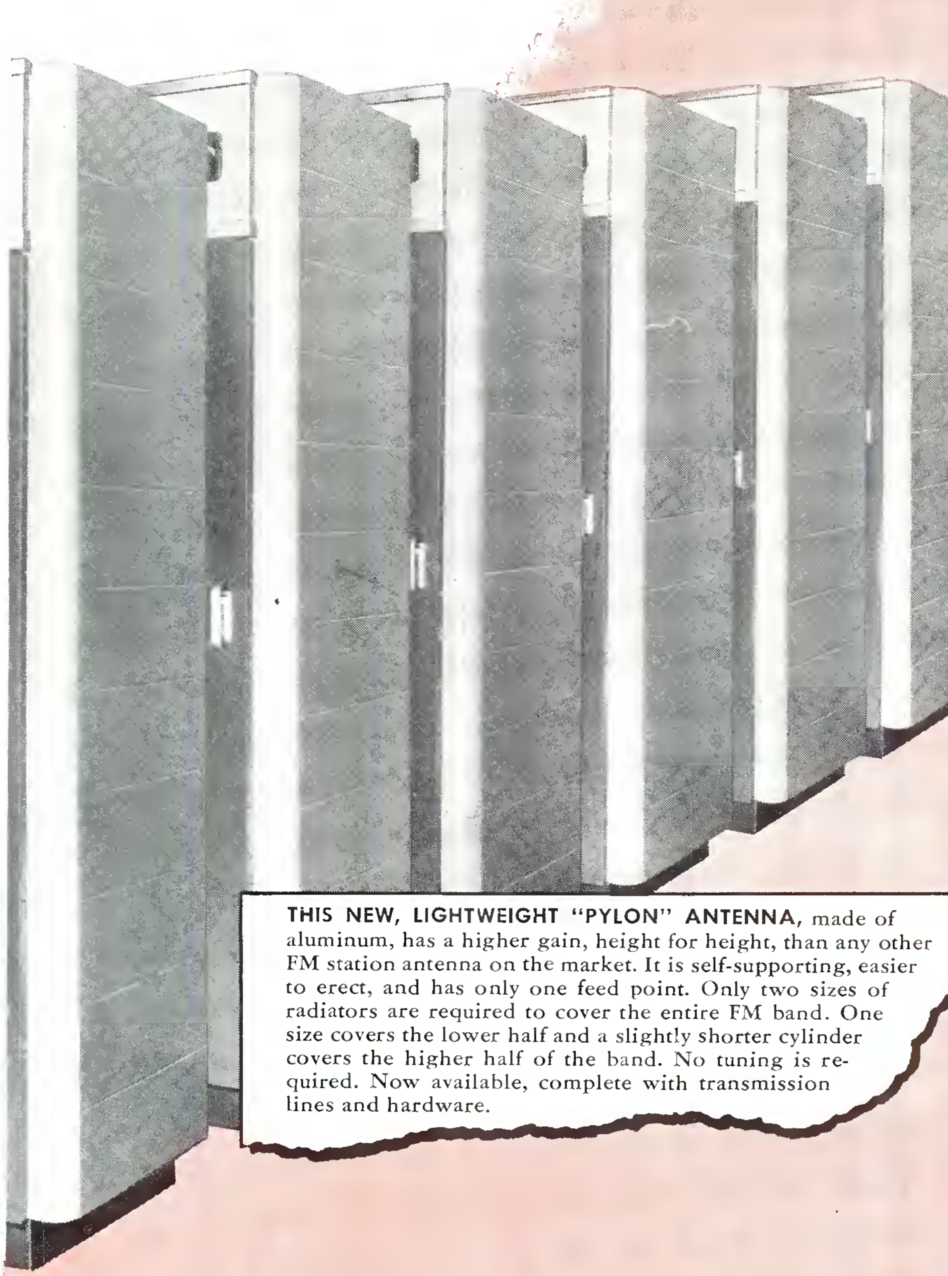
The BTF-250-A incorporates RCA's exclusive "Direct FM" exciter. The straightforward circuits in this unique design keep distortion and noise level lower than with any other type yet developed. Distortion is less than one-half of one per cent over the entire FM range of 30 to 15,000 cycles. Frequency response is constant within ½ db over the same range.

The entire transmitter is mounted in one smartly styled cabinet . . . with full-width doors, front and back. Vertical-panel construction is used throughout. All exciter components are front-panel mounted; all wiring and controls are easily accessible.

In conjunction with the new RCA Pylon FM antenna (see opposite page), we believe this to be the finest transmitting equipment now available—for everyday use in low-power stations, and for standby installation with higher power transmitters.

We'll be glad to send you complete specifications and prices. Write: Dept. 35-B, Broadcast Equipment Section, Radio Corporation of America, Camden, New Jersey.

250-watt FM Transmitter...



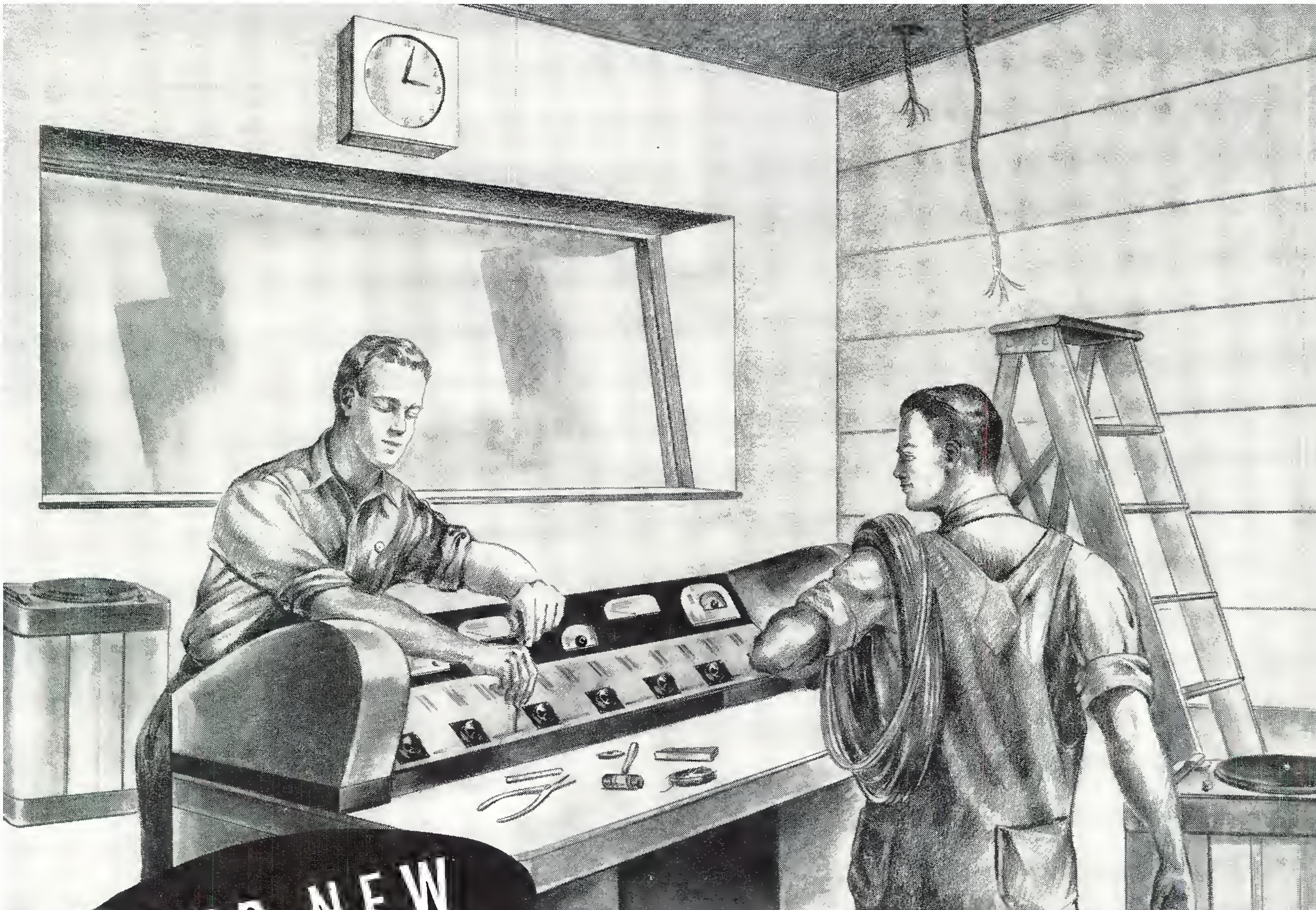
THIS NEW, LIGHTWEIGHT "PYLON" ANTENNA, made of aluminum, has a higher gain, height for height, than any other FM station antenna on the market. It is self-supporting, easier to erect, and has only one feed point. Only two sizes of radiators are required to cover the entire FM band. One size covers the lower half and a slightly shorter cylinder covers the higher half of the band. No tuning is required. Now available, complete with transmission lines and hardware.

BROADCAST EQUIPMENT

RADIO CORPORATION of AMERICA

ENGINEERING PRODUCTS DEPARTMENT, CAMDEN, N.J.

In Canada: RCA VICTOR Company Limited, Montreal



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Custom Built Langevin audio facilities for broadcast studios are designed and manufactured to fit the requirements and specifications of the individual broadcaster.

Using Langevin FM quality amplifiers as the basic building blocks, complete audio facilities, including the type console you want, can be engineered and fabricated in our "custom built" department. The Langevin service also includes on-the-job installation supervision, if desired.

In many cases a Langevin custom built audio system, tailored to fit your needs, is no more costly than a combination of standard packaged speech input units.

A Langevin Audio Facilities Engineer is always on call . . .
Let him help you with your equipment planning . . .

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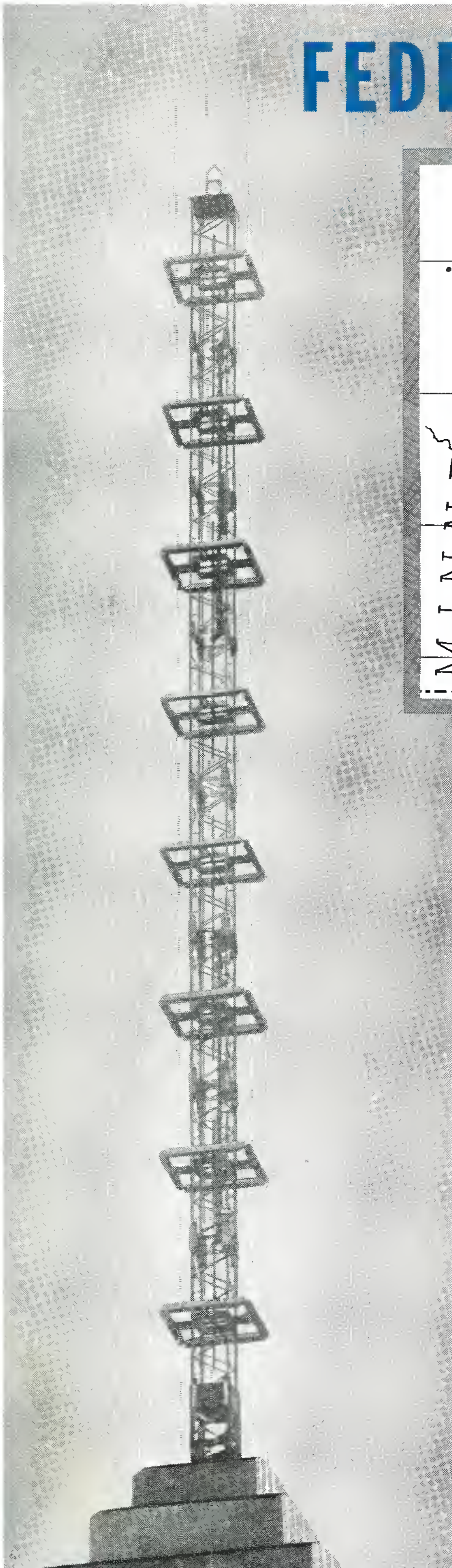
FEDERAL'S 8-ELEMENT



A survey of surrounding cities indicates a radiation pattern approximately as shown by the shaded area above. Listeners almost 150 miles away reported excellent volume and clarity of reception. The remarkable coverage is due to the power gain of Federal's Square-Loop Antenna. The clarity and tone quality is made possible by the exceptional fidelity and mean carrier stability of Federal's "Frequematic"* Modulator — an exclusive feature of every Federal FM transmitter.

*Trade Mark

Federal's 8-Element Square-Loop Antenna dominates the Minneapolis skyline from the top of the Foshay Tower — highest building in the Northwest. Ruggedly constructed to withstand heavy winds and icing loads, this 80-foot antenna has already proved its dependability in temperatures down to 22 degrees below zero!

Federal Telephone

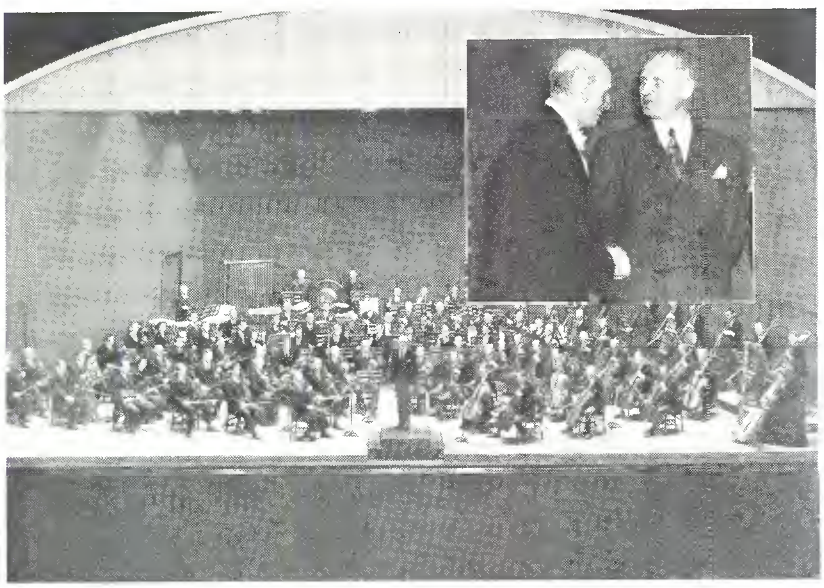
In Canada:—Federal Electric Manufacturing Company, Ltd., Montreal.
Export Distributors:—International Standard Electric Corp. 67 Broad St., N.Y.C.

SQUARE-LOOP FM ANTENNA MAKES WORLD DEBUT!

WTCN-FM, Minneapolis, goes on the air with most efficient FM Antenna installed anywhere . . . boosts 3kw transmitter to 25kw . . . with coverage of 30,000 square miles

FEDERAL'S 8-Element Square-Loop Antenna made radio history with the opening of the Twin Cities FM station, WTCN — the first super-directive antenna of its type and power gain to be installed anywhere. It gives the 3kw Federal transmitter an effective radiated power of 25kw — providing excellent reception over an area of approximately 30,000 square miles. This makes WTCN the world's *most efficient* FM station—and, with an FCC permit for an output of 400kw, it will eventually be one of the country's *most powerful* stations, too. With Federal's high-gain antenna, this maximum rating of 400kw can be achieved with the installation of only a 50kw transmitter!

WTCN is among the FM stations with permits for the most powerful ratings in the country. Others are KWK, St. Louis, with 369kw — and WTMJ, Milwaukee, with 349kw. These three stations have *all* selected *FM by Federal!* And Federal can equip your new FM station, too — from microphone to antenna. Write today for complete information. Dept. B320.



Station WTCN was officially opened by a gala inaugural program featuring the Minneapolis Symphony Orchestra, Dimitri Mitropoulos conducting. With FM by Federal, listeners at home were enabled to hear this famous orchestra with the same brilliance and tonal color as the studio audience. Insert shows Mr. Mitropoulos and Governor Luther W. Youngdahl of Minnesota, at opening of ceremonies.

"Wonderful! Magnificent! A terrific step of progress." This was the comment of the famed conductor, Dimitri Mitropoulos, when he heard his own orchestra over an FM receiver, during an on-the-air rehearsal.

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THIS Clinic sponsored by the Pioneer Manufacturer of FM Broadcast Equipment was dedicated to the advancement of FM Engineering and the improvement of Commercial Broadcasting.

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Bound volumes No. 11 and 12 of *FM* AND TELEVISION for January to June, 1946, and July to December 1946 are now being made up. Price, each, $5.50 plus 25¢ shipping charges.

Since 1940, this Magazine has been the broadcasters' chief source of information on FM activities and progress.

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FM AND TELEVISION *presents:*

April, May, June Issues

Practical Considerations Affecting FM Coverage

By PAUL A. deMARS and THOMAS A. WRIGHT

The highly controversial issues of propagation and coverage at FM frequencies have been resolved by Messrs. deMars and Wright into essential, workable factors that can be applied to the realistic determination of FM transmitter performance. Three articles will treat with these principal subjects:

APRIL: General Considerations of Propagation — Effect of Troposphere on Signal Intensities vs. Distance for Varying Antenna Heights.

MAY: Realistic Determination of Coverage — Effects of Terrain and Shadows.

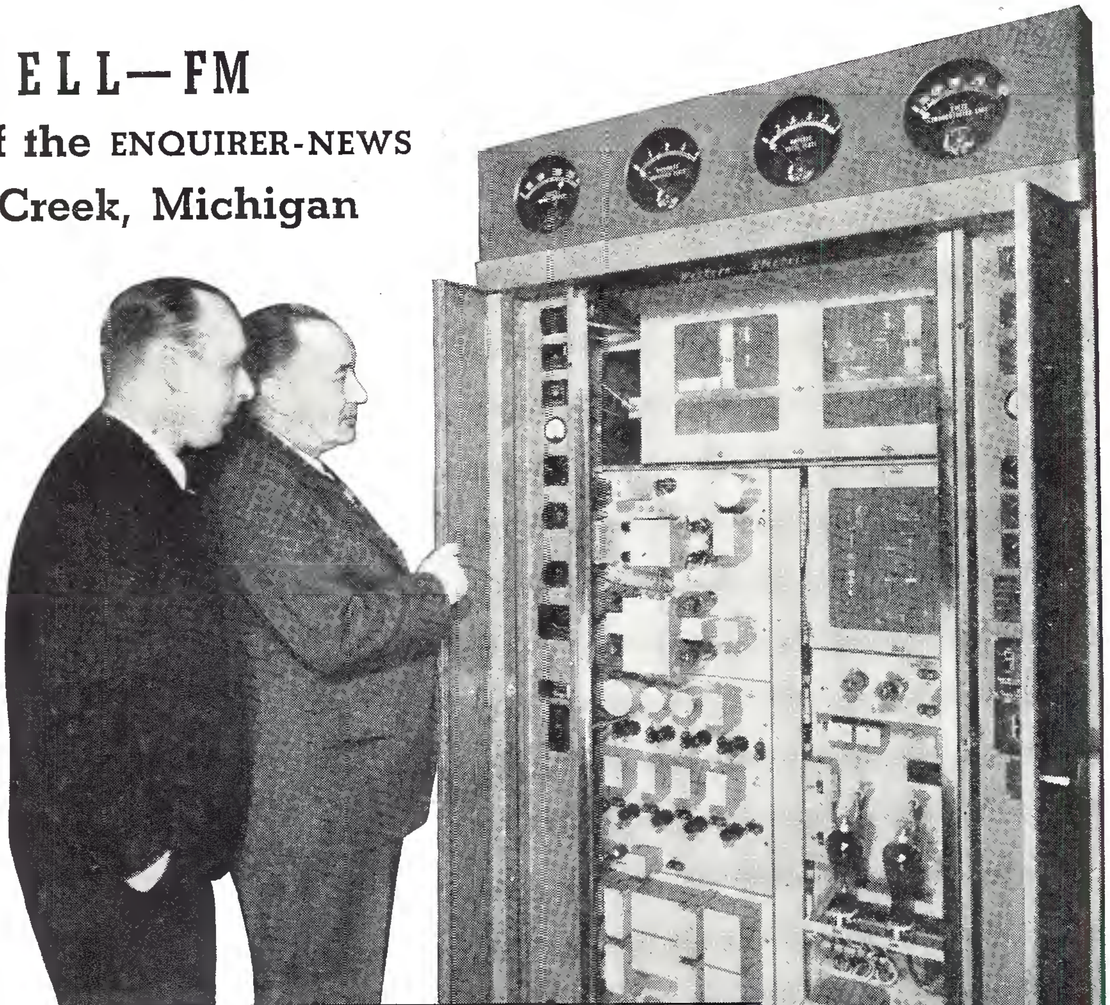
JUNE: Relation between FM Station Allocations and Actual Areas of Coverage.

for BROADCAST & COMMUNICATIONS ENGINEERS

First TRANSVIEW design FM Transmitter goes on the AIR

...at WELL—FM

Station of the ENQUIRER-NEWS
Battle Creek, Michigan



Chief Engineer Earl Stone (left) and Manager D. E. Jayne inspect their new Western Electric transmitter.

IN tune with the times. Station WELL-FM of Battle Creek, Michigan—operated by Federated Publications, Inc., publishers of the daily *Enquirer-News* and other Michigan papers—recently completed installation of the latest word in FM transmitting equipment . . . the Western Electric 503B-2 TRANSVIEW design 1 kw.

The glass door of this strikingly attractive FM transmitter provides a clear view of all tubes at all times. From the large, easy-to-read meters down to the smallest components, this new design means visibility *and* accessibility.

You'll find the same clear superiority in operation, too. For this new Western Electric transmitter holds intermodulation and harmonic distortion down to a new low . . . contains the efficient *Synchronizer* for accurate, automatic frequency control.

The complete line ranges from 250 watts to 50 kw of power. For full information, call your local Graybar Broadcast Representative or write Graybar Electric Co., 420 Lexington Ave., N. Y. 17, N. Y.

Distributed by GraybaR
OFFICES IN 95 PRINCIPAL CITIES

Western Electric — QUALITY COUNTS —

ROY HOFHEINZ SUPPLIED THE STEAM, WAS ELECTED PRESIDENT

MAJOR ARMSTRONG EXPLAINED THAT FM IS PAST DEAD-CENTER

ORGANIZERS OF FM ASSOCIATION MOVE FAST

Aims and Needs Outlined—Adequate Funds Assured—Bylaws Approved—Directors and Officers Elected

BY MILTON B. SLEEPER

NEVER has a radio group accomplished so much as quickly as did the manufacturers and broadcasters who met at Washington on January 10th to form the FM Association. — And this observation is made by one who has attended radio trade meetings of all kinds, for all purposes, during the past 30 years!

In a single day, following a discussion of the problems involved in the national expansion of FM, bylaws for FMA were read and accepted, a nominating committee was set up, directors were named and accepted, and officers were chosen. Meanwhile, the sum of $50,000 was pledged to carry out the work of the Association, and Bill Bailey resigned from *Broadcasting* in order to accept the post of FMA executive director and assistant secretary-treasurer.

Now, with new membership applications being added daily to the original total of 100, working committees are getting under way, and plans are being formulated for the first national conference, to be held within the next four months.

They Said It Couldn't Be Done ★ So much for those who withheld their support because, they said, the small stations supported the FMA plan in the hope of bringing in the big operators to do the work and pay the bills, or because they felt that no new association could be formed without them.

EVERETT L. DULLARD, VICE PRESIDENT, FURNISHED OFFICE SPACE & MAN POWER

If those who stayed away were surprised at the accomplishments of the organization meeting, so were those who attended! No one in the broadcasting or manufacturing business had had a previous opportunity to gauge the strength of the postwar FM leaders and their leadership.

But this meeting was only the start of the beginning. The FM Association will be formally launched at its first national conference, when it will have been brought up to full initial membership strength. Also, by that time, FM receiver production will have passed 125,000 a month, and will be climbing toward the 200,000 mark.

Looking Ahead ★ There are a number of reasons why 1947 will be FM's year. Major Armstrong summed up the situation in a sentence when he said that "FM is now off the dead-center position where it was stuck as a result of the change in frequencies."

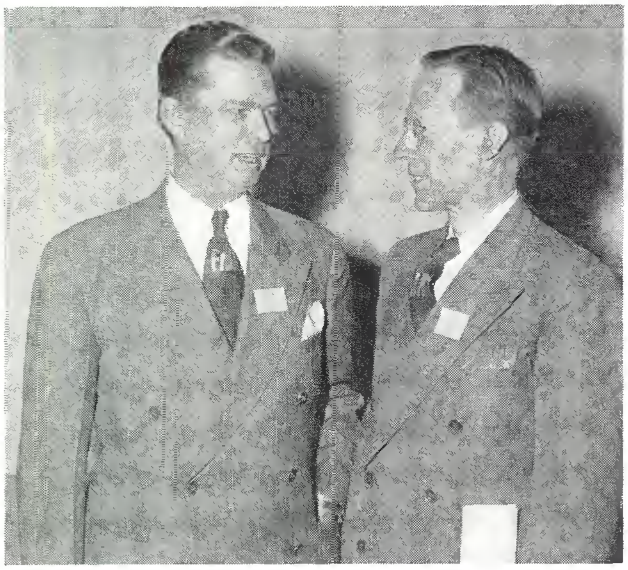
A more detailed account of the favorable factors is given in the talks by FCC Chairman Charles Denny, and by Hugh Lavery, an executive of McCann-Erickson, which appear on page 24 and 25. Summed up briefly, the principal factors are:

In manufacturing: 1) the lack of adequate profits in 1946 from a record number of cheap AM sets produced, 2) lack of demand for high-priced AM models, 3) the great and rapidly increasing demand for expensive FM-AM receivers and phonograph combinations, and 4) the success already achieved by those manufacturers who have made an aggressive bid for the FM market.

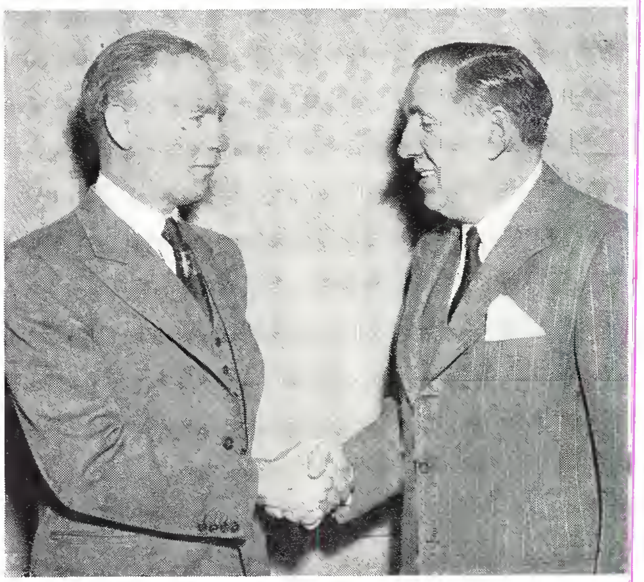
In broadcasting: 1) the opportunity afforded by FM to enter the broadcasting field, 2) the ability to offer favorable time spots on FM, 3) the need of AM broadcasters to protect themselves against competition from newcomers and other AM stations which are going into FM, 4) the fear that sponsors will investigate the progressive reduction in AM nighttime coverage due to added AM stations, and 5) the need of anticipating a growing interest on the part of sponsors in the superiority of FM broadcasting.

Frankly, the motives of both broadcasters and manufacturers are purely selfish. Fortuitously, however, this is a situation where the public will gain. Chairman Denny told the FMA members, "Your program will result in more radio and better radio for the American people. You have not combined to withhold but to give. This course of action to get the benefits of a great technological discovery to the largest number of consumers in the shortest possible time is in accord with the highest traditions of enlightened, free enterprise."

In this case, it is certain that the ends of public interest, convenience, and necessity will be served because it offers a profit motive to the industry.



ROY HOFHEINZ AND W. R. DAVID OF G.E., WHO WAS ELECTED A DIRECTOR ON FMA'S FIRST BOARD



GORDON GRAY, DIRECTOR AND MEMBER OF LIAISON COMMITTEE, WITH ARTHUR FREED, ELECTED TREASURER

Highlights of the Meeting ★ Roy Hofheinz, fast-talking ex-judge from Houston, not only provided the steam that kept up the pressure of events at the FMA organization meeting, he also furnished handpainted Hucksters, bearing the letters FMA, to the members of the steering committee.

Major Armstrong started the session with a brief discussion of FM receiver production progress, disclosing that sets manufactured in December had reached the rate of $100,000,000 per year. Thus, he explained, FM has been pushed over a dead-center position, assuring an adequate supply of sets to build audiences rapidly since, for obvious competitive reasons, manufacturers cannot afford to pass up their share of a sales volume that has attained such a level in the industry.

This situation he compared to a baggage car pulling out of a station, carrying a hundred million dollars on board and manned by the FM set manufacturers, with the standpat AM producers running after the rear train-lights. (This description inspired Walter Buehr's cartoon on page 31.)

CY BRAUM, HEAD OF FCC'S FM ENGINEERING, SMILING, HELPFUL, DIPLOMATIC

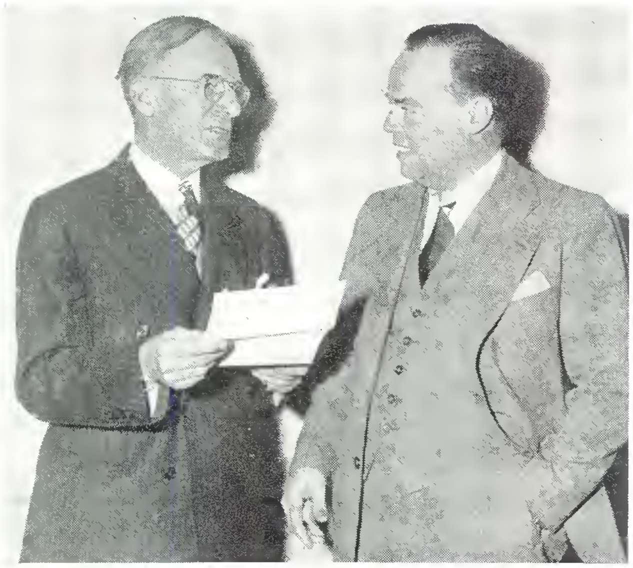
Other speakers discussed the steadily improving delivery schedules on FM transmitters of 10 to 50 kw., the new high record of FM set production achieved in December, and the RMA's plan to spend $50,000 on receiver sales promotion. Although this subject was discussed by Edward R. Taylor, a true FM enthusiast since he is director of advertising at Zenith, there was a definite feeling that this drive will be aimed chiefly at helping members dispose of the present surplus stocks of AM table models and, in many cases, excessive inventories of parts still to be assembled.

In addition, Hugh D. Lavery, an executive of the McCann-Erickson advertising agency, won the most enthusiastic applause in his discussion of FM broadcasting from the advertisers' viewpoint. Because of its great interest to advertisers, the full text is presented on page 25.

FCC Chairman Denny and the Commissioners, as well as Senator Edwin C. Johnson (D-Colo.) and Representative Clarence F. Lea (D-Calif.), joined the FMA at lunch. At this time, Mr. Denny reviewed the accelerating growth of FM broadcasting and the actions by which, under his administration, the FCC has implemented this expansion. He said, furthermore: "I promise you that the Commission will continue to take every other step which may be necessary from time to time to ease the growing pains of FM and assist it to mature in the shortest possible time."

At the suggestion of one of the FMA members, he promised to release a monthly report of FM stations on the air.

Asked if this is an appropriate time for an FMA committee to work with the FCC on a study of future needs for a wider FM band, with the idea of giving set manufacturers a 5-year warning before a change would be put into effect, Mr. Denny replied that this is an appropriate time for an FMA liaison committee to discuss overall industry problems with the FCC,



DR. RAY H. MANSON, FMA DIRECTOR, AND EDWARD R. TAYLOR OF ZENITH, WHO EXPLAINED RMA PROMOTION

but not the matter of changing the FM band. The feeling of uncertainty concerning FM frequencies, he explained, held up postwar production of sets and, since the band of 88 to 108 mc. has been definitely allocated to FM, it would be unwise to give any consideration now to its expansion, even at some time perhaps 5 years hence.

Other points covered by Mr. Denny are of such interest to the radio industry that the full text of his talk is given on page 24.

When the bylaws were presented in the afternoon, they were read and voted upon section by section, with practically no discussion, and without a single dissenting vote. This was a real tribute to the work of Leonard Marks, attorney for FMA, and the members of the steering committee.

The bylaws provide only one class of membership, to which both companies and individuals are eligible, provided convincing evidence of a desire to further the interests of FM broadcating is presented to the membership committee.

The following directors were proposed by the nominating committee, and were elected by a unanimous vote:

Three years —
- C. M. Jansky, Jr. — Jansky & Bailey
- W. R. David — General Electric Company
- Roy Hofheinz — KTHT — KOPY Houston
- Everett L. Dillard — KOZY Kansas City, WASH Washington.

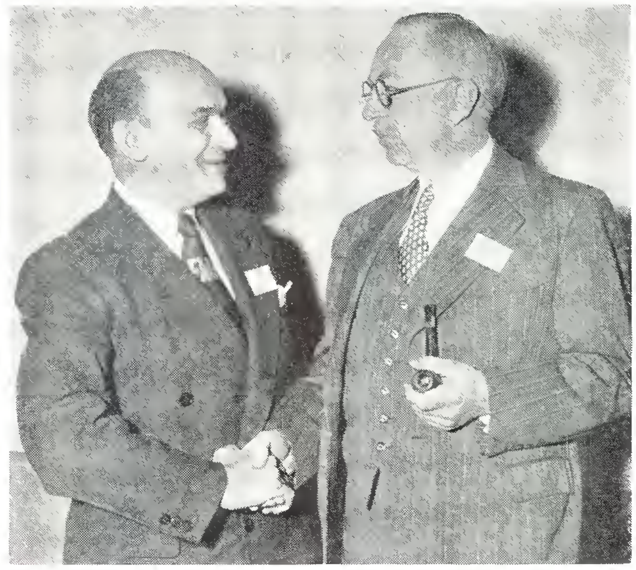
Two years —
- Stanley Ray — WRCM New Orleans
- Leonard Asch — WBCA Schenectady
- R. F. Kohn — WFMZ Allentown
- Frank Gunther — Radio Engineering Labs.

One year —
- Gordon Gray — WMIT — WSJS Winston-Salem
- Ira Hirschman — WABF New York
- Wayne Coy — WINX — FM — WINX Washington
- E. J. Hodel — WCFC Beckley

The appointment of Bill Bailey, associate editor of *Broadcasting*, as the paid manager was confirmed, effective February 1st. Then the meeting was adjourned.

That evening, the board of directors announced the names of the officers. They are:

- Roy Hofheinz, president — KTHT — KOPY Houston
- Everett L. Dillard, vice president — KOZY Kansas City & WASH Washington.
- Frank Gunther, secretary — Radio Engineering Laboratories, Inc.
- Arthur Freed, treasurer — Freed Radio Corp.



TWO FM PIONEERS: BATTLING LEONARD ASCH, ANOTHER FMA DIRECTOR, WITH FACSIMILEMAN JOHN V. L. HOGAN

FRANK A. GUNTHER WORKED HARD, HAD FUN, AND WAS ELECTED SECRETARY

Subsequently, offices for FMA were set up at 1010 Vermont Avenue, Washington, D. C., where Bill Bailey will make his headquarters. The telephone number is National 1612.

With all these details of organization settled, the first meeting to formulate a course of action was set for February 10th.

National Conference ★ High on the FMA agenda is the planning of a National FMA Conference. It is expected that this conference will emphasize the business end of Frequency Modulation, rather than engineering. Thus, the program will probably include features of particular interest to national advertisers and advertising agencies. This indicates comparative demonstrations of FM and AM broadcast reception, to bring out the effectiveness of FM programs, and special FM studio techniques.

This will be an appropriate time to consider the problems of high-fidelity networks, and to ask for statements of policy from both the present nets and the Bell Telephone System.

While the American Federation of Musicians has caused considerable discussion in broadcast circles by their demands for double pay when live-talent music is transmitted on both FM and AM, the feeling is that even if this situation is not corrected by new labor legislation, it will be straightened out before long by pressure from program sponsors.

(CONCLUDED ON PAGE 60)

FCC CHAIRMAN DENNY, SPEAKING AT THE FMA LUNCHEON, JANUARY 10TH

HOW THE FCC VIEWS FM

"The Best There Is in Aural Radio Is FM"—136 Stations Now on the Air—FCC Expects 736 in 1947

BY CHARLES R. DENNY, JR.*

THE nation-wide system of static-free, high-fidelity FM broadcasting which you gentlemen have been planning for so long is now taking shape.

Today, there are 136 FM stations on the air. One hundred American cities in 33 states and the District of Columbia have FM broadcasting.

By the end of 1947, I expect that there will be more than 700 FM stations on the air.

I base this prediction on these figures: You have 136 stations on the air now. The Commission has granted permits for the construction of 400 additional stations. They are required under our rules to get on the air within the year. That will make 536. In addition we have 199 conditional grants which soon will be converted into construction permits. Also we have 118 applications in hearing and decisions on many of these can be expected in the near future. Finally, 174 applications are pending and these are being processed at the rate of 50 a month. That's a backlog of 491 applications in various stages of processing. I estimate that at least 200 of those can be given final grants in time to go on the air in the next 12 months. That would make 736 FM stations by next Christmas.

If the FCC, the broadcasters, and manufacturers can put that many additional FM stations on the air in 1947, 1947 will be a banner year in American broadcasting.

We owe it to the American people to aim for that kind of a quota.

I am confident that if we achieve this goal, the American people will respond by purchasing FM receivers as fast as they come off the production lines, and by tuning in and supporting these new stations.

Let's see what has been done up to now: Only 48 FM stations were on the air when war came. All honor to them. They gave Americans their first taste of just how good radio can be when it comes through the ether with all the glory of unlimited tonal range, unmarred by atmospheric and man-made static. These pioneer stations were the proving ground for FM, and I trust that their names will always be given their due prominence in FM's hall of fame.

The war, of course, halted FM construction. Promptly after the war ended, we were ready with new and improved technical standards and with a nation-wide plan for allocating the channels to the various communities.

Since then, we at the Commission have adopted every procedure that we could think of to speed up our processing of FM applications. One of our first steps was to issue conditional permits.

Another step was to allow interim operation on a less than the maximum authorized power. On the whole this interim operation plan is working out satisfactorily, but I do want to add a word of warning: Interim operation should be adequate to provide a satisfactory FM service in the city and adjacent areas proposed to be served. I want to emphasize that the Commission expects full construction of FM stations to go forward as rapidly as equipment can be obtained so that the full benefits of FM will be available as soon as possible.

I want to emphasize, too, that FM permittees on interim operation have a responsibility to make it perfectly clear to their listeners that they are not putting out their maximum signal. Otherwise listeners in the fringe areas may mistake the midget interim signal for full-grown FM, and be disappointed.

Another step which the Commission is announcing today is a procedure which will enable prospective FM applicants for cities or areas to which no FM channels are allocated, or in which all channels allocated under the tentative plan of December 19, 1945 have been exhausted, to file applications specifying a particular channel and, if necessary, request a re-arrangement of the tentative allocation plan.

A question which has been bothering a number of FM applicants and prospective applicants is whether it will be possible for one individual or concern to have two FM stations so located that their service areas overlap. If so, how much overlap will be tolerated. Up to now we have made a number of grants which involved some overlap of the 50 μv/m contours. Now, we are being asked in several pending cases to make grants which would result in an overlap of a small percent of the 1,000 μv/m contours which, of course, means a very substantial overlap of the 50 μv/m contours. We don't know whether it would be wise to permit such an overlap. Maybe there are some cases where, on the facts, it should be allowed, and maybe there are other cases where it should not be authorized. We desire to fashion an intelligent and consistent policy. Therefore, we are today requesting oral argument in some nine groups of cases which involve overlaps which are troubling us. By getting the story on all of these situations in one series of arguments, we hope to be able to formulate a clear and satisfactory policy.

I promise you that the Commission will continue to take every other step which may be necessary from time to time to

(CONCLUDED ON PAGE 54)

* Chairman, Federal Communications Commission, Washington, D. C. An address given before the FM Association at Washington, D. C., on January 10, 1947.

HOW THE TIME-BUYERS VIEW FM

What's Lacking in the Present Picture — FM's Advantages — How to Capitalize on Them

BY HUGH D. LAVERY*

MOST of you are undoubtedly familiar with the operation of advertising agencies. In fact, there have been even more books written about our business in the past year than there have about yours. For those of you who haven't been able to keep up with best sellers of recent months, it might be best to open this discussion with a brief outline of the function of an advertising agency as it relates to the commercial aspects of FM broadcasting. An advertising agency, with the approval of its clients, plans complete national advertising campaigns, selects the media used, makes the contracts, prepares the advertising, pays for the space or time, and bills the client, absorbing, in the process, a commission of 15% of the gross billing. We are alternately aided and handicapped in the process of planning and buying space and time by a host of salesmen and sales organizations, each out to get for its particular medium the largest possible share of the advertiser's dollar.

When we handle printed advertising, we are usually responsible only for the creation and production of the advertising message. We have staffs of copy-writers, art directors, production people, and auditors.

In radio, however, we are responsible not only for the commercial message but for the editorial content of the media as well. We have, therefore, in our radio departments, producers, directors, casters, musical directors, program pre-testers, and a great many other people whose work is closely allied to the show business side of radio.

In radio, too, we are likewise aided and handicapped in planning for clients by a similar horde of salesmen and sales organizations, time salesmen for stations and networks, as well as salespeople for package show producers, artists' agents, jingle writers and what-not. Also, we have a rating service that has become the end-all of radio. From the weekly Hooper, the whole advertising world considers itself in a position to judge which stations are stronger than others, and which agencies are doing good jobs for their clients.

The advertising agency is, in fact, becoming more and more a nest of researchers. Consumer polls are used to determine the best selling appeals for advertising. Then, after the advertising begins, Starch reports and Hooper Ratings are made to tell whether or not anyone saw or heard it. In fact, it is almost considered bad form nowadays in the advertising business to make a public appearance without making a survey first.

So before coming here today, I, too, made a survey. I wanted to be able to lay before you as accurate and as impartial a picture as I could obtain of the existing agency-attitude toward FM. To make these remarks constructive as well, I secured some concrete suggestions of things you can do to make FM a great deal more interesting to the agency field.

My survey involved conversations with agency time buyers, advertising managers, account executives, and others responsible for the selection of radio time and radio programs. All in all, I covered half a dozen of the largest agencies in radio billing, as well as three or four of the largest radio advertisers. I would like to give you now a composite picture of how these large agencies and advertisers look at FM.

First — on the positive side: Individually, almost everyone talked to knew what FM is. Almost everyone felt, in a vague way, that eventually FM will replace most AM stations.

Individually, many of the people I talked to are avid FM listeners. They appreciate what FM does for them in their own free time.

But — on the negative side: They are just not conscious of FM as a commercial medium.

With few exceptions, they do not realize that commercial time is already being offered by many FM stations, with listening audiences already large enough to merit serious consideration. They do not realize that choice time spots, now available on FM, in many cases represent better advertising investments for many products than marginal time spots on weak AM stations.

Another point in FM's favor that has not been driven home to radio time buyers is the high degree of saturation provided by an FM station throughout its service area, in contrast to the recognized peculiarities of AM signal coverage.

Another point: paradoxically, the well-known high-fidelity of FM has become something of a liability commercially. This is because FM has become associated in the minds of many time buyers with long-haired music. And long-haired music gets low Hoopers. In the future, let's associate Benny Goodman and Elliot Lawrence with FM, along with Koussevitsky and Stokowsky. Let's have some FM jump music, with jive for the bobby sox brigade, so they'll be growing up with FM.

If this picture of the agency attitude toward FM is indicative of the future, and if FM is left to drift in the radio advertising world, it could be years before FM becomes commercially profitable.

Now, let us look for a minute at a different scene, at another method of electronic communication — television.

No agency has yet made a nickel on television broadcasting. Yet every big

(CONTINUED ON PAGE 54)

*McCann-Erikson, Inc., 50 Rockefeller Plaza, New York City. An address given before the FM Association, Washington, D. C., on Jan. 10, 1947.

DUAL-DIVERSITY TRANSMISSION ON 75 MC.

N. H. State Police Extends Its Radio Coverage with a New Station on Mt. Washington

BY LIEUT. BASIL CUTTING*

FIG. 1. THE 75-MC. RELAY ANTENNA IS INSIDE THE YANKEE NETWORK BUILDING

WITH the New Hampshire State Police radio system now handling an average of 450 messages a day, and peak loads up to 675 messages in 24 hours, it is easy to understand why we have had to expand our facilities far beyond what we were using two years ago.[1] And, considering that our radio system saves the State upwards of $50,000 in telephone charges alone, it is clear that the improvement in our service to the public is accomplished at a great saving to the taxpayers.

First Results on 75 Mc. ★ The first change was made last Spring when, in line with the FCC's reallocation of frequencies, we shifted our repeater on Mt. Kearsarge from 118.55 mc. to 75.98 mc. This unattended station, set up in a fire tower at an altitude of 3,000 ft., picks up our FM car transmitters on 37.38 mc. and beams their signals to our Headquarters at Concord, the State capitol. This path of 28 miles is not line-of-sight because high ground intervenes. But, as we expected, the shift to 75 mc. gave us an improvement of about 25% in the signal at Headquarters, due partly to better coverage on the lower frequency, and also to improved receiver sensitivity.

At the transmitter, we simply changed the crystal and coils, and retuned the circuits. The old 3,704.875-kc. crystal was replaced by another ground for 2,374.375 kc. The original Motorola receiver was replaced with a new one.

The success of this circuit for picking up our cars in southern New Hampshire on 37.38 mc. and relaying their signals to Concord headquarters led the author to the eventual fulfillment of a long-standing ambition. This was to erect a relay station on Mt. Washington, 85 miles north of our Concord barracks. This, as the accompanying relief map shows, Fig. 3, would give us direct 2-way communications with our cars throughout the northern and central parts of the State. Also, it would cover the spots within the normal area of Mt. Kearsarge where shadows were cutting off signals from the cars.

Mt. Washington Repeater ★ Finally, by arrangement with the Yankee Network, through their chief engineer Irving Robinson, plans were worked out to install a repeater in the building occupied by FM station WMTW. This gave us an altitude for our relay transmitter of 6,288 ft. above sea level, the highest point on the north Atlantic seaboard.

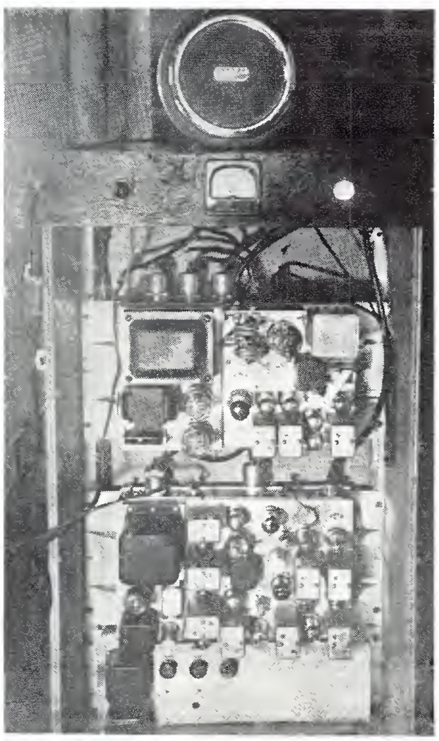


FIG. 2. MOTOROLA 37-MC. RECEIVER AND 75-MC. RELAY TRANSMITTER

It was not until June 30th that the road up the mountain was open. Early that day, the author and Ralph Anderson, Motorola's representative, drove to the summit in a car loaded with radio gear.

The Yankee Network's building, as you can see from Fig. 1, looked rather forbidding on that summer day. Nevertheless, by 2:00 p.m. that afternoon we had installed the transmitter and receiver, Fig. 2, on the top floor, together with an inside receiving antenna and an antenna and reflector, directed toward Concord, for the transmitter. The 85-mile distance to Concord is not line-of-sight, so we crossed our fingers when we put in the first call. However, our Headquarters station WRPT snapped right back with an acknowledgment and a report of very good reception. Fig. 4 shows the simple 75.98 mc. antenna rig we had put up on the State House annex, adjacent to the Concord station.

Dual-Diversity Transmission ★ Engineering-wise, the most interesting and significant feature of this installation is what we call dual-diversity transmission. That is, we employ one receiver at Concord to pick up the relays, transmitting simultaneously much of the time and at the same frequency, on Mt. Kearsarge and Mt. Washington. That is, depending upon the direction of travel of any one car, we may pick up signals from that car over either or both relays.

In one instance, the author observed that, in the case of pursuing a stolen car, one of our cruisers left the Mt. Kearsarge area, drove into the Mt. Washington area, and then, rounding a curve, was back in the Mt. Kearsarge area again.

The normal signal from Kearsarge over a distance of 28 miles, is about 4 times stronger than that from Mt. Wash-

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*Chief Radio Engineer, Department of State Police, Concord, N. H.

[1] See "New Hampshire State Police Radio System" by Lieut. Basil Cutting, *FM* AND TELEVISION, Jan. 1945.

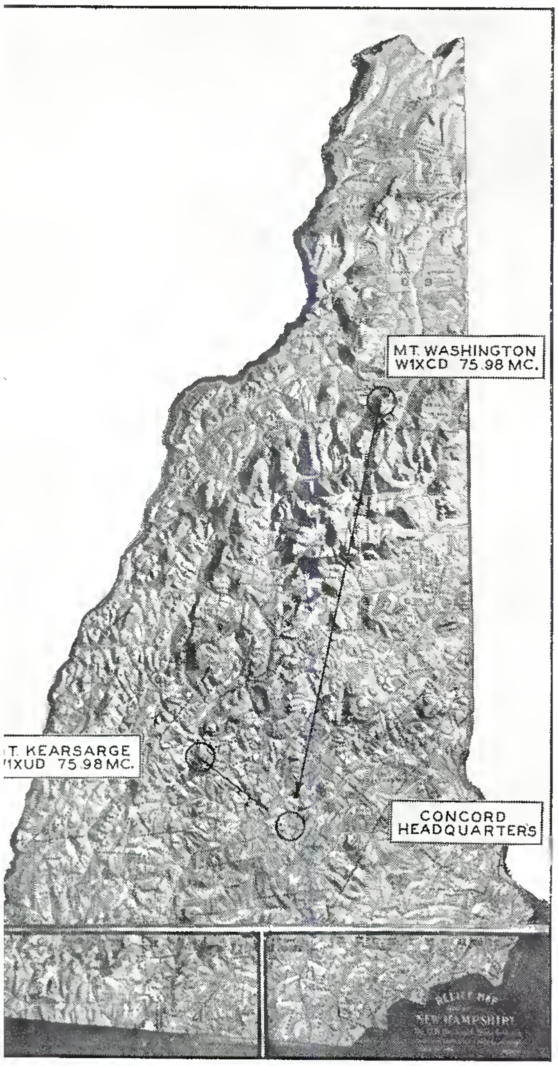

FIG. 3. THIS RELIEF MAP INDICATES THE TERRAIN PROBLEMS IN N.H.

ington. However, the Headquarters operator is not conscious of any change in signal level, whether a car comes in on one or both of the relays. Such a system, using one receiver, would be impossible on AM, because the heterodyne squeals would drive the operator mad.

If we had accepted some of the engineering opinions we have read, we wouldn't have attempted this dual-diversity FM transmission system. We have been told that, theoretically, objectionable effects would be caused by reflections, bringing in signals out of phase over paths of different lengths. In our system, we were setting up conditions which, in theory, should have given us serious trouble, since one transmitter is 28 miles from the receiver, and the other is 85 miles away. The secret of our success probably lies in the use of a receiver with an adequate limited.

It should be pointed out that this is not due to any accident of good fortune. Neither transmitter uses a temperature-controlled crystal. Since Mt. Washington has weather conditions all its own, with temperatures varying from +85° in July to −35° reported on this particular day of writing in January, the temperature drift of the crystal there has no relation to that at Mt. Kearsarge, where the weather is much less extreme.

Without going into technical details, it is possible to report from over 6 months of practical experience that there are no adverse results, and some definite advantages from using one receiver to pick up signals from relay transmitters at widely different distances.

Incidentally, our checks on the Mt. Washington transmitter show a frequency drift from 75,980 kc. to 75,977 kc. over a temperature range of 120°. This is less than .004%.

Coverage ★ Our experience with the relative performance of the Mt. Kearsarge and Mt. Washington relays seems to confirm recent theoretical and practical observations in other locations. While the repeater at Mt. Washington is at an altitude of 6,280 ft., the coverage area is not much greater than from Mt. Kearsarge, at 3,000 ft. The former, as Fig. 3 shows, is only 1,000 to 1,500 ft. above the surrounding mountains, while the latter is an isolated elevation, with a drop-off of 2,500 ft. around it.

Reception from the ears is more consistent at Mt. Kearsarge, since we get some exceptionally long-haul signals, far beyond line of sight, on 37.38 mc. at Mt. Washington. At 75.98 mc., performance has been very uniform and dependable. There has not been any noticeable sky-wave or skip on this frequency, and no temperature-conversion short-haul skip. This makes for reliability. That's what we want in police work, for a circuit that works well one day and falls down the next is an invitation to use the old alibi about weather conditions.

Another fact which has come to light concerns snow static. On Mt. Kearsarge, where the antenna is in the open, and is exposed to the weather, we have observed snow static. The antenna on Mt. Washington located inside the building, has shown no evidence of such interference. This is particularly interesting in view of the fact that Mt. Washington, famed for having the worst weather in the world, provides every variety of snow, sleet, and freezing mist that any researcher could ask for, and in almost daily doses.

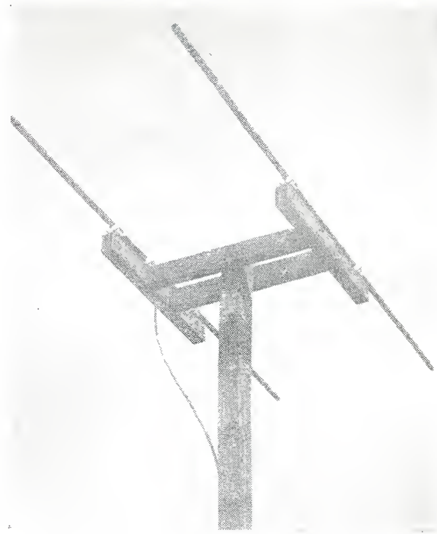

FIG. 4. SIMPLE ANTENNA RIG USED AT CONCORD TO PICK UP MT. WASHINGTON

Checking the Circuit ★ We use a very simple method of checking the condition and performance of the repeater on Mt. Washington. The 75-mc. transmitter is equipped with a microphone circuit and switch to allow one of the Yankee Network operators to call us at the Concord headquarters. Thus, once a week, we get a report directly from the transmitter. This gives us a check on the transmitter itself, without introducing any variations in car-to-repeater operation.

Our observations over a period of 6 months have shown the 75-mc. repeater circuit uniformly satisfactory.

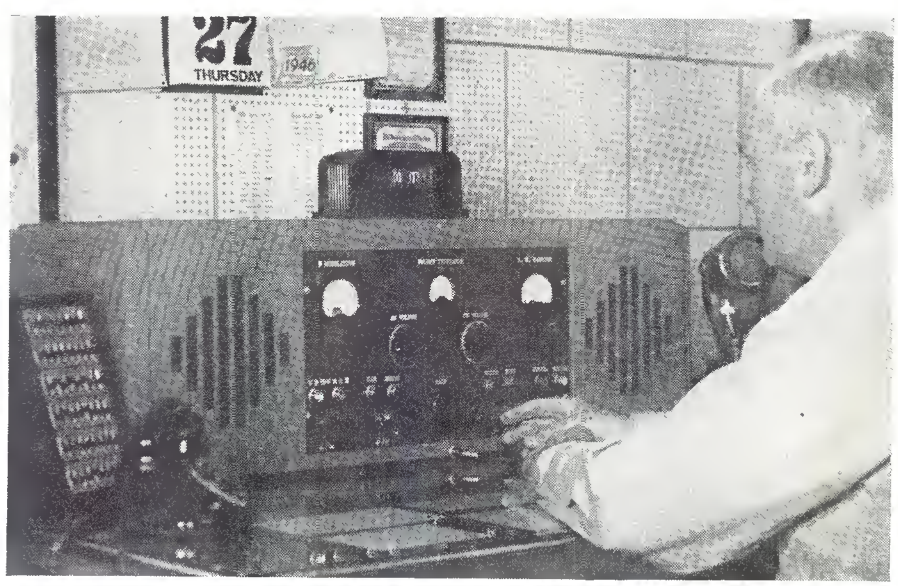

FIG. 5. A NEW CONTROL CONSOLE AT CONCORD WAS BUILT INTO A MOTOROLA CABINET

OPPORTUNITY FOR A "FREE RADIO" THROUGH FM

What a "Free Radio" Means — How FM Makes It Possible — Why It Is Necessary

BY C. M. JANSKY, JR.*

THE consulting radio engineering firm of which the writer is a partner recently carried in the major broadcast trade magazines full page advertisements which read as follows:

The future of American Broadcasting depends upon the untrammeled development of FM.

Properly allocated with adequate spectrum space, and free of unnecessary restrictions, FM possesses the following remarkable advantages over AM:

1. FM can deliver larger coverage areas from single transmitters than can be obtained from any of the existing AM stations, except a small percentage fortunate enough to enjoy unusually favorable assignments.
2. FM offers the opportunity to cover areas of any size on an economical basis by the use of automatic interconnection.
3. FM stations enjoy the same coverage areas at night as in daytime.
4. FM provides high-grade reception free of noise and interference throughout the areas served thereby, for the first time offering the opportunity for truly high-fidelity reception to large numbers of listeners.
5. FM can provide a truly American system of broadcasting in which competition will be between programs for listeners, and not between broadcasters for facilities.

An understanding of the truth of the above statements requires some consideration of the simple technical characteristics of FM and AM broadcast systems. In the reception of programs from a desired broadcast station, it is necessary that the strength of the radio signal received from that station at the listener's radio set be sufficient to over-ride the intensity of static, electrical noise, and the interfering effects of signals from unwanted stations. The great inherent limitation of AM is the tremendous preponderance of intensity which the desired signal must have if it is to over-ride these interfering disturbances.

Expressed in quantitative terms, the ratio of desired signal to disturbance must be at least 100 to 1 if AM reception is to be clear and satisfactory. This severe requirement, while it imposes drastic allocation limitations in the daytime, is of even greater importance at night. This is because, at night, in the band assigned to AM, the peculiarities of radio propagation cause signals to travel great distances. Therefore, at night it is common practice to find AM broadcast stations on the same channel, separated by 500 or 1,000 miles or even more, severely restricting the coverage areas of each other by their mutual interference.

The present AM allocation structure now consists of 106 channels occupying the spectrum space between 545 and 1,605 kilocycles. To secure the widest possible coverage without interference, some of these channels have been designated as clear channels and at night are occupied by only one station each. The others are designated as shared channels, used by a number of stations and, therefore, capable of delivering only limited coverage.

Broadcasting has become an highly profitable business and an extremely popular activity. It has in the past and still does render great public service. Therefore, the Federal Communications Commission is under constant pressure to grant more and more licenses to new stations, as well as to grant existing stations more favorable assignments which will give them greater coverage per station.

With regulation of broadcasting in the hands of a government responsive to the pressure of public opinion, as is the case in this country, it is natural that the trend should be towards more and more stations with less and less coverage per station. Therefore, what is taking place today, as a result of yielding to the demand for more facilities, is a constant deterioration of the size of the coverage areas of existing stations to the point where coverage obtained by each is gradually growing less and less.

Since the demand for new AM facilities exceeds by far any reasonable supply, it is obvious that if the Commission grants to one applicant the right to establish a station, of necessity it is denying that right to others. As a result, there has grown up in this country a philosophy of regulation based upon the principle that it is not only the right but the duty of the Federal Government to see to it that existing stations operate in what the radio law defines as the "public interest, convenience and necessity." Regulation of broadcasting in the "public interest, convenience and necessity" is today interpreted to mean at least some review of the program record of a station preliminary to deciding whether or not its license should be renewed. Presumably, someday it might well mean the establishment and maintenance by Government of standards prescribing the kinds of programs to be broadcast. Under this philosophy can there exist in this Country such a thing as a "free radio" in the truest sense of the words, particularly if the term "free radio" is interpreted as meaning a broadcasting system entirely free of control or influence by Government with respect to program content?

Freedom of Speech guarantees to anyone the right to hire a hall, collect an audience and, within the bounds of decency and respect for law, say anything he chooses. Freedom of Press permits anyone, without governmental restraint, to start a newspaper or magazine and, subject to the same limitations, to publish in it anything he wishes. It is obvious that, with the number of broadcast outlets limited to those which can be accommodated within the confines of the AM band, broadcasting could never be free in the way that we have freedom of speech and freedom of the press. Some authority must determine who gets radio station licenses and who does not. That authority is and will continue to be Government.

Unless the granting and denial of licenses is to be entirely arbitrary, there must be some yardstick for discriminatory action by government. What other yardstick can the Federal Communications Commission defend except one which is, or at least purports to be, based upon an evaluation of the applicant's ability to deliver programs in the public interest? The application of such a yardstick is and can be nothing else but program censorship, the ultimate endpoint of which might well be the complete control of program content by Government. Those who object most strenuously to Government regulation of programs do not realize or perhaps prefer to ignore that the only alternative is control and censorship by the limited few fortunate enough to hold broadcast licenses. With limited facilities the question is not "Shall there *be* control and censorship?" but "*Who* shall control and censor?"

The establishment of a truly free American system of broadcasting in this country requires the creation of an allocation structure sufficiently extensive to be capable of providing enough stations with adequate coverage to permit the issuance of broadcast station licenses to all who, within reason, desire to operate them. Only the creation of such an allocation structure can provide for a "free radio" in the fullest sense of the words. Only the creation of such an allocation structure and its adequate protection by law can provide a medium in which the character of broadcast programs is free of Govern-

* Jansky & Bailey, National Press Building, Washington, D. C.

ment restraint and control. In short, the future of American broadcasting as a public service is inevitably dependent upon the technical potentialities of the art.

The overwhelming preponderance of radio signal strength over noise and interference necessary at the receiving set, if satisfactory AM reception is to exist, has been pointed out. With FM this preponderance of signal over interference is not necessary. With FM, if the ratio of signal strength from a desired station to that of noise and interference is only 2 to 1 or better, reception will be as satisfactory or more satisfactory than with AM where the ratio is 100 to 1. This, then, is the fundamental difference between FM and AM: namely, the difference between 2 to 1 and 100 to 1 in the required ratio of signal to disturbance for good reception.

There is a second advantage which FM holds which contributes to its superiority. This is the fact that on the frequencies assigned to FM the long range sky wave effects so troublesome in AM are almost entirely absent. This makes possible practically an almost unlimited duplication of assignments upon a single channel. There are other contributing advantages which I shall not enlarge upon here. For instance, in a single area of AM broadcasting, only one in every four available channels can be used, regardless of freedom from co-channel problems involving other parts of the country. In FM broadcasting, under the same conditions, every other channel can be used in the same locality.

Bearing in mind that the principal basic difference between FM and AM is the difference between a required ratio of signal to disturbance for satisfactory reception of only 2 to 1 for FM, as contrasted with a required ratio of 100 to 1 for AM, refer back to the five outstanding advantages FM possesses over the present AM system.

1. FM can deliver larger coverage areas from single transmitters than can be obtained from any of the existing AM stations except a small percentage fortunate enough to enjoy unusually favorable assignments.

A 20,000-watt FM station with an antenna 500 ft. above surrounding terrain, in the absence of interference, will deliver adequate rural service over an area having a radius of approximately 60 miles. Even a 250-watt station with an antenna 250 ft. above surrounding terrain can give high-grade rural service area with a radius of approximately 30 miles.

2. FM offers the opportunity to cover areas of any size on an economical basis by the use of automatic interconnection.

Technically, it is possible to go to the outskirts of the coverage area of an FM station and, by the use of a special but a comparatively simple installation, receive that station with sufficient clarity to rebroadcast its programs on another channel. This process can be repeated at the outskirts of the coverage area of the second station, and so on. This type of operation has already been demonstrated. However, today it is not possible with stations under common ownership, because of regulations which prevent it.

3. FM stations enjoy the same coverage areas at night as in the daytime.

The advantages of such a system need no further comment.

4. FM provides high-grade reception free of noise and interference throughout the areas served, thereby for the first time offering the opportunity for truly high-fidelity reception to large numbers of listeners.

The reaction of the broadcast listener to noise and interference in AM reception causes him to adjust the tone control of his receiver to eliminate the higher audio frequencies. While this tends to minimize the effect of disturbances, at the same time it destroys the possibility of true fidelity. The noise reducing property of FM makes this adjustment of the tone control unnecessary, thereby permitting truly high-fidelity reception to a sufficiently large number of listeners to justify the broadcaster in producing and transmitting high-fidelity programs.

5. FM can provide a truly American system of broadcasting in which competition will be between programs for listeners and not between broadcasters for facilities.

The importance of this potentiality transcends all others. What are the allocation requirements for a "free radio"? They are not difficult to state. However, if these requirements are to be met, it is necessary that they be set forth clearly, and that the issues they raise be understood.

(a) The width assigned to an FM broadcast channel must be sufficient to permit taking the fullest possible advantage of the great interference-reducing properties of the FM system.

This requirement has already been met by providing a channel width of 200 kilocycles.

(b) There must be allocated to FM broadcasting enough channels so that, within reason, all who desire to establish stations may do so, without reducing the coverage areas of other stations already operating.

This is a basic requirement. Already the demand for FM facilities exceeds the presently-allocated supply. Already it has been found necessary to hold hearings to choose between applicants for FM stations in a fairly large number of cities. What will be the situation when more FM receiving sets are in the hands of listeners, and the public becomes fully awake to the future value of this new service? Obviously the shortage of channels will become much more acute.

Prior to the highly controversial action of the Federal Communications Commission in moving FM broadcasting to a band in the vicinity of 100 mc., FM was assigned the band extending from 42 to 50 mc. Now, FM has been assigned the band between 88 and 108 mc. However, if FM is assigned an adequate number of channels, the issue regarding the relative merits of the lower band and the upper band, while still important, will cease to have a bearing upon the allocations. This is because, to be sure that for all time to come broadcasting will have enough channels, it may be necessary to add to the present 88- to 108-mc. FM band a large percentage of the space between 44 and 88 mc.

Since 80% of this space is now assigned to six television channels, it is obvious that any appreciable expansion of the FM band must come by taking frequencies now assigned to television. If, as a practical matter, FM is to have more space, the conflict between television and FM is inescapable. Ultimately, the American people must decide which they prefer: 1) The limited television service possible below 100 mc., or 2) a practical FM allocation structure capable of providing "free radio."

(c) FM broadcasting must be freed of rules, regulations and engineering restrictions not necessary after this service has been assigned adequate spectrum space.

A review of the history of broadcasting regulation since the passage of the Radio Act of 1927 will show the extent to which the whole philosophy of regulation is based upon the principle of scarcity of facilities. To illustrate: AM licensees are required to utilize practically all of the time assigned them; stations are divided into classes and must be so located that their coverage areas coincide as nearly as possible within areas prescribed; stations under common ownership must not be so located that there is an overlapping of their coverage areas, etc. In the AM band congestion has reached such proportions that stations are protected against interference within areas which are only a small percentage of what they would serve in the absence of interference. In addition, to accommodate more stations, elaborate steps are taken through the use of directional antennas to reduce the effects of mutual interference, frequently at the expense of coverage which would otherwise be delivered in areas badly needing service.

The existence of more applications for new FM stations than can be accommodated in the 88- to 108-mc. band has resulted in carrying over into FM the same philosophy of scarcity and the restrictive regulations growing out of scarcity now found in the AM band. FM stations are also divided into classes with varying degrees of protection against interference. In certain parts of the country, FM stations of one class are protected against interference out to only the 1000-microvolt signal strength contour, whereas in rural areas, without interference, such stations could deliver service to the 50-microvolt contour. A station capable of serving out to 60 miles may find that, because of congestion and the necessity for providing for stations in other areas, it

(CONCLUDED ON PAGE 62)

SPOT NEWS NOTES

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

Directory of Emergency Stations: The Directory scheduled for our January issue was omitted at the recommendation of the FCC. We were advised that, without an increase of manpower to process the great number of applications being filed, records now available would not enable us to bring the July, 1946 Directory up to date. However, we are assured that a plan will be worked out in time to publish an up-to-date listing in our July issue.

Transmitter & Tube Sales: In the third quarter of 1946, broadcast transmitter sales totalled: AM $1,159,433; FM $233,600; Television $269,900; antennas and miscellaneous items $88,415. Export sales were $624,512. Communications equipment amounted to $655,392, plus $1,224,997 for commercial aircraft equipment, plus $21,949 for ground stations. Government sales were $33,645,531. Transmitter tubes amounted to $2,689,533; cathode ray tubes $700,554; and quartz crystals $247,728. These are RMA figures.

New England IRE Meeting: First annual New England IRE meeting and exhibit will be held on May 3rd at Hotel Continental, Cambridge, Mass.

San Bruno FM: Eitel-McCullough have received authorization for a 50-kw. FM station to be erected at their San Bruno plant. Equipment has been designed already by Eimac engineers. Modulator will be a dual-channel type, from REL. Later, the transmitter will be moved to 3,848 ft. Mt. Diablo, 30 miles from San Francisco.

Communications Equipment: New Kaar FM mobile units for the 152- to 162-mc. band feature the use of instant-heating tubes. Since standby battery drain is zero, it is estimated that storage battery drain is reduced 96% over conventional units. Thus the need for special generators and heavy-duty batteries is eliminated. Overall transmitter-receiver audio response is rated flat within 5 db from 200 to 3,500 cycles, accounting for the surprisingly natural wire reproduction.

Frank Stanton: CBS president, testifying at FCC color television hearing on December 9, 1946, "— our interest is identical with that of the great majority of broadcasting licenses, because our primary interest starts, instead of stops, when a purchaser buys a receiving set, whether it be a radio set or a television set." This confirms our long-standing contention that broadcasters do not care about the *performance* of sets in use, but only about the *number* of them.

Citizens Radio: General impression is that the industry has no background of experience with small, low-power, portable equipment operating on 460 to 470 mc. Fact is that highly effective FM transmitter-receiver units, small enough to fit in a man's front pocket, were used very effectively for secret communications during the war. Antenna was a miniature dipole, folding to the size of a pencil. Small batteries supplied power for range of several miles. Frequency was slightly below Citizens band.

Television C.P's.: Have been issued to E. F. Peffer, Stockton, Calif., for channel 8, and to ABC for channel 7 in San Francisco. Total is now 49, in 22 states.

Fremont, Ohio: The SRO sign was hung up at one of the local theatres, and 300 people were finally left out on the sidewalk when WFRO–FM was formally dedicated on January 15th. An elaborate live-talent program on the stage was set up so that the audience actually listened to FM reception over loudspeakers. Those at the rear of the balcony were amazed to hear the rustle of manuscripts, and footsteps on the stage.

West Coast Studios: Don Lee Broadcasting System is preparing to break ground for a $2½ million building on Vine Street, between Homewood and Fountain Avenues, to house FM-AM and television studios. The building, 300 ft. square, will contain 112,000 square feet of studios and offices. Orders have been placed for equipment totalling $1¼ million.

APCO Conference: Will be held in Los Angeles, on August 25th to 29th. Lieut. W. H. Durham, of the Los Angeles Police Department, is in charge of arrangements.

Transformer Coves: Grain-oriented silicon-iron, manufactured by Westinghouse under the trade name Hipersil, was first produced 10 years ago with a thickness of 0.014 in. Because of its high permeability, it has been used widely for AF and RF coils in radio equipment. Now, to meet new demands, it is being rolled in strips .007, .005, .003, and .002 in. thick.

Transmitter Sales: Raytheon, newcomers in the broadcast transmitter field, has 75 installations on the air, and has sold 120 FM and AM installations.

Dr. Lee de Forest: Speaking at the TBA meeting in New York on January 7th: "Television networks will be chiefly by radio linkage, for I doubt if the Telephone Company will find such use for its coaxials economically profitable. Certainly not when we deal with 1,000-line picture standards, whither the art is in process of time definitely destined."

N. Y. — Chicago Relay: AT & T applied on January 24th for authority to set up terminal stations in New York and Chicago for a radio relay system which will cover that distance in 40 hops. Full operation is expected in 3 years.

FM Portables: AC-battery portables, for FM tuning only, are expected this summer. They will be welcomed by vacationers who have never had satisfactory AM reception in resort areas now covered by FM transmission.

Facsimile Patent: U. S. patent 2,413,962, covering a spring-loaded, self-compensating printer bar, – as issued to W. G. H. Finch.

FM for Tugboats: Baltimore & Ohio Railroad has installed an FM communications system for dispatching its tugs in the Baltimore harbor. Equipment was supplied by Bendix Radio.

Chicago Parts Show: Advance registration for the Show to be held at the Stevens from May 11th to 16th indicates that the attendance will break all records. It is understood that salesmen manning the exhibits will be equipped with order books this year.

FM Transmission tests: According to informal reception tests made by Fredric F. Blair, chief engineer of WSAP-FM Portsmouth, Va., the range of this station on 94.7 mc. is much greater than the theoretical coverage. The transmitter is a 3-kw. Federal installation, now using a single square loop, with a radiated power of 1,000 to 1,200 watts. Calculated range is about 20 miles. However, full limiter operation was obtained on a Zenith model 8H032 receiver at a number of locations 65 to 81 miles distant from the transmitter.

Color Television: We don't know any of the details, but patents 2,389,645-6, granted to George E. Sleeper, Jr., formerly with Farnsworth and now chief engineer of Color Television, Inc., San Francisco, indicate a new system of color television.

FM Auto Radio: A 6-volt, 2-band FM automobile receiver is now in production at Radio Engineering Laboratories. It is designed primarily for FM field measurements. Price is $320.

NEWS PICTURE

HERE is the picture story of the plight of the AM set manufacturers who, as Major Armstrong put it at the first FMA meeting, have suddenly seen the taillights of the FM train pulling out with a $100,000,000 volume of FM set business aboard. While this figure will be greatly exceeded in 1947, it represents the annual rate of production which was reached last December, according to RMA figures. Represented by the men operating this train are Zenith, G. E., Stromberg-Carlson, and Freed Radio, companies which have taken a leading part in the production and sales promotion of FM receivers. Meanwhile, growing public acceptance of the slogan "If it doesn't have FM, it's obsolete when you buy it" is destroying the market for straight AM models.

Walter Buehr, artist and industrial designer who drew this sketch, will illustrate an article on FM set designs and installations in our March issue.

INSURANCE NEEDS FOR RADIO STATIONS

Analysis of Insurance Requirements of Radio Stations, and Types of Coverage Available — Part 2

DIVISION 2 — PROTECTION OF OTHER ASSETS

Many of the forms of insurance described in Division 1 also apply in connection with other property. For example — fire insurance and its various related forms of coverage should be carried on towers, transmitters, receivers, generators and other forms of equipment as well as furniture and fixtures which the station may own and install in its premises.

A. Indispensable Insurance ★ Towers: Radio towers constructed on tops of high buildings or on mountain tops or other high places are vulnerable to damage by windstorm, lightning, fire, aircraft accidents and other forms of catastrophies. Such exposures can be insured under a very broad form of policy which will include protection against loss or damage by reason of the perils just mentioned and also by reason of explosion, strike, riot and civil commotion, malicious mischief, earthquake and collapse.

Fidelity Bonds: There are various forms of Fidelity Bonds which cover loss through the dishonesty of employees. The most commonly written form of protection is under a Blanket Fidelity Bond of either of two types known as the "Blanket Position Bond" and the "Commercial Blanket Bond". The first form provides a stated amount of insurance on each position (such as treasurer, watchman, etc.) in the organization with the amount of coverage applying to each position rather than to each loss. Thus the broadcasting company would be granted the most comprehensive coverage on losses involving collusion among several employees. The latter form of blanket bond applies on losses caused by any employee or employees in the organization but, in the event of a loss, the amount of insurance is the amount of the bond regardless of the number of employees involved. Individual Fidelity Bonds or Schedule Bonds naming certain specific individuals or positions are also available.

It is important to note that firms whose employees are not bonded are more exposed to infidelity losses since the investigation facilities of a surety company permit an exhaustive search of each employee's career. As indicated in the beginning of this article, the scope of the insurance company's investigation service is so great that no individual employer can make such a complete check.

Burglary, Robbery and Theft: There are various forms of Burglary and Robbery insurance policies available which provide protection against loss caused by the risks which are indicated in the names of the policy contracts themselves. Such policies are Interior Robbery or Holdup, Outside Messenger Robbery or Holdup, Safe Burglary and Paymaster Robbery or Holdup. Burglary means a felonious and forcible entry into the safe and there must be visible marks of violence on the safe or vault. The term robbery means that property must be taken from an employee by violence or by threat of violence.

Insurance is also available against loss by burglary of equipment, furnishings and fixtures located in the premises of the broadcasting company. This would include such property as radio parts, tools, meters, furniture, pictures and office machines and appliances. In this instance Burglary means felonious and forcible entry into the premises of the radio station. Such entry must be effected when the premises are not open for business and there must remain visible marks of forcible entry.

The Broad Form Money and Securities Policy provides practically an "all loss" form of protection as respects money and securities and can be written to cover this type of exposure either on or off the premises of the broadcasting company, or both. This insurance not only provides the standard forms of Interior Robbery, Safe Burglary, Outside Messenger Hold-up, etc. but also includes protection against the actual destruction, mysterious disappearance or damage to money and securities. It is the only policy issued that covers loss of money and securities by fire, thievery, pocket picking, or through many other means of causing the disappearance of money. This insurance is usually written blanket in the same amount within all premises occupied by the broadcasting company and also may be written in a blanket amount on all outside messengers or custodians. The coverage is automatically extended to include additional locations, both permanent or temporary, which may be brought about by normal expansion.

Improvements and Betterments: In the event that the broadcasting company, as tenant in a building, should install studios, theatre equipment, decorations or other types of installations which ordinarily would be considered a betterment or improvement to the building and by the terms of the lease must be removed from the premises at the expiration of the lease, this property is obviously the property of the broadcasting company. Such property should be insured in the company's name, rather than in the name of the building owner, against the risks of fire, explosion, windstorm, riot, sprinkler leakage and the various coverages granted by the so-called "Extended Coverage Endorsement."

Machinery Breakdown: This insures against direct loss or damage by sudden and accidental breaking of the insured object into two or more separate parts or the sudden and accidental burning out of the object or any part thereof. Breakage of vacuum tubes, gas tubes, fuses, brushes, insulation, shear pins, safety links, or the loosening of assembled parts is not covered. Burning out of insulation (unless accompanied by short-circuit) vacuum tubes, gas tubes, fuses or brushes is not covered.

Certain types of equipment, such as transmitter panels, electrical control panels, switchboards, etc. would be insured on an object limit basis. This is done by determining the total valuation of the unit and deducting the value of the tubes which are not covered as well as the value of other parts of the panel or unit which are not subject to the burning out hazard. The net value so obtained is generally used for the object limit and the difference between the gross value and the net value establishes the ratio for selection of a co-insurance limit. For example — a transmitter unit may have a total or gross value of $10,000 and the tubes forming a part of the unit a valuation of $2,000, making the net of $8,000. In such a case, the object limit would be $8,000 subject to a co-insurance limit of 80%.

The types of machines generally insured against the breakdown hazard are transmitters including all instruments and other equipment mounted thereon, motor-generator sets, rotary converters, switchboards, pumps, electric motors (except fractional horsepower motors), power or distribution transformers, and similar types of electrical apparatus.

Automobile Material Damage: This policy will reimburse the broadcasting company for any loss of or damage to owned automobiles or trucks from fire, theft, collision or other risks.

The so-called "Comprehensive" form covers any loss or damage due to any cause except collision or upset. For example — this means insurance against loss by reason of such perils as fire, theft, explosion, earthquake, windstorm, hail, water, flood, vandalism, riot and civil commotion, falling objects, breakage of glass and other types of loss.

Collision or upset insurance covers loss or damage caused by collision of the insured automobile with any other object or vehicle, or by the upset of such automobile. This insurance is usually written on a deductible basis, which means that the designated amount is deducted from the amount of each loss occasioned by any single collision or upset. The most commonly written form is on a $50 deductible basis but for expensive equipment the deductible amount may be $100 or as high as $250.

Any receivers, transmitters, generators or other pieces of radio equipment which are permanently fastened to the truck or vehicle would be considered a part of the vehicle in the event of a loss and would be covered by this form of insurance. Microphones, television cameras and other types of equipment which are not a permanent part of the vehicle would be insured under the so-called "Portable Equipment" form discussed in the next section.

Portable Equipment: Equipment which is used outside the studio, such as television cameras, microphones, meters, testing instruments and other equipment of a portable nature may be insured under a so-called "Scheduled Property Floater." This insurance is usually written to cover all risks of physical loss or damage from any external cause, including fire and theft. It may be written, however, to cover against only certain specific perils, such as fire, lightning, windstorm, theft, riot, etc. The usual exclusions pertain principally to losses caused by dampness or extremes of temperature, carelessness or rough handling, processes of repairing, and infidelity of any persons to whom the property may be entrusted.

In some instances property must be listed and specifically valued. It is important that the amount of insurance be commensurate with the value of the property.

The assets of a radio broadcasting station are represented in its investment in real property and other forms of property which have been discussed in the first division of this article. There are, however, insurable risks of a somewhat intangible nature which have an equally important bearing on the protection of the assets of a station. They will be discussed in this section, also.

Use and Occupancy or Business Interruption: This form of insurance may be written with fire, extended coverage, vandalism and malicious mischief, sprinkler leakage, water damage, earthquake, explosion of boilers and pressure vessels and machinery breakdown.

The coverage will repay the insured for loss of profits and those necessary expenses in the event of shutdown due to the causes insured against and mentioned in the preceding paragraph. Such expenses are salaries, rents, taxes, interest charges, legal expenses, insurance premiums, advertising and other expenses which must be maintained during a shutdown.

This policy is written for a stipulated sum for each day of shutdown for a specified number of days.

Power Interruption: Insurance is available against loss by reason of deprivation of usable power that is supplied *by others* from premises elsewhere, due to any accidental occurrence to the physical equipment of the public service system which immediately prevents delivery of usable service to the station premises. The insurance is written with a limit per hour of interruption during those hours when the station would have or could have used the service. The policy excludes coverage if the power interruption is caused directly or indirectly by riot, strike, or civil commotion.

B. Insurance of Secondary Importance ★ Valuable Papers: Insures against loss, damage or destruction of valuable papers except such losses caused by misplacement and mysterious disappearance, wear and tear, gradual deterioration and vermin. This is practically an "all loss" form of protection against loss of important documents which may be expensive or difficult to replace. The policy defines valuable papers as including such things as books, records, maps, drawings, manuscripts and other papers and documents used in the business of the insured. This would of course include musical scores, engineering drawings, technical data and scripts. The principal items which are excluded from coverage are currency, stamps, securities, checks and evidences of debt.

Safe Deposit Box Contents: This policy insures the safe deposit box renter against practically all types of losses which may occur to property maintained in a specified safe deposit box. The only exclusions pertain to dishonest or criminal acts of officers and employees of the broadcasting company and to the voluntary delivery of property.

A more limited form of insurance is also available against loss of securities, jewelry and silverware contained in a specified safe depost box against the perils of burglary and robbery. This insurance will also provide indemnification for all damage (except by fire) to the insured property in the safe deposit box when such damage is caused by persons attempting to make forcible entry into the box.

Miscellaneous Property: Various types of property owned by the broadcasting company may be insured under an "All Risk" form of protection. This would apply to such property as musical instruments (including pianos), special costumes, etc. Equipment leased or rented to others under partial payment plans or under service agreements whereby the lessee agrees to maintain and service the property and to replace obsolete portions of such equipment with new and up-to-date equipment may also be insured in this manner.

Neon Signs: Electric and neon signs used for display or advertising purposes are insurable against all risks of physical loss or damage. Each claim is subject to a $10 deductible clause except when caused by fire, lightning, theft, earthquake, flood, external explosion, or derailment, overturn or collision of a vehicle on which the sign is being transported.

Outage: This form of policy provides for a specified indemnity in the event that the functions of an insured object are prevented by an accident to the object. The insurance is written on a "per hour of shutdown" basis and will reimburse the radio station for losses of the type not reflected by prevention or reduction of operation.

Leasehold Interest: Leases usually contain a clause permitting cancellation as a result of certain events, such as: fire or windstorm. In the event a lease is terminated in such a manner and the radio station is required to pay a higher rental under another lease, the loss thus sustained is insured under this form.

Extra Expense: This form covers the additional expense of doing business elsewhere than on the original premises in the event that this is made necessary because of a fire or other disaster at the premises occupied. The policy does not cover profits, fixed charges or the usual expenses of the radio station.

101st ANNIVERSARY

One of the oldest concerns supplying materials to the radio industry is celebrating its 101st anniversary. The company is Zophar Mills, Inc., founded in 1846 by Zophar Mills, one of the famous figures of New York in the middle of the 19th century. In those days of bucket-brigades, hand-pumpers, and galloping horses, Zophar Mills was president of the New York City Fire Department, from 1847 to 1851. In recognition of his outstanding service, the City named a new fire boat after him, in 1882.

After his death at age 78, the business was carried on by his son. Then, in 1924, the company was bought and expanded greatly by the present owners. Today, in addition to many chemical products, Zophar Mills, Inc. manufactures in its wax division impregnating waxes of many types, aviation-marine glue, and shell wax coatings.

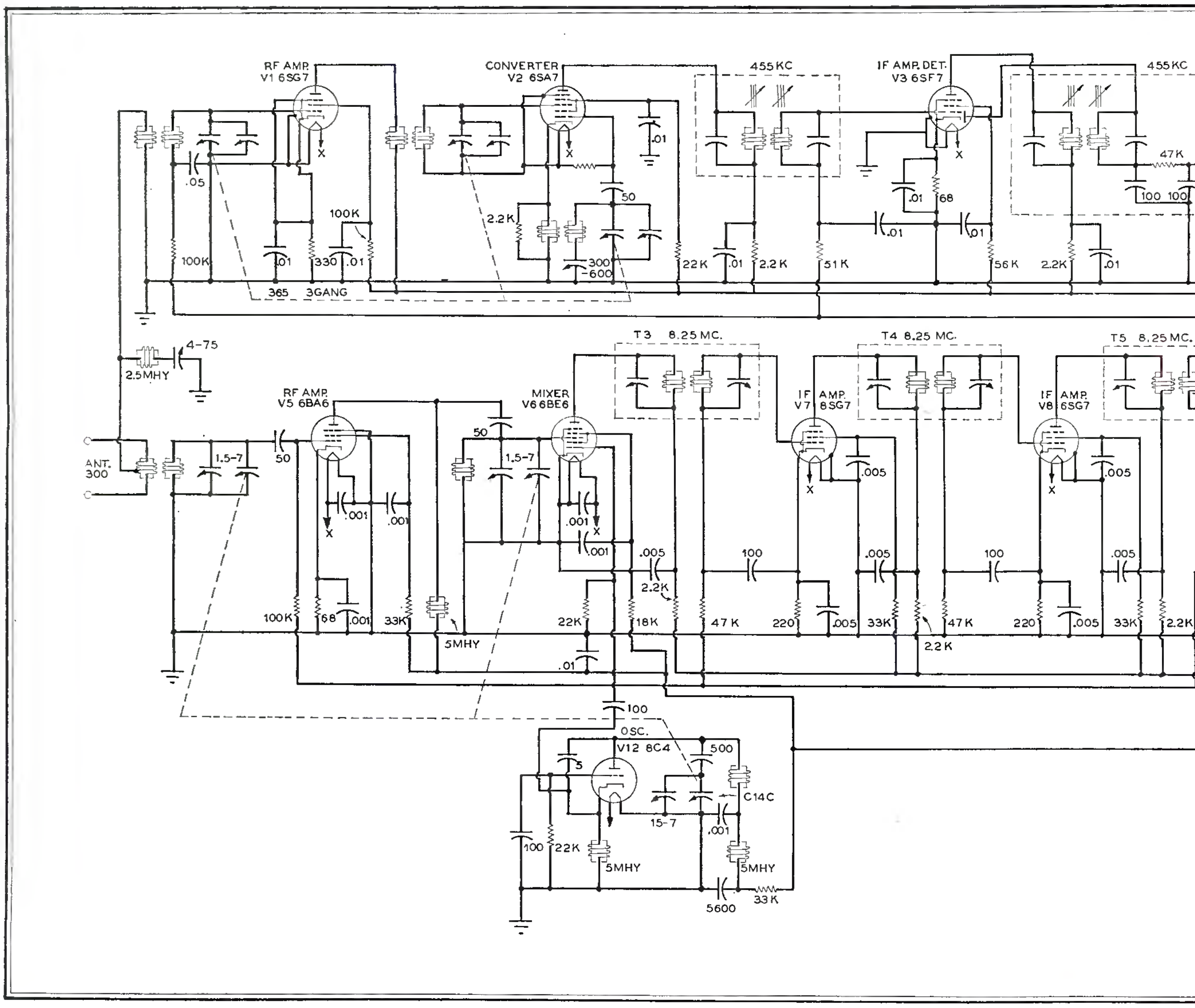

FIG. 1. CIRCUIT DIAGRAM OF THE BROWNING FM-AM TUNER. TERMINALS ARE PROVIDED FOR A SEPARATE POWER SUPPLY

DATA ON THE BROWNING FM-AM TUNER

Circuit and Service Information on a Tuner Designed for Use with Any Suitable Audio System

BY F. A. SPINDELL*

FROM the technical point of view, any piece of apparatus to be used primarily for the reception of radio entertainment must perform in such fashion that the listener is not conscious of electro-mechanical reproduction. Perceptible distortion, extraneous noises, fading, and complexity of operation focus attention directly on the technical means and must, therefore, be eliminated as far as the state of the art will permit. In the design of the Browning tuner to be discussed here, every effort was made to meet this challenge on both the AM and FM bands. Tuning covers 88 to 108 mc. on FM, and 540 to 1,650 kc. on AM, with completely separate channels for the FM and AM sections, thus eliminating dual-purpose components and ensuring peak performance on both types of operation. Fig. 1 gives the complete circuit.

AM Section ★ The AM section comprises a superheterodyne circuit having one RF stage and one IF stage. A diode detector provides audio and AVC voltage. The use of recently developed tube types permits attainment of sensitivity of 1 microvolt or better over the entire band. The bandpass of the IF amplifier provides the high selectivity so necessary in average locations for interference-free reception. Some noise reduction benefits are realized with this selectivity, yet the quality of reproduction remains good. A complete audio response curve from antenna to audio output jack is shown in Fig. 2. In order to restore the extreme high-frequency end of the audio curve, some simple treble compensation in the amplifier was considered desirable. It was felt that this method of obtaining full response out to 5,000 cycles offered advantages in obtaining freedom from noise, inter-station heterodynes, and the like, rather than widening the IF bandpass.

As with all high-sensitivity receivers, high-level signals at the intermediate frequency present on the antenna could be

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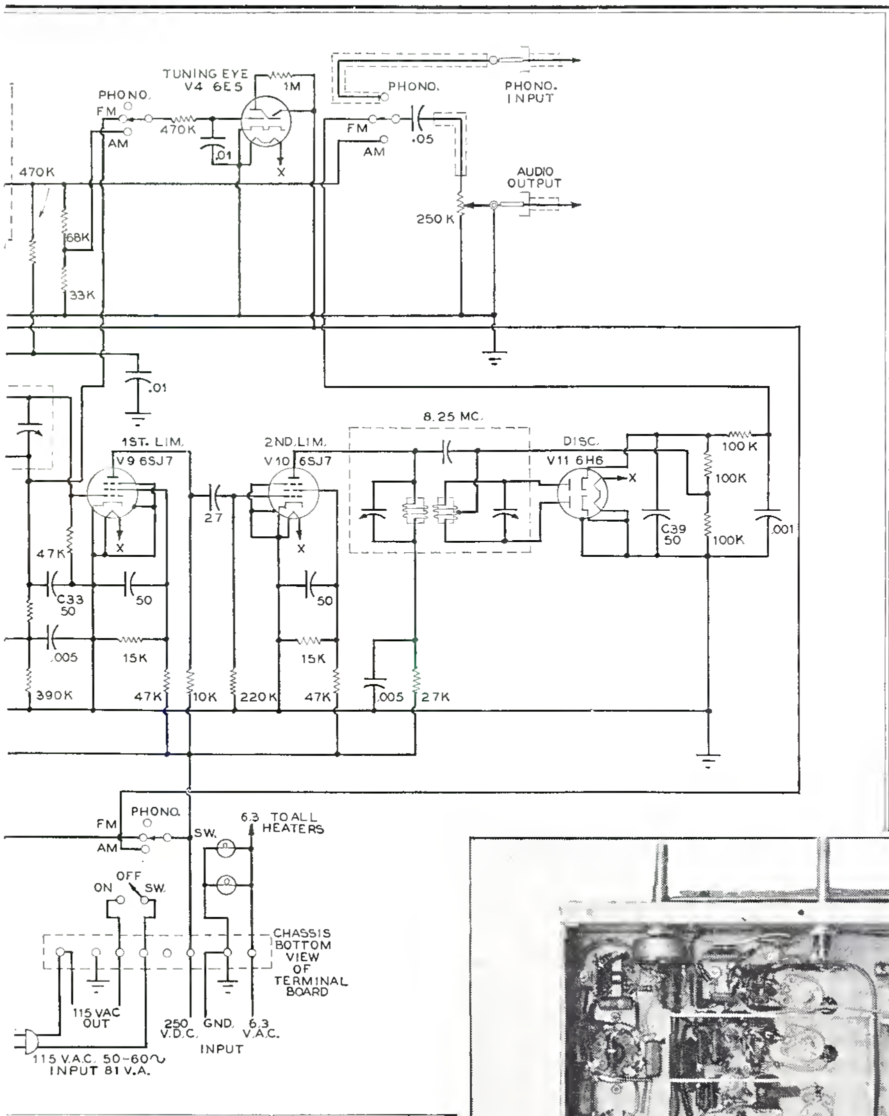

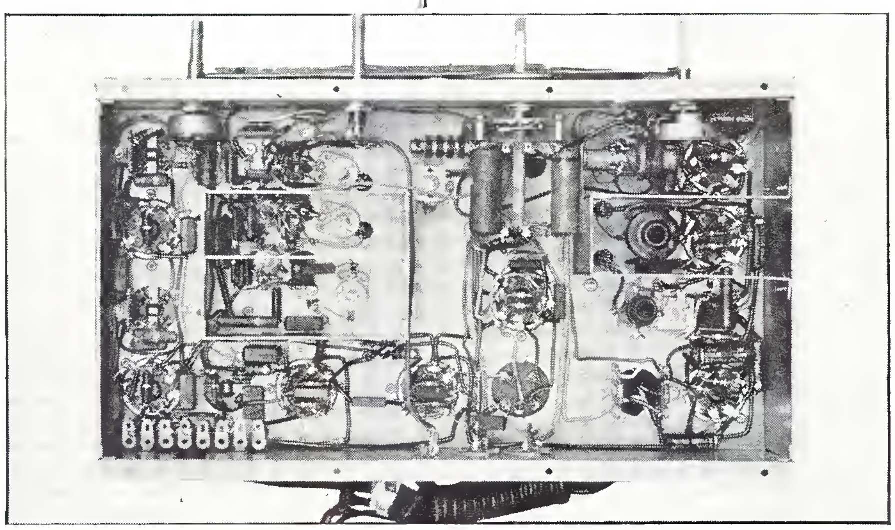

UNDER SIDE OF THE CHASSIS SHOWING THE POSITION OF THE PARTS REFERRED TO IN THE ALIGNMENT INSTRUCTIONS, AND INDICATED IN FIG. 9

distinguished in the output as interference. To eliminate local high-power, low-frequency code stations, a series-resonant wave trap is connected from antenna to ground. This trap is tuned to 456 kc. and provides a low impedance path to ground for any signal which might otherwise cause interference.

FM Section ★ The FM section of the tuner is a superheterodyne circuit following the Armstrong method of reception. The RF portion makes full use of the new miniature tubes with a 6BA6 RF amplifier, 6BE6 mixer, and a 6C4 triode oscillator. Good gain is realized in the RF stage and in conversion to the intermediate frequency. Following the mixer are two IF amplifier stages operating at a center frequency of 8.25 mc. Overcoupled transformers between stages provide full 150-kc. bandpass. For the most effective quieting, two limiters are used in cascade. The dynamic curve of noise silencing with increasing signal is shown in Fig. 3. From this curve it can be seen that a 20-microvolt signal results in approximately 20 db reduction in background noise. Even weak signals are, therefore, useful with this degree of quieting.

Assuming proper limiting, the major source of distortion in FM receivers lies in non-linearity of the discriminator characteristic. When this curve of frequency versus output voltage is linear over the range of modulation, there can be no distortion in detection. In the practical case of this tuner, an excellent characteristic is obtained, as indicated in Fig. 4. This curve shows linearity from plus 75 to minus 75 kc., corresponding to the upper and lower limits of frequency swing with modulation.

High-frequency pre-emphasis purposefully introduced at the transmitter must be compensated for in the receiver if linear audio output is expected. This function is performed in the tuner by a suitable high-frequency attenuator connected across the discriminator output, compensating for the standard degree of pre-emphasis applied at the transmitter.

General Considerations ★ Where the outputs from an FM discriminator and an AM detector are fed into a common audio channel, there exists an audio level problem which must be considered. In the case of the FM output, the signal is fed to the discriminator through limiters which fix the maximum RF voltage available to this circuit. The voltage output of the discriminator, therefore, does not depend on the strength of the received carrier, but solely upon the frequency swing of modulation and on the voltage-versus-deviation characteristic of the discriminator transformer. Reference to Fig. 4 will show that the instantaneous audio voltage generated in the discriminator of the tuner is about .5 volts per 10-kc. frequency swing. Under average conditions of modulation, then, the RMS audio voltage to be expected is about 2.0 volts.

In the AM section, however, the RF voltage applied to the detector varies considerably with signal strength, even though an excellent AVC system is employed. Since detector output is proportional to amplitude, there is an appreciable difference in audio output when tuning from a strong AM station to a weak one. In designing the tuner, the output from the AM detector was permitted to exceed that from the FM discriminator, in order that the AM output on weak signals would compare with the FM output. Strong AM signals received on the tuner will generate about 7 to 10 volts of audio, with weak signals yielding considerably less.

Some of the appeal of this tuner lies in its adaptability to mounting in confined or otherwise unusual places. To further the ends of flexibility, it was designed to occupy as small a space as is consistent with fine performance and ease of servicing. The overall dimensions of the tuner are $7\frac{3}{8}$ ins. high, $13\frac{1}{2}$ ins. wide, 9 ins. deep. The power supply is a small, separate unit which can be mounted at a distance from the tuner chassis, thus easing the mounting problem in cramped quarters. This separation makes it possible to completely eliminate the separate supply if power for the tuner can be derived from the amplifier. Where space permits, particularly in the case of a rack-mounted unit, the power supply can be secured directly to the tuner chassis. The rack-panel model is available in black leatherette finish, with commercial rack drilling.

Tuning is by means of a reduction-drive mechanism. Edge-lighted scales are calibrated in frequency.

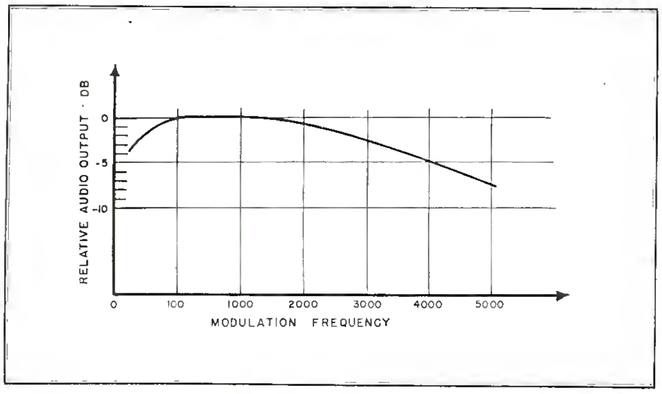

FIG. 2. COMPLETE AUDIO RESPONSE CURVE OF THE AM SECTION, FROM ANTENNA INPUT TO AUDIO OUTPUT

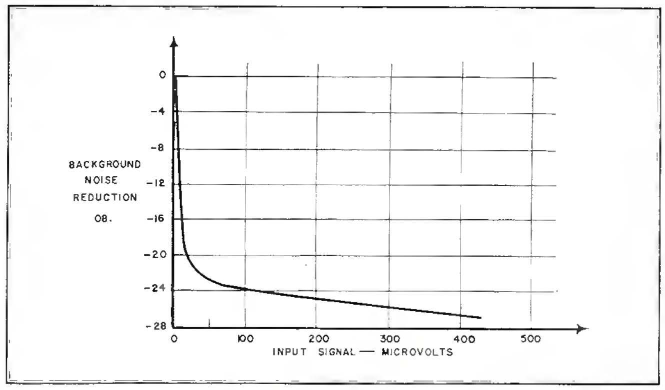

FIG. 3. NOISE-SILENCING ACTION OF FM SECTION INCREASES WITH INCREASING SIGNAL INPUT, AS THIS CURVE SHOWS

One of the most frequent questions in connection with the use of a tuner is: what type of amplifier should be used in conjunction with it? Needless to say, any amplifier with sufficient gain will work. However, to derive full advantage from the design of this tuner, the use of a high-quality amplifier cannot be too strongly recommended. The response should be linear from at least 50 cycles to the upper activity-limit of the speaker system. The power output will depend upon the size of the room and its acoustics. For home use, no more than 10 watts are usually needed for sufficient sound level. The gain of the amplifier should be such that an input signal of 0.25 volts RMS will drive the amplifier to full output, thereby giving ample reserve for weak AM stations.

It is important, if it is desired to power the tuner from the amplifier, that the amplifier power supply be capable of delivering 250 volts DC at 65 milliamperes, and 6.3 volts AC at 4 amperes above and beyond the requirements of the amplifier.

Note that one side of the 6.3-volt heater system is grounded in the tuner, and must be correspondingly grounded in the amplifier. This design was dictated by the limited space about the miniature sockets, and by improved operation of the RF section of the FM tuner circuit. Amplifiers having a center-tap ground on the heaters cannot supply voltage for the tuner heaters, and the use of a separate filament transformer is recommended. This transformer should deliver 6.3 volts at 4.0 amperes.

Anticipating the use of a phonograph pickup, an input was provided on the tuner for this purpose. This input is brought to the 3-position bandswitch, so the AM, FM, or phonograph can be fed to the amplifier. The volume control on the tuner chassis controls the level of any input selected.

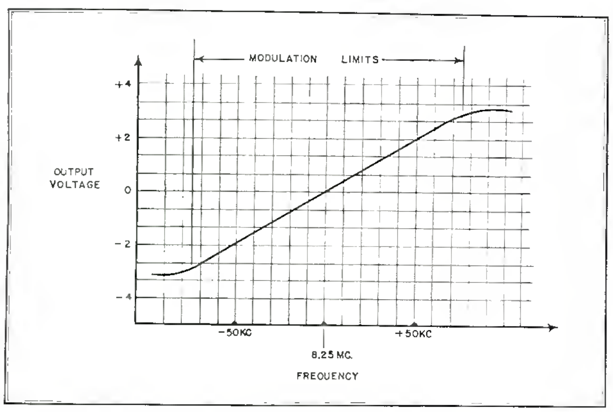

FIG. 4. DISCRIMINATOR CHARACTERISTIC IS LINEAR OVER THE FULL SWING OF FREQUENCY MODULATION

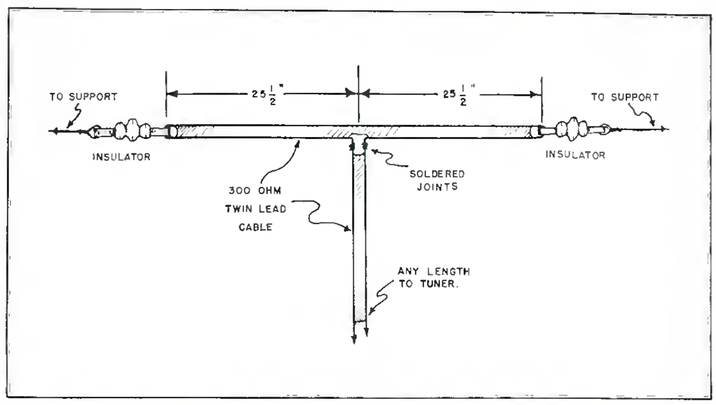

FIG. 5. CONSTRUCTION OF A FOLDED DIPOLE THIS MATCHES THE IMPEDANCE OF THE STANDARD 300-OHM TWIN LEAD-IN LINE

Antenna ★ As with any other type of UHF receiving equipment, FM results will be only as good as the antenna used. The tuner is designed for optimum performance with an FM antenna having a downlead impedance of 300 ohms, as standardized by the RMA. Any good commercial antenna having this impedance should prove satisfactory. Those who desire to take advantage of the new 300-ohm line recently put on the market can construct a simple, yet effective antenna which has surprisingly good characteristics over the entire band. The details are shown in Fig. 5. This type of antenna is known as a folded dipole. As with simple dipoles, it has a pronounced directional pattern and should be aligned with the broadside at right angles to the most important direction of reception. It is important that no part of the antenna or feeder be grounded, as the FM input is balanced to ground, and the entire system acts as the AM antenna. Always remember the higher the antenna is mounted above the ground, the more effective it will be.

AM Alignment ★ The alignment of the AM portion of the tuner is not difficult. It can be done with standard equipment, in the following manner: Adjust the frequency of the AM signal generator to 456 kc., and apply the signal to the grid (Pin 8) of the converter. This point can be reached most conveniently by clipping onto the stator plates of the middle section of the AM tuning condenser, as indicated in Fig. 6.

Connect a DC voltmeter, capable of measuring approximately 3 volts negative, and having an impedance of at least 20,000 ohms per volt, to the AVC bus. Adjust the 456 Kc. Adj. screws shown in Fig. 6 in succession for maximum meter reading. Reduce the signal strength as required to keep the AVC voltage at about 1 volt. Set the signal generator to 600 kc., and apply the signal to the antenna terminals. Adjust the tuner dial to 600 kc. and adjust Osc. Padder until meter again reads maximum.

Set signal generator and tuner dial to 1,500 kc. and adjust "Osc. Trimmer" until the signal generator is properly tuned in as indicated on the meter. Keep the AVC voltage to approximately 1 volt by reducing the signal generator output and adjust "RF Trimmer" and Ant. Trimmer in succession for maximum indication on meter. Leave the signal generator connected to the antenna terminals and adjust its frequency to 456 kc. Increase the output until an AVC voltage of about 3 volts results. Rock the tuning of the generator to obtain exact tune. Adjust the small wavetrap trimmer, situated under the chassis immediately adjacent to the bandswitch, until the AVC reaches a minimum, indicating best rejection (See Fig. 9 for location of the wavetrap). That completes the alignment of the AM section.

FM IF Alignment ★ The center frequency of the IF amplifier bandpass in the FM portion of the tuner is 8.25 mc. Overall bandwidth of the entire amplifier is about 150 kc., and is double-humped because of the overcoupling in the IF transformers. Simple alignment with signal generator and meter for maximum readings does not produce correct alignment under these conditions. If such equipment is used, a point-by-point method must be employed. A greatly superior method, and that used in our factory for aligning new tuners, is the visual or dynamic procedure which makes use of a Harvey[1] frequency-modulated signal generator and an oscilloscope. Both methods will be outlined for the benefit of servicemen who do not possess the required equipment for the visual method.

The Harvey FM signal generator is capable of sweeping repetitively through a range of about 8.0 to 8.4 mc. in sawtooth fashion, and simultaneously generates sawtooth sweep voltage for horizontal deflection of an oscilloscope. In addition, a good signal generator of the ordinary variety is needed.

The simplified theory of this method may assist in its application. A frequency-modulated signal of constant amplitude is swept through the bandpass region of the amplifier. The spot on the screen of an oscilloscope is swept across the face of the tube horizontally at a rate proportional to the rate at which the frequency is being changed. The output of the amplifier is detected and applied to the vertical deflection plates of the oscilloscope as a signal. As the spot moves across the screen, its horizontal position is a measure of the frequency of the applied signal, while its vertical position is directly proportional to the amplitude response of the circuit. In this way, the picture as a whole is a graph of the response of the amplifier.

Visual Method: To align the IF section of the tuner using the visual method, connect the sweep voltage output of the frequency-modulated signal generator to the horizontal deflection input of the oscilloscope, and adjust the controls until the horizontal sweep nearly fills the screen. Adjust the FM signal generator to sweep from about 8.0 to 8.4 mc., and apply the output to the grid of the second IF stage (V8). Connect the vertical deflection input of the oscilloscope across C33 in the grid circuit of the first limiter. The rectifying action of the grid circuit of this stage will provide a signal corresponding to the amplitude response of the preceding circuits. Adjusting the controls of the scope should produce a picture of the response curve. Always use as small a signal from the generator as possible consistent with a good image. In order to provide a frequency marker for alignment, apply a signal of exactly 8.25 mc. from the AM signal generator to the same grid where the FM signal is applied. This is best done by using a small mica isolation condenser in series with the 8.25-mc. source. Adjust the amplitude of the 8.25-mc. AM signal until a small marker pip appears on the response pattern, as shown in Fig. 7. Use only enough marker voltage in all cases so that the pip is just discernible. The location of this marker pip on the curve indicates the center alignment frequency of the amplifier. The adjustment screws of T5, shown in Fig. 6, should now be set for the desired characteristic. In all cases, the marker pip should be left at the center or axis of symmetry of the curve. Adjustment of the screws will produce varied patterns. For guidance, the curves of typical misalignment and proper alignment are shown in Fig. 7. Greater amplitude of the pattern indicates higher gain, so adjustments should be made not only for best symmetry but for optimum gain as well. Having adjusted T5 in this fashion, the output from the signal generators must now be applied to the grid of the first IF amplifier (V7). Next, T4 should be adjusted in the same manner. Signal generator outputs should be reduced as a stage of gain has been added. When T4 is aligned satisfactorily, apply the signal generators to the grid of the mixer tube (V6). Because of the short-circuiting effect of the high-frequency tuned circuit at 8.25 mc., it is advisable to apply signal to grid No. 1 of the 6BE6. This is the grid where oscillator voltage is ordinarily injected. The signal can be more conveniently applied to the stator plates of the variable condenser (oscillator section) C14C. Align T3 for the best possible response curve. The pattern appearing on the screen at this point is the overall response of the whole IF amplifier and should be similar to that shown in Fig. 7 for proper alignment before going on to align the discriminator.

Meter Method: Satisfactory alignment can be made using only an AM signal generator and a high impedance DC voltmeter by the following method, although it is considerably more time-consuming than the visual procedure. The meter

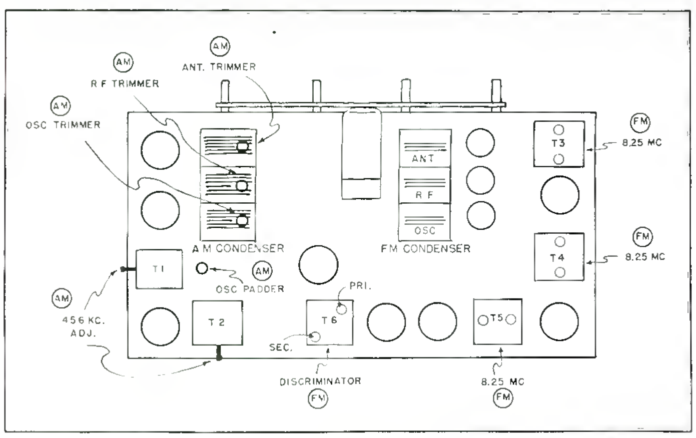

FIG. 6. TOP OF CHASSIS, SHOWING AM AND FM ALIGNMENT

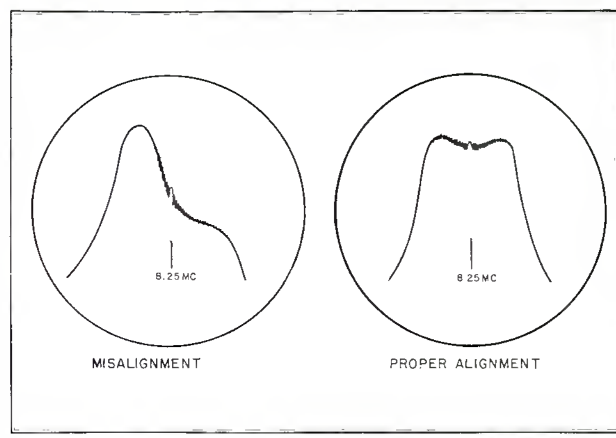

FIG. 7. PATTERNS FROM VISUAL FM ALIGNMENT

[1] See "How to Align FM Receivers" by Bernard Cosman, *FM and Television*, July, 1946.

should have an impedance of at least 20,000 ohms per volt, and be capable of reading negative DC voltage of approximately 3 volts. Connect this meter across C33 in the grid circuit of the first limiter, with the ground side of the meter going to the grounded side of the condenser. The tuning eye employed in the tuner can be used for indicating maximum response. However, this is not as satisfactory as a meter. Apply the output of the

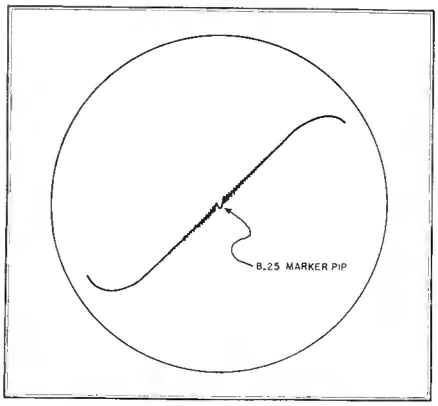

FIG. 8. PATTERN OBTAINED WITH FM DISCRIMINATOR ALIGNED CORRECTLY

AM signal generator to the control grid of the second IF amplifier tube (V8). Set the signal generator to 8.25 mc. When making these adjustments, always use an input signal level which results in meter readings of from 1 to 2 volts.

Adjust the screws on T5 for maximum meter reading. The frequency of the signal generator should be changed in steps of 20 or 30 kc. above and below 8.25 mc., and the readings noted in order to determine if the curve is symmetrical about the 8.25-mc. center frequency. If the results show that the curve is not symmetrical, further adjustments must be made and rechecked until a well-balanced curve results. When checks show the desired result, apply the signal to the grid of the first IF stage (V7). Tune transformer T4 in the manner prescribed for T5. When this has been accomplished, transfer the AM signal generator to the grid of the mixer. As in the case of the visual method, it is preferable to inject the signal on grid No. 1, or to the stator plates of the variable condenser C14C.

Touch-up: For a simple touch-up, the whole IF system can be realigned by applying the FM signal to the stator plates of the variable condenser (oscillator section) and tuning each transformer in turn to obtain a symmetrical curve. Align T3 at approximate maximum at 8.25 mc. Vary the frequency of the signal generator slowly through a range of 8.15 to 8.35 mc., and watch the behaviour of the meter. Definite double peaks should be in evidence and in all probability they will not be symmetrical about 8.25 mc. Make a small adjustment on one of the screws and again run through the curve with the signal generator to determine what effect it has. A great many trials may be necessary to arrive at the proper adjustments for both screws. When the amplifier is aligned correctly, the meter readings can be plotted versus the signal generator frequency, and the resulting curve will be similar to that shown in Fig. 6 for proper alignment except that the marker pip will, of course, be absent.

FM Discriminator Alignment ★ *Visual Method:* Alignment of the discriminator is easy with the visual method. Apply the output of the frequency-modulated generator to the grid of the first limiter. Apply a signal from the AM generator at 8.25 mc. to the same point. Connect the vertical input of the oscilloscope across C39 in the output of the discriminator. Make certain that the ground of the oscilloscope goes to the ground side of this condenser. Adjust the controls for the best image, using as small RF signals from both generators as practical. Alignment must be made for symmetry about the 8.25-mc. marker pip, and linearity above and below this point as shown in Fig. 8.

Meter Method: When only a meter and AM signal generator are available, connect the output of the generator to the grid of the first limiter, and a vacuum tube voltmeter, reading plus or minus DC voltage of about 2.0 volts, across C39 in the discriminator output. Set the frequency of the signal generator to exactly 8.25 mc. Adjust the secondary of the discriminator, indicated in Fig. 6, until the meter reads zero. Change the frequency of the generator in 20-kc. steps above and below 8.25 mc., and note the voltage generated at each step. Readings should increase linearly each side of center frequency out to 75 kc. Should more voltage be generated on one side than the other, adjust the primary of this transformer and recheck. A number of trials and checks should result in a curve very similar to that shown in Fig. 8.

FM RF Alignment ★ To align the RF portion of the tuner, a signal generator covering 88 to 108 mc. and a DC meter having an impedance of at least 20,000 ohms per volt and capable of reading 3.0 volts are required. Apply the signal generator to the antenna terminals and connect the meter across C33 in the first limiter. Set the signal generator at 108 mc. and set the tuner dial to the same frequency. Adjust the HF Osc. Trimmer shown in Fig. 9 until the signal is heard or the meter indicates maximum voltage. Set the tuner dial at 90 mc. and the signal generator to correspond. With a non-conducting rod, compress or expand the oscillator inductance as needed to tune in the signal. Return the generator and dial to the high-frequency end and recheck. Readjust the trimmer if necessary. Adjustments of the

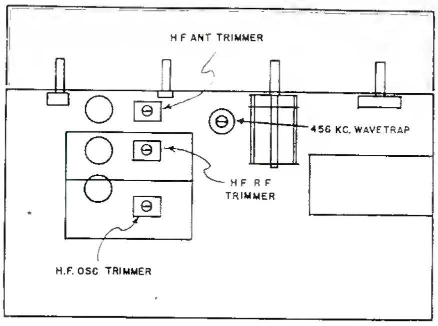

FIG. 9. BOTTOM OF THE CHASSIS SHOWING ALIGNMENT AND WAVE-TRAP CONTROLS

inductance and trimmer are interacting, and several adjustments of each may be required for exact alignment. Reset the signal generator and tuner dial to 108 mc. Rock the tuning for maximum voltage indication on the meter. Adjust the signal level as necessary to maintain the voltage at less than 2.0 volts. Adjust the "RF Trimmer" for highest meter reading. Set the generator and dial to 90 mc. and rock the tuning for highest meter reading. Adjust the RF coil inductance with the non-conducting rod for best gain. Here again, several adjustments at both ends of the band will be necessary for the best alignment since adjustment at the one end will affect tuning at the other. The antenna circuit can simply be trimmed at the high frequency end of the band and left, since the application of antenna or signal generator to the antenna terminals severely damps this circuit and the tuning is not critical. When this adjustment has been made the tuner is completely aligned.

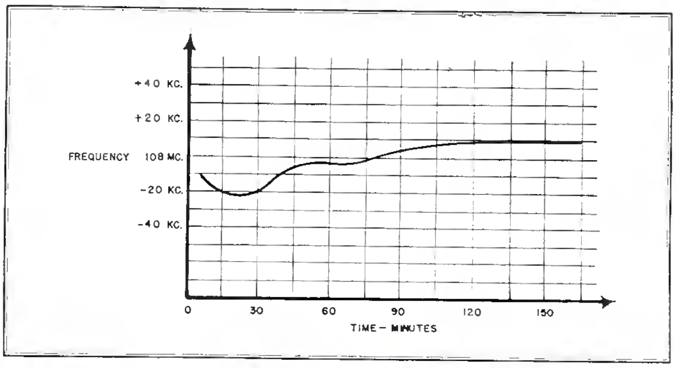

FIG. 10. CURVE SHOWING THE HIGH STABILITY OBTAINED AFTER 5 MINUTES

Engineering Notes ★ A rather important factor in the design of a high frequency tuner is the minimizing of oscillator drift. It is

(CONCLUDED ON PAGE 54)

TELEVISION HANDBOOK

CHAPTER 1—Conclusion of Part 1: Scanning Methods—Significance of Standards

BY MADISON CAWEIN

3. Scanning ★ Close examination of a television picture shows that it is made up of black, white, and gray dots arranged in a series of parallel horizontal lines. Across the line, these dots do not have an extremely sharp boundary, but rather grade into one another. In the vertical direction, however, there is relatively a sharp break between black, white and various shades of gray due to the line structure of the picture.

These dots, called *picture elements,* can be considered to have a square shape for all practical purposes. The number of such picture elements which the eye can resolve in a picture is the measure of the detail of the picture. Ordinarily the average eye, at the proper viewing distance, can resolve about 200,000 details in a picture 6 by 8 ins. This size is standard practice for television receivers or monitors employing 10-in. cathode ray tubes.

Our eyes do not detect all the details at once, but have a tendency to run rapidly over the picture in order to familiarize the brain with the various parts of it. Concentration is then centered on those parts in which there is the greatest interest, and the brain meanwhile retains a background memory of other portions of the picture in relation to one another. This process is called *scanning.* The word *scan* refers to the process of looking over a field of view at a relatively rapid rate and in some predetermined pattern. You can check this fact for yourself by suddenly glancing at the wall of a building, for example. In determining the details in this wall, as to whether there are windows and doors and how many of each, you will find that you move your eyes back and forth across the building rather rapidly, usually starting at the top left hand corner and moving your eyes back and forth in a zigzag pattern, ending up at the lower right hand corner. This is the method employed in television scanning. Although it may not be standard with all human beings due to psychological differences, it is for most people, and is the television method.

The process of scanning used for the transmission of television images originates at the transmitter. The actual method used depends upon the pick-up tube. It will be described here for the simple case of a pick-up tube which utilizes an electron beam to scan an electrical image which is stored on a screen inside of a vacuum tube, such as in an iconoscope which contains a mosaic of photo-sensitive islands deposited on a flat plate or screen. This screen is arranged to be scanned by an electron beam which originates at a gun placed on one side of the screen, and which focuses the beam of electrons normally somewhere near the center of the screen.

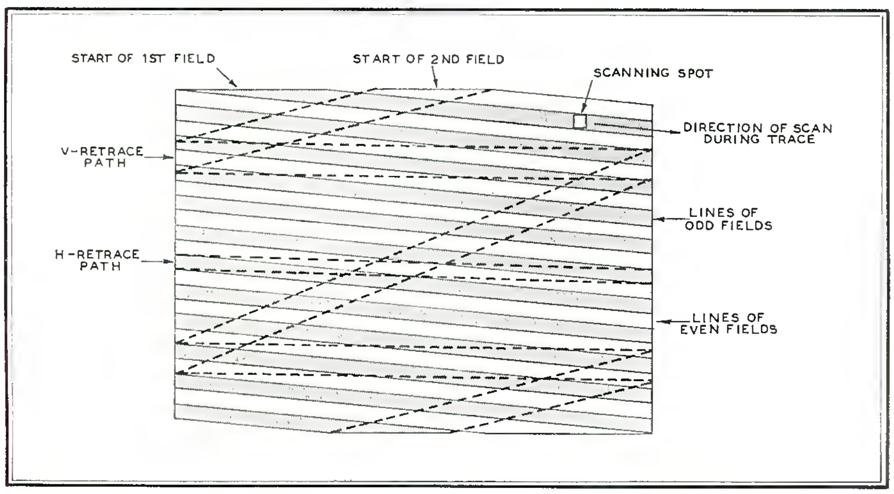

FIG. 7. ILLUSTRATING THE STANDARD METHOD USED FOR TELEVISION SCANNING

The electron beam is scanned back and forth across the screen from left to right slowly, and from right to left rapidly, and at the same time it is moved slowly downward from top to bottom so that the pattern of lines scanned has a slight slope, as shown in Fig. 7. The scanning process is accomplished by means of controlled electrostatic or electromagnetic fields which determine the number of lines into which the picture is divided and the number of pictures, or frames, which are scanned per second. The order of the scanning is controlled by the form and speed of the electric fields. Under present standards, this order consists of two interlaced patterns as shown in Fig. 7, each of which constitutes a field, the two fields combining to make up a complete frame of the picture. These fields will be designated for purposes of explanation as the even and odd half-frames, indicated by white and shaded strips in Fig. 7. Each field, under present day commercial standards, is made up of 267½ lines, so that there are 525 total lines scanned in each frame, constituting the complete reproduction of a picture. There are 30 frames scanned per second so that the field scanning rate is 60 per second.

This choice of standards for the field-deflection rate is based on power-line frequency which is standardized throughout the United States, for the most part, at 60 cycles. The system is a practical one from the standpoint of flicker and for minimizing the effect of 60-cycle hum on television pictures. The interlacing of the fields is a trick which was necessary in order to prevent flicker, and at the same time to limit the projection of television frames to a value somewhat closer to that used in motion pictures.

The slanting lines which are scanned are located one directly underneath the other, and spaced apart by the width of a line, so that the lines of interlaced fields fall between one another.

The whole transmission is performed so rapidly that the eye cannot perceive the motion of the spot of light at the receiver, which is synchronized with the motion of the scanning spot at the transmitter. Thus the brain is deceived into seeing the entire picture at once, as a continuous thing. Since there are approximately 200,000 picture elements per frame and 30 frames per second, the television system must be capable of transmitting approximately 6,000,000 details per second. It can be shown that such a rate of transmission of information requires approximately 6 mc. of space in the ether with the present standards set for commercial television. The reason for this will be discussed later.

In order to achieve such speeds of transmission of information, it is necessary that the spot formed by the intersection of the electron beam and the screen should move laterally across the screen at a velocity, along the line, of approximately 10,000 ft. per second during the trace of each line. In order to get back from the end of each line at the right hand side of the picture to the start of the next line on the left hand side of the picture, the velocity of the spot is speeded up to approximately ten times the speed during the trace. This is in order to conserve time. Any signals generated during the retrace of the beam are blanked out by means of electrical pulses known as *blanking signals*, applied in negative polarity to the grid of the cathode-ray tube in order to cut off the electron beam during the retrace path.

The lateral speed of the spot during retrace is of the order of 100,000 ft. per second across the screen. Since the velocity of the electron beam itself, perpendicular to the screen, is approximately 10,000 ft. per second, there are plenty of electrons to excite each elementary area or picture element. During the retrace, however, since the speed of traversal is ten times greater, the spot lingers only one-tenth as long as during the trace, so that there are one-tenth as many electrons for purposes of excitation. This would result in a *ghost* picture only one-tenth the intensity of the desired picture, even without recourse to blanking.

Deflection circuits for scanning cathode-ray tubes will be discussed in detail in a later section. This section on scanning was inserted as an introduction to the general subject of television in order to present a picture of the method by which a television image is constructed and the manner in which a television signal is generated.

The electric fields of force operating on an electron beam or an electron image are three in number. One is the so-called focus field which causes the beam to converge to a spot at the screen being scanned. When the beam is in focus, the spot size is smallest. That is, the electron beam has the smallest cross-section area which the electron optics of the tube can produce at the screen. The other two fields are at right angles to the direction of the focus field and to each other, one of them acting to deflect the beam in a horizontal direction at line speed, and the other acting to deflect the beam in a vertical direction at field speed. The focus field is a DC field, while the horizontal and vertical deflection fields are AC fields of sawtooth waveform and at different frequencies, the horizontal frequency being 525 times as fast as the vertical frequency. These three fields of force acting mutually at right angles to one another produce a composite force which may be considered as acting, for all practical purposes, as an electron-directive force pointing in a straight line from the center of the electron beam, where it intersects the centers of the three fields, to some point on the screen. The electrons follow the direction of this directing force and strike the screen in focus at points whose position is in synchronism with the magnitude of the deflecting fields at every instant of time.

The scanning spot, or end of the electron beam, is thus caused to scan very rapidly in a predetermined pattern (shown schematically in Fig. 7) across the screen of the transmitter pick-up tube, or of the cathode-ray picture tube. The scanning at the transmitting end of the system and at the receiving end must be in synchronism: that is, the position of the spot on each screen must be in the same relative place at each instant of time in order to reproduce a good picture. The pick-up-tube spot generates an electrical signal which is transmitted, received, and fed through an electrical network to the receiving tube. The receiving-tube spot generates a point of light at the fluorescent screen in accordance with this electrical signal, and this point of light moves or scans in sync with the pick-up-tube beam so that all the reproduced picture elements fall into the correct pattern of the picture on the fluorescent screen.

The reproduced picture may be smaller or larger than the one scanned at the transmitter. Relative size or magnification depends upon the relative strength of the deflecting fields at receiver and transmitter. Usually, at the transmitter, a small optical image of only three or four inches in width is projected on the pick-up-tube screen to charge up the photo-sensitive surface, but the receiving-tube image is almost always larger than this, sometimes several times larger. Synchronism is maintained through an electrical network by sending pulses at the end of each sawtooth trace, and during the retrace, to cause the scanning fields at the receiver to start at the same relative time or the same relative position as at the transmitter. Any difference in waveform of the deflection fields at transmitter and receiver will cause geometrical distortions, or non-linearity of the reproduced picture. This means that the rate of change of speed of horizontal and vertical scanning must be kept as close to zero and as constant as possible both at transmitter and receiver, aud they must be kept equal.

When an electron beam moves across the screen of a pick-up tube, the stored electrical image on the photo-sensitive surface, created by the projection of the optical image it is desired to transmit, is wiped out by impact of the electrons. This wiping-out action produces a series of electrical signals, at the output signal-plate, which are strung out in time-sequence corresponding to the picture elements along each line. Blanking signals are injected through a mixing amplifier at the end of each line and at the end of each field to complete the formation of the so-called video signal. The waveform of the video signal, usually referred to as the video wave, is shown as the portion labeled V in Fig. 1.

The system of scanning employed in television, known as rectilinear scanning, requires sawtooth waveforms of the deflecting fields. A sawtooth wave is a complex wave. Important details relative to sawtooth waves will be discussed in a later section on the subject of deflection circuits. It will suffice for present practical purposes to describe the sawtooth wave at this time. The form of a sawtooth wave was shown in Fig. 4. It consists of two linear portions, along one of which the amplitude changes linearly with time at a slow rate and, along the other of which the amplitude changes in the opposite direction with time, at a relatively fast rate. The ratio of the slopes of the linear portion of the wave depends upon the time required to execute the completion of the two portions of the cycle. The slow portion of the cycle is referred to as the *trace* and the fast portion as the *retrace*. These correspond to the trace of the electron beam across the image field during the time that the picture information is being transmitted, and to retrace of the beam from one side of the raster to the other at the completion of each line of the picture, as far as horizontal deflection is concerned. As for field deflection, they correspond to the slow, linear progress of tracing one line beneath another to form the line-structure of the picture, and to retrace of the vertical deflection-field from bottom to top of the picture at the end of each field presentation. The retrace of the field usually requires several lines for its completion, so that the beam returns from bottom to top of the picture along a relatively zigzag path during which time it oscillates from side to side of the raster. The waveform of the horizontal deflection field can be observed during the field retrace if the picture is brightened up for this purpose.

Usually, the beam current is cut off during retrace of each line and of each field, so that only the trace portions of these cycles appear on the raster. This is illustrated in Fig. 7 for a raster composed of relatively few lines, shown as wide, black and white strips. The black strips illustrate the lines which occur during the odd-numbered fields and the white strips represent the alternate lines occurring during the even-numbered fields to fill in the line structure of a complete frame. The dotted lines indicate the retrace of the beam position during the time that it is cut off. Actually, the beam itself does not return across the screen during cutoff, but only the direction which it would follow if present, directed by the deflecting field.

The deflection field changes its direction at the end of the interval of time during which the beam is cut off. When the beam is turned on again, for the trace of picture information to start, it increases in such a direction as to start the line at the left hand side of the raster at one line-width below the preceding line. It requires two deflecting fields to accomplish this result: the horizontal field which deflects the beam from side to side at a fast rate; and the vertical field which deflects the lines from top to bottom at a relatively slow, steady rate.

4. Significance of Standards ★ In order to establish an operating, commercial system of transmission of television images, it can be seen from the foregoing discussion on scanning that it is necessary to establish a set of standards for many things, and primarily in regard to the deflecting frequencies for all equipments which are scanned in the system.

These standards have been the subject of much controversy during the last fifteen years, and are still a matter of discussion in regard to television systems of the future.

The fidelity requirements of the various circuit components in a television system depend directly upon the scanning repetition rates. A computation of the required band of frequencies necessary to transmit the information contained in a television picture, therefore, must be based on the chosen system of scanning standards. These standards are based on the standards of alternating-power frequency in the locality where the images are transmitted and received. This choice is governed by the prevention of objectionable hum patterns, as has been discussed by Engstrom and others.

There are four major considerations in setting up the scanning standards for a television system. These are:

1. Hum, at the cyclic rate of the alternating-power frequency, and at its harmonics.
2. Flicker, at the field-repetition frequency of the image.
3. Continuity, due to line structure.
4. Crawl, due to the order of the interlaced fields (frame frequency).

Let us consider these four factors individually:

1. The first of these items, power frequency, is a standard which is so well intrenched in various parts of the world that no choice remains to the practical engineer but to accept it as a basis for scanning standards. One of the fundamental repetition rates in the scanning system must be chosen identically to, or as a subharmonic of, the AC frequency which is available for the operation of television receivers. Otherwise, undesirable beat-frequency patterns between the power-system frequency and the receiver image-pattern will occur when inexpensive power supply filters are included in the receiver. In Europe, this base frequency is 50 cycles; in the United States it is 60 cycles. These differences account, in the main, for the differences in scanning standards adopted, on the one hand, in England and Germany; and on the other, in the United States. The above comments apply to any portable television system having a self-contained power supply of any cyclic repetition-rate whatsoever.

2. The second item, field frequency, requires a standardization of scanning repetition-rates which is based on the physiology of the human eye, and the psychology of the human brain. The average persistence of vision is approximately .12 seconds. It is imperative, then, that the repetition rate of a scansion of the image, or field frequency, should be greater than 8 repetitions per second.

The projection of an image field at 8 cycles produces a psychological effect which is usually referred to as flicker. The threshold of flicker is somewhere around 40 cycles for images of satisfactory brilliance. The motion picture industry has adopted 48 cycles as a frequency of image projection which is free from flicker. There are individuals, however, who maintain that a flicker manifests itself to them in images alternating at a frequency of 48 cycles. This is especially true if the images are very brilliant.

So, in television, it is necessary that image projection be interrupted electrically to produce at least 48 image-field projections per second in order to avoid flicker. One solution of this problem would be to transmit 48 images per second, which would be wasteful of the frequency band required to transmit the intelligence. A better solution is the method of interrupting each frame projection by interlacing the image fields.

Thus, one image-field scansion in an interlaced television system covers the field of the image dimensionally from side to side, and from top to bottom, but contains only a fraction of the total information, or detail, of the image. Certain portions of the image are skipped in each field scansion, and these missing portions are supplied by later scansions. The entire information of the picture, then, is supplied by causing successive fields to fall in their proper positions so that each fraction of the information is received in its proper, spatial sequence. This process has been referred to as interlace.

More specifically, in an interlace system of projection of images, a number of picture elements uniformly scattered over the image field is projected during one interval of time, or field interval. The reciprocal of this interval is called the field frequency. The remainder of the picture elements is projected during successive fields, until all the information in the image has been projected. Each field includes a certain fraction of picture elements, scattered over the entire frame of the image. The reciprocal of this fraction is the number of field projections required for one complete frame projection. A frame may be defined as the projection of the complete information of an image.

In relating the psychological considerations with the power frequency, it becomes obvious that the logical rate of projection of image fields should be equal to the power frequency, where that frequency is of the order 50 to 60 cycles. Thus, the field frequency usually has been chosen to be identical with the power frequency.

3. The most satisfactory manner yet devised for electrical scanning of an image is the method of scanning the image in parallel lines. In interlaced scanning, each image-field scansion consists of an integral number of lines plus a fraction of a line. The fraction will depend upon the number of interlaced fields per frame, and upon the special sequence of these fields; i.e., upon which group of lines is selected from the frame for each field scansion. The product of the number of lines per field by the number of fields per frame, divided by the height of the image (which is at right angles to the direction of line scanning) yields a quantity which may be called the *line structure* of the image. Ordinarily, this quantity is expressed in lines per inch, and is a measure of the detail of the picture. A digression concerning line structure will be indulged in at this point.

The viewing distance of greatest resolution for the human eye is approximately 10 inches. The normal eye can resolve points whose separation subtends an angle of about one minute of arc at the eye, so that if it were possible to produce a cathode ray tube with .003-in. spot size, a television picture made up of closely packed lines, 333 per inch, would represent the practical limit of effort in regard to detail. Such a picture, viewed directly upon a fluorescent screen, would bear the closest scrutiny to which it could ever be subjected by unaided vision. Three thousandths of one inch, however, does not represent a commercially realizable spot-size if the spot is to produce any practical amount of brilliance; 10 mils is the approximate limit of line width at present in a practical design of cathode-ray tube for direct-vision (or anoptric) use, so that line structures of 100 lines per inch can be attained.

Ten mils is in keeping with present commercial tubes operated at suitable brilliance. If the television image is to be continuous, i.e., if it is to show no resolved line structure at a viewing distance of five or six feet, the line structure must be of the order of 50 lines to the inch. The number of lines per frame is then determined by the height of the picture, or the amplitude of frame scanning. For an 8- by 10-inch picture, it is necessary to scan 400 to 500 lines per frame, when using a line structure of 50.

The line repetition frequency is the product of the line structure, the frame height, and the frame repetition frequency.

4. The frame repetition frequency is obtained by dividing the field repetition frequency by the number of interlaced fields per frame. If the prime factors of the field frequency (prime factors of 60

are $2 \times 2 \times 3 \times 5$) are not also factors of the line frequency, then the number of interlaced fields will be the product of the field frequency factors not common to the line frequency. The standard line frequency is 15750 (prime factors are $2 \times 3 \times 5 \times 5 \times 5 \times 5 \times 5$).

The field-frequency factor not common to the line frequency is the number 2, so that there are two interlaces in the 525-line, 60-field system. This is known as the double-interlace system.

The double-interlace system, which is in general use throughout the world at present, employs two interlaced fields per frame. This means that there must be a factor of 2 in the field frequency which is not common to the line frequency. If there is an odd number of lines per frame and the line frequency contains all the prime factors of the frame frequency except 2, this condition will be fulfilled. Interlace in such a system is accomplished by making each field scanning-amplitude the same.

Multiple interlace systems showing N sequential interlaces are obtained by choosing the line frequency so that it does not contain a factor N contained in the field frequency.

Because of the psychological persistence of vision mentioned in a preceding paragraph, the maximum number of possible interlaces which could be used in a television system, before flicker became objectionable, is obtained from $N = P/8$, where P is the field frequency.

This number is 7 for a 60 cycle field. Seven sequential interlaces would, however, exhibit the phenomenon of "crawl." Crawl occurs when the eye begins to move at a proper rate, N lines per second, along the television image in the direction of the N-sequence scanning progression. It has been observed on images containing as few as three interlaced fields per frame. In a double-interlaced system with a line structure as great as 50 lines per inch, it is hardly noticeable. A double-interlaced picture will crawl if the line structure is too coarse. Unlike multiple-interlace pictures, however, which always crawl in the direction of sequential order, double-interlace may crawl either upward or downward if crawl can be detected at all.

This section has dealt principally with the significance of standardization in the method of constructing a television image, as these standards are related to several factors. From the foregoing discussion it can be readily appreciated that some sort of standardization was imperative so that all transmitters and receivers would present the same number of frames per second and the same number of lines per frame.

For reference in what follows, some RMA scanning standards are listed here in reference to symbols, which are defined. Average values are given for RMA standard where tolerances are allowable.

S = Line structure in lines per inch
F = Frame frequency = 30 cycles
b = Useful (or trace) fraction of the frame cycle (fraction during which picture elements are transmitted) = 93.5% nominal
P = Field frequency = 60 cycles
F′ = Line frequency = 15750 cycles
b′ = Useful (or trace) fraction of the line cycle = 83% nominal
N = Number of lines per frame = 525
h = height of picture in inches
A = Aspect ratio of picture (width/height) = 4/3

Line frequency can be expressed as the product of number-of-lines-per-frame times frame frequency:

$F' = NF = 525 \times 30 = 15{,}750$ for RMA Standards.

Next month: Part 2. Characteristics of Images. This covers such information as detail and focus, contrast and gamma, brilliance and flicker, size and shape of television images.

FM IN FOREIGN COUNTRIES

THE extent to which interest in Frequency Modulation for broadcast and communications services has spread all over the world is indicated by the subscription list of *FM* AND TELEVISION. The following list of 38 countries, plus U. S. possessions, shows the distribution of 602 subscribers. Most of these subscriptions were received since September, 1945.

Argentina	12	Ireland	1
Australia	43	Java	2
Belgium	8	Malaya	1
Brazil	8	Mexico	6
British W. Indies	1	Netherlands W. Indies	1
Canada	180	New Zealand	1
Chile	2	Norway	8
China	8	Persian Gulf	1
Cuba	16	Peru	1
Czechoslovakia	1	Portugal	1
Denmark	13	Russia	73
Egypt	2	Scotland	2
England	52	So. Africa	3
Ecuador	2	Straits Settlements	1
Finland	1	Sweden	11
France	26	Switzerland	32
Greece	1	Turkey	1
Holland	41	U. S. Possessions	29
India	7	West Africa	1
Italy	2	Total	602

This list was made up from the records of our October, 1946 issue. Since then, the number of foreign subscriptions has been increased by new orders received almost every day.

Manufacturers who are expanding their export sales will find much interesting information in an analysis of the distribution represented in these figures. It should be noted that a large part of these subscription orders are from government offices and universities.

WHAT'S NEW THIS MONTH

(CONTINUED FROM PAGE 4)

this period. But this was a depressed period for business. A much more logical basis for comparison would be the years 1926–29, when business was relatively prosperous. With these years as a base, it is found that compensation to employees increased from 1926–29 to 1946 by 90 per cent, as compared to 66 per cent for profits, while dividend payments to stockholders declined by 2 per cent.

"Demands that disregard essential facts merely arouse false hopes, create bitterness, and jeopardize industrial relations which are so badly in need of mending.

"The Nathan report contends that the only way to expand purchasing power is to raise wages but not prices, and it maintains that this can be done because of the estimated "staggering" profits. It was the same authority that made a similar proposal at the end of the war. At that time it was held that the automobile industry could give a 30 per cent wage increase without an advance in the price of cars. After a long strike, a substantial increase was granted by the industry but the consequent costs were so great that OPA permitted an increase in prices. Despite this and other increases, the industry sustained a net loss of more than $5 million for the first nine months of 1946, while the boost in car prices has caused a substantial decline in the potential market for automobiles.

" — To make demands for extravagant wage increases at this stage when there are indications of being at or near the crest of the boom is most untimely since such a procedure would aggravate distortions in purchasing power among the various groups, and might well precipitate a business recession, with its attendant heavy unemployment.

" — The public should not give support to any organization that through false propaganda attempts to grab more than its fair share of industrial gains at the expense of the rest of the community. It should be pointed out that it was the same group that initiated the wave of strikes this year which raised costs, disrupted production, and nearly wrecked the reconversion program. The road to industrial peace and higher living standards does not lie in arbitrary and exorbitant demands by special interests, whether labor or management, but in coöperation for increased productivity, which is the source of greater wage payments and higher income for business, as well as revenue for the Government."

To bring these remarks home to the radio industry, you can make your own estimate of increased retail prices on sets

(CONCLUDED ON PAGE 54)

FM BROADCAST STATIONS ON THE AIR

Corrected to January 25, 1947—Asterisk Indicates Low-Band Frequency

ALABAMA

BIRMINGHAM
WAFM Voice of Alabama WAPI 94.3

CALIFORNIA

FRESNO
KRFM J. E. Rodman KFRE 102.3
LOS ANGELES
KHJ-FM Don Lee Bcstg. System KHJ 99.7
RICHMOND
KRCC Contra Costa Bcstg. Co. 104.7
RIVERSIDE
KPOR Bcstg. Corp. of Amer. KPRO 102.1
SACRAMENTO
KANY McClatchy Bcstg. Co. KFBK 102.5
SAN DIEGO
KFMB-FM Jack Gross Bcstg. Co. KFMB 100.5
SAN FRANCISCO
KRON Chronicle Pub. Co. 96.1
KJBS-FM KJBS Broadcasters KJBS 98.5
STOCKTON
KGDM-FM E. F. Peffer KGDM 101.3

CONNECTICUT

HARTFORD
WTIC-FM Travelers Bcstg Serv. Corp. WTIC 106.7 *45.3
WDRC-FM WDRC Inc. (*46.5) WDRC 106.3

DISTRICT OF COLUMBIA

WASH Com. Radio Equip. Co. 98.9
WINX-FM WINX Bcstg. Co. (*43.2) WINX 92.9

FLORIDA

MIAMI
WQAM-FM Miami Bcstg. Co. WQAM 95.5
WIOD-FM Isle of Dreams Bcstg. Co. WIOD 97.5
MIAMI BEACH
WKAT-FM A. F. Katzentine WKAT 96.7
PALM BEACH
WWPG-FM Palm Beach Bcstg. Corp. WWPG 97.9
PENSACOLA
WCOA-FM Pensacola Bcstg. Co. WCOA 92.9

GEORGIA

COLUMBUS
WRBL-FM Columbus Bcstg. Co. WRBL 96.7
WGBA Ga.-Ala. Bcstg. Corp. 96.3
MACON
WBML-FM Middle Ga. Bcstg. Co. WBML 102.3
WMAZ-FM Southeastern Bcstg. Co. WMAZ 101.9
SAVANNAH
WSAV-FM WSAV, Inc. WSAV 98.9
WTOC-FM Savannah Bcstg. Co. WTOC 98.5

IDAHO

BOISE
KIDO-FM KIDO Inc. KIDO 102.1

ILLINOIS

CHICAGO
WBBM-FM CBS Inc. WBBM 99.3
WDLM Moody Bible Inst. WMBI 99.7
WGNB WGN Inc. (*45.9) WGN 98.9
WEFM Zenith Radio Corp. (*45.1) 98.5
DECATUR
WSOY-FM Commodore Bcstrs. Inc. WSOY 98.7
FREEPORT
WFJS Journal-Standard Pub. Co. 102.1
MT. VERNON
WMIX Mt. Vernon Radio & Telev. 103.7

INDIANA

EVANSVILLE
WMLL Evansville on the Air WGBF 94.7
FT. WAYNE
WOWO-FM West'hse Radio Stations WOWO 95.9 *44.9
INDIANAPOLIS
WABW Assoc. Bcstrs. WBBW *47.3
SOUTH BEND
WSBF South Bend Tribune WSBT 101.3

IOWA

BURLINGTON
KBUR-FM Burlington Bcstg. Co. KBUR 99.3

KANSAS

TOPEKA
KTJS Topeka State Journal 102.9
WIBW-FM Topeka Bcstg. Assn. WIBW 102.5

KENTUCKY

PADUCAH
WPAD-FM Paducah Bcstg. Co. WPAD 96.9

LOUISIANA

ALEXANDRIA
KPDR-FM Central La. Bcstg. Co. KPDR 100.5
BATON ROUGE
WBRL Baton Rouge Bcstg. Co. WJBO 96.1
NEW ORLEANS
WRCM Supreme Bcstg. Co. WJMR 95.3
WTPS-FM Times Picayune Pub. Co. WTPS 94.5
WWLH Loyola Univ. WWL 94.9

MARYLAND

BALTIMORE
WITH-FM Maryland Bcstg. Co. WITH 102.5

MASSACHUSETTS

BOSTON
WBZ-FM West'hse Radio Stations WBZ 100.7 *46.7
NEW BEDFORD
WFMR E. Anthony & Sons 97.3
PAXTON
WGTR Yankee Network *44.3 WNAC 103.1
SPRINGFIELD
WBZA-FM West'hse Radio Stations WBZA 97.1 *48.1
WORCESTER
WTAG-FM WTAG Inc. WTAG 102.7

MICHIGAN

BATTLE CREEK
WELL-FM Federated Pub. Inc. WELL 102.1
BAY CITY
WBCM-FM Bay City Bcstg. Co. WBCM 97.9
DETROIT
WLOU Booth Radio Sta. Inc. WJLB 96.5
WENA Evening News Assn. (*44.5) WWJ 96.9

MINNESOTA

MINNEAPOLIS
WTCN-FM Minneapolis Bcstg. Corp. WTCN 97.1
ROCHESTER
KROC-FM Southern Minn. Bcstg. Co. KROC 94.7
ST. PAUL
KSTP-FM KSTP Inc. KSTP 102.1

MISSOURI

JOPLIN
WMBH-FM Joplin Bcstg. Co. WMBH 102.3
KANSAS CITY
KOZY Com. Radio Equip. Co. 99.9
KMBC-FM Midland Bcstg. Co. (*46.5) KMBC 97.9
ST. LOUIS
WIL-FM Missouri Bcstg. Corp. WIL 92.1
KWK-FM Thomas Patric, Inc. KWK 95.3

NEBRASKA

OMAHA
KOAD World Pub. Co. KOWH 92.5

NEW HAMPSHIRE

MT. WASHINGTON
WMTW Yankee Network (*43.9) 98.1

NEW JERSEY

ALPINE
W2XEA E. H. Armstrong 92.1
W2XMN E. H. Armstrong *44.1

NEW YORK

BINGHAMTON
WNBF-FM W. B. Jones Advt. Agency WNBF 96.3 *44.9
BUFFALO
WBEN-FM WBEN Inc. WBEN 92.1
WEBR-FM WEBR Inc. WEBR 92.5
HORNELL
WWHG W. H. Greenhow Co. 99.9
ITHACA
WHCU-FM Cornell Univ. WHCU 101.3
NEW YORK CITY
WNYC-FM City of New York WNYC 95.3
WCBS-FM CBS Inc. WCBS 96.9
WGHF W. G. H. Finch 99.7
WQXQ Interstate Bcstg. Co. (*45.9) WQXR 97.7
WMGM Marcus Loew Bkg. Agency WHN 99.3
WABF Metropolitan Telev. Inc. 98.5
WGYN Muzak Bcstg. Sta. Inc. 96.1
WNBC-FM NBC Inc. WNBC 97.3
ROCHESTER
WHFM Stromberg-Carlson Co. (*45.1) WHAM 98.9
WHEF WHEC Inc. (*44.7) WHEC 96.9
ROME
WRUN Rome Sentinel Co. 98.3
SCHENECTADY
WBCA Capitol Bcstg. Co. (*44.7)
WGFM General Electric Co. (*48.5) WGY 100.7
SYRACUSE
WSYR-FM Central N. Y. Bcstg. Corp. WSYR 93.5
TROY
WTRI Troy Bcstg. Co. WTRY 102.3
UTICA
WIBX-FM WIBX Inc. WIBX 97.9
NIAGARA FALLS
WHLD-FM Gazette Pub. Co. WHLD 95.7

NORTH CAROLINA

BURLINGTON
WBBB-FM Alamance Bcstg. Co. WBBB 101.3
GOLDSBORO
WGBR-FM East. Car. Bcstg. Co. WGBR 99.7
HIGH POINT
WMFR-FM Radio Station WMFR WMFR 97.7
RALEIGH
WRAL-FM Capitol Bcstg. Co. WRAL 95.3
WINSTON-SALEM
WMIT Gordon Gray (*44.1) WSJS 97.3

OHIO

CANTON
WCMW-FM Stark Bcstg. Co. WCMW 96.3
CINCINNATI
WLWA Crosley Bcstg. Corp WLW 98.1
COLUMBUS
WELD RadiOhio Inc. (*44.5) WBNS 94.5
FOSTORIA
WFOB Laurence W. Harry 105.1
FREMONT
WFRO R. F. Wolfe Co. 104.7
TOLEDO
WTOD-FM Unity Corp. WTOD 97.7
WARREN
WRRN-FM Nied & Stevens WRRN 104.3

OKLAHOMA

MUSKOGEE
KMUS Muskogee Bcstg. Co. 92.1
OKLAHOMA CITY
KTOK-FM KTOK Inc. KTOK 100.5
KOCY-FM Plaza Court Bcstg. Co. KOCY 98.5
WKY-FM WKY Radiophone Co. WKY 98.9

OREGON

PORTLAND
KGW-FM Oregonian Pub. Co. KGW 95.3
KPRA Pac. Radio Advt. Serv. 95.7
KPFM Bcstrs. Oregon Ltd. 94.9

PENNSYLVANIA

HARRISBURG
WHP-FM WHP Inc. WHP 97.3
PHILADELPHIA
WPEN-FM Wm. Penn Bcstg. Co. WPEN 99.5
WIP-FM Penn. Bcstg. Co. WIP 97.5
WCAU-FM WCAU Bcstg. Co. WCAU 102.7
KYW-FM West'hse Radio Sta. (*45.7) KYW 100.3
WFIL-FM Triangle Pubs. (*45.3) WFIL 99.9
PITTSBURGH
KDKA-FM West'hse Radio Sta. KDKA 92.9
WMOT WWSW Inc. (*47.5) WWSW 94.5
LANCASTER
WEAX Peoples Bcstg. Co. WLAN 92.3
WGAL-FM WGAL Inc. WGAL 92.7
WILKES-BARRE
WIZZ Scranton-Wilkes-Barre-Pittston Bcstg. Co. 103.3

SOUTH CAROLINA

SPARTANBURG
WSPA-FM Spartanburg Advt. Co. WSPA 92.1

TENNESSEE

CHATTANOOGA
WAPO-FM WAPO Bcstg. Sys. WAPO 97.9
JACKSON
WTJS-FM Sun Pub. Co. WTJS 95.1
KNOXVILLE
WROL-FM S. E. Adcock WROL 93.1

TEXAS

DALLAS
KERA A. H. Belo Corp. WFAA 94.3
HOUSTON
KOPY Texas Star Bcstg. Co. KTHT 98.5
KPRC-FM Houston Ptg. Corp. KPRC 99.7
SAN ANTONIO
KISS Walmac Co. KMAC 100.1
KYFM Express Pub. Co. 101.5
WOAI-FM Southland Industries WOAI 102.3
TEXARKANA
KCMC-FM KCMC Inc. KCMC 92.5
WICHITA FALLS
KTRN Times Pub. Co. 97.7

UTAH

SALT LAKE CITY
KSL-FM Radio Serv. Corp. of Utah KSL 100.1

VIRGINIA

HARRISONBURG
WSVA-FM Shenandoah Valley Bcstg. Corp. WSVA 94.3
PORTSMOUTH
WSAP-FM Portsmouth Radio Corp. WSAP 94.7
RICHMOND
WCOD Havens & Martin Inc. WMBG 92.5
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MAGNETRON: GENERATOR OF CENTIMETER WAVES

The Theory of the Magnetron, and Its Development as a Practical Means for Generating Centimeter Waves—5th Installment

BY J. B. FISK, H. D. HAGSTRUM, AND P. L. HARTMAN

As n goes from 9 down to 5, the distribution in mode frequency appears as a distribution should for which the mode periodicity increases. The two branches of the mode frequency distribution curve thus appear as approximate mirror images which are shifted relative to one another along the frequency scale by virtue of the difference in phase of the mutual coupling between the two sets of resonators. As far as frequency is concerned, the π mode of the total system has the characteristics of a mode whose field pattern is independent of angle, and its frequency is well separated from those of other modes.

As in the case of both unstrapped and strapped symmetrical resonator systems, equivalent circuits have also been devised and studied for the rising sun structure. Suffice it to say here concerning them that in each case it has been possible to explain and predict the mode frequency behavior to a surprising degree of accuracy.

As a magnetron resonator, the rising sun system has both advantages and disadvantages. Its most obvious advantages are its lack of strapping with consequent ease of construction for short wavelengths, and the ability to make an anode structure of any length with no penalty in mode frequency separation. Although the frequency separation of the π mode from other modes is not as great as is possible in strapped magnetrons, its independence of anode length and the fact that it can be realized at higher values of N are both important for high-power magnetrons. Furthermore, the rising sun structure, having no strap losses, possesses an inherently higher unloaded Q than strapped resonator systems. This results in an improvement in circuit efficiency by a factor which may be as high as 1.2 at 1.25 cm. wavelength.

The major disadvantage of the rising sun resonator system is the presence in its π mode interaction field of a strong admixture of a component independent of angle. How this comes about can be seen from the following considerations: The π mode frequency of the composite resonator system lies somewhere between the free oscillation frequencies of the large and small resonators. When oscillating in the π mode, therefore, the large resonators are longer and the small resonators shorter than an equivalent quarter-wavelength. Said another way, the electrical distance from the back of a large resonator to its opening in the anode, across the segment face, and to the back of the adjacent small resonator is an electrical half-wavelength along which the voltage and current vary approximately sinusoidally. For this reason the maximum in the RF voltage and the corresponding current node do not appear at the mouth of either cavity but at a point (M of Fig. 28) somewhat inside the opening of the large cavity. This means that the electric field across the mouth of the larger cavity is greater than that across the mouth of the smaller cavity. The excess, since all the large cavities are in phase, adds up around the anode to form an electric field component independent of angle, like the $n = 0$ mode field in Fig. 23. Further, it is seen in Fig. 28 that at any instant there are currents flowing across the faces of the anode segments which are all in the same direction around the anode. With this net circumferential current is associated the unidirectional RF magnetic field component parallel to the axis shown also in Fig. 23.

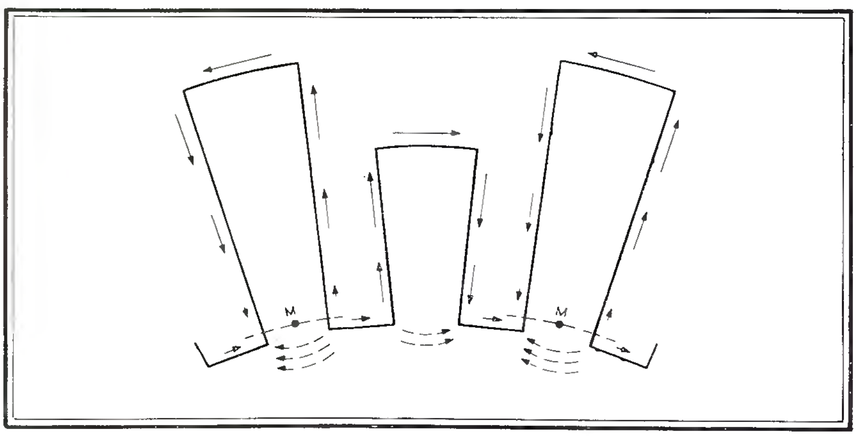

FIG. 28. A diagram illustrating the origin of the component independent of angle in the π mode interaction field of the rising sun resonator system. The length of the arrow lying parallel to and just inside the resonator wall at any point is proportional to the magnitude of the RF current flowing there. The RF current node, and hence RF voltage maximum, occurs at M, inside the mouth of the larger cavity. Note that this gives rise to currents flowing in the faces of the anode segments which are in the same direction around the interaction space, and that the RF field strength across the mouth of a larger cavity is greater than that across the mouth of a smaller cavity. This latter is indicated schematically by means of the dashed arrows.

The amount by which the two sets of mode frequencies of the rising sun structure are separated increases with increasing ratio of resonator sizes. Corresponding to this, the amount of $n = 0$ like component in the interaction field increases.

The presence of the component independent of angle in the interaction field is thus an inherent characteristic of the rising sun resonator system. One is faced with the problem of designing for sufficient mode separation without unduly increasing this component. How the presence of this component in the interaction field perturbs the electronic interaction with the π mode, resulting in a performance characteristic like that of Fig. 20, has already been discussed.

8. Output Circuit & Load ★ 8.1 *Output Circuit:* In the general physical description of the centimeter-wave magnetron whose constituent parts are shown in Fig. 1, there remains the discussion of the output circuit. The output circuit is the means of coupling the fields of the magnetron resonator to the load and, as such, it must contrive to induce a voltage across a coaxial line or a waveguide to which the load circuit is connected. Several types of coupling are involved in magnetron construction. These are illustrated schematically in Fig. 29. Here the resonator of the magnetron is represented by a simple $L-C$ circuit and any transformer action of the output circuit between the resonator and the load is to be accounted for by the unspecified network T. The scheme of Fig. 29 (a) involves magnetic coupling, that of (b), electrostatic coupling, those of (c) and (d), two forms of direct coupling.

Type (a), it is clear, corresponds to the output coupling accomplished by a loop, like that shown in Fig. 1, feeding a coaxial line. The loop may be placed inside the cavity as in Fig. 1, may be placed above the resonator in the end space as in the case of the so-called *halo* loop, or may be placed with its plane parallel to the axis of the anode between the resonators in the end space. In each case the coupling is effected mainly by linking of magnetic lines of force by the loop. The coupling is not entirely magnetic, however. There is electrostatic induction in the loop by the anode segments near it, corresponding to coupling of type (b) of Fig. 29, and in the case of the third possible placement of the loop listed above, there is involved some direct coupling of the type (c) of Fig. 29, since the loop is terminated on an anode segment on which there is RF potential.

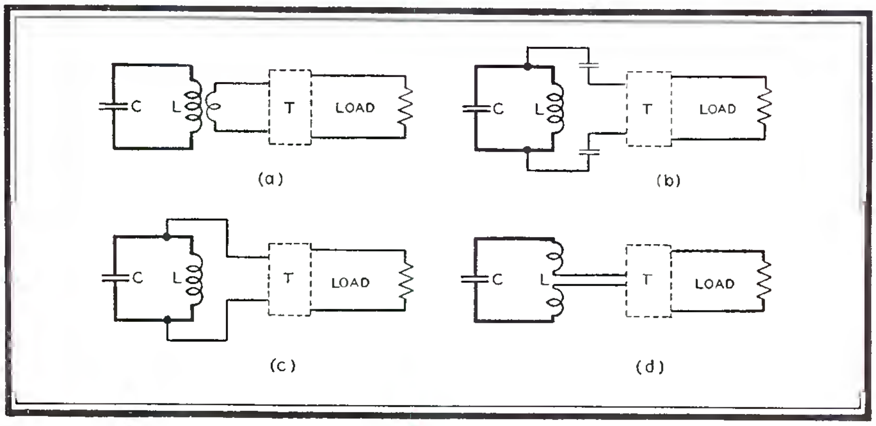

FIG. 29. Schematic circuit diagrams representing four types of output couplings. Type (*a*) is magnetic coupling, (*b*), electrostatic, (*c*) and (*d*), two forms of direct coupling. The unspecified network T represents the output circuit between the points where it couples to the resonator system and the load.

In most cases the coaxial line must expand in dimensions from the loop extremity, pass through the vacuum envelope, and be provided with a means of coupling to the coaxial load line of the system in which the magnetron is used. The output circuit from the loop to the smooth line of the system must provide the transformer action necessary to load the loop by an admittance which gives the desired Q. See equation (23). What this admittance must be is dependent, to be sure, on the size and position of the loop, that is, upon the degree to which it couples the magnetic lines in the resonator. Generally, the attempt is made to build the transformer into the magnetron, preferably inside the vacuum envelope where any large standing waves present are less likely to cause RF voltage breakdown.

The type of magnetron output circuit represented schematically by Fig. 29 (d) is the so-called waveguide output. Here one of the resonators is broken into by means of a slit as shown in Fig. 30. Attached to this slit is a transforming section which feeds directly into the load waveguide. The impedance R at the resonator, presented by the output circuit, must be small. The characteristic impedance Z_0 of the waveguide is large. The transformer usually consists of a quarter-wavelength section of characteristic impedance equal to the geometric mean of R and Z_0, $\sqrt{RZ_0}$. The vacuum seal is made by a dielectric window in the waveguide. The quarter-wave transformer section may be a parallel plate transmission line cut in the resonator block or may be a waveguide line of rectangular or dumbbell-shaped cross section. Here again, the specific amount of its transformer action must be adjusted, usually by variation of the small dimension, until it provides the proper value of Q_{ext}.

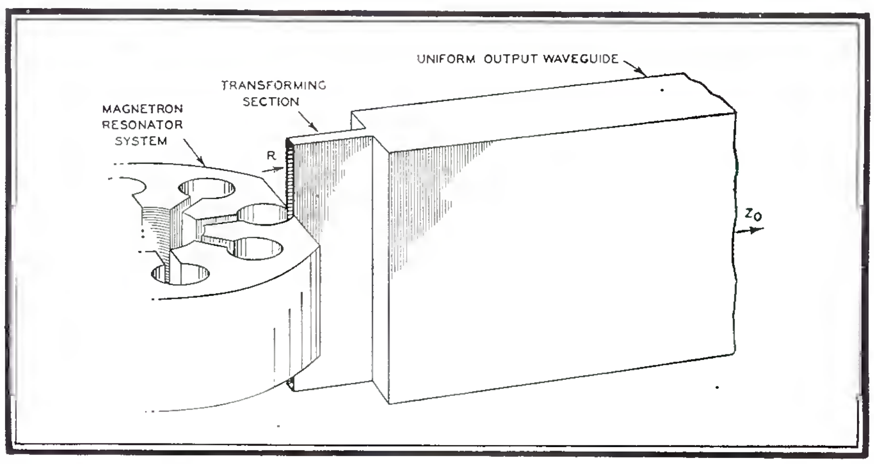

FIG. 30. An example of a type of waveguide output circuit. It is representative of the type of coupling of Fig. 29 (*d*). Other types of resonator systems may be used (compare Fig. 26), and the transforming section, for example, may be of dumbbell-shaped cross section rather than of rectangular cross section as shown.

Another type of output circuit involves coupling a coaxial line directly onto the straps. This represents practically a pure case of the type of coupling shown in Fig. 29 (c).

8.2 *Load:* The load admittance which the output line presents to the output circuit of the magnetron oscillator depends upon the characteristic admittance Y_0 of the line and upon the manner in which the line is terminated. In discussing the single resonator of the magnetron resonator system as a section of lossless transmission line terminated by a short circuit, the input admittance and its relation to the standing waves on the line were mentioned. Since the termination reflects all the energy incident upon it in the shorted line, the voltage standing-wave ratio σ, defined as the ratio of the maximum voltage to the minimum voltage along the line, is infinite. The input admittance of a shorted section of length ℓ has been given in equation (26).

In the general case in which the line is terminated by an admittance Y_T, not all the energy incident upon the termination is reflected, the standing wave, whose position is determinated by the phase of Y_T, has a finite avlue of σ greater than unity, and the input admittance is given by the expression

$$Y = Y_0 \frac{Y_T + jY_0 \tan \frac{2\pi\ell}{\lambda}}{Y_0 + jY_T \tan \frac{2\pi\ell}{\lambda}}. \quad (29)$$

If the voltage reflection coefficient $\vec{r}$ is defined as the ratio of the complex voltage amplitudes of the reflected and incident waves A_R and A_I,

$$\vec{r} = \rho e^{j\phi} = \frac{A_R}{A_I},$$

the standing wave ratio can be written

$$\sigma = \frac{|A_I| + |A_R|}{|A_I| - |A_R|} = \frac{1+\rho}{1-\rho},$$

and the input admittance Y expressed as

$$Y = Y_0 \frac{1-\vec{r}}{1+\vec{r}}.$$

Conversely:

$$\vec{r} = \rho e^{j\phi} = \frac{\sigma - 1}{\sigma + 1} e^{j\phi} = \frac{1 - Y/Y_0}{1 + Y/Y_0}. \quad (30)$$

If the line is matched, that is, terminated in its characteristic admittance $Y_T = Y_0$, it is clear that the input admittance Y is equal to Y_0, the voltage reflection coefficient $\vec{r}$ is zero and the voltage standing-wave ratio σ is unity.

These concepts are recalled here because they are used in specifying the magnetron load. The remaining point of interest with respect to admittance relationships on transmission lines is the transformation of admittance which occurs in going through a line of variable characteristics such as the output circuit of the magnetron. Such a section of nonuniform line may in general be considered as a lossless transducer, the admittance transformation through which is expressed as a bilinear from. In terms of the reflection coefficient $\vec{r_2}$ looking into the load at the output terminals of the transducer, the reflection coefficient $\vec{r_1}$, looking into the transducer at its input terminals, can be written thus:

$$\vec{r_1} = e^{-j\vec{\alpha}_{12}} \frac{\beta_{12} + \vec{r_2}\, e^{j\vec{\alpha}_{21}}}{1 + \beta_{12}\vec{r_2}\, e^{j\vec{\alpha}_{21}}}. \qquad (31)$$

In this expression the number β_{12} and the angles $\vec{\alpha}_{12}$ and $\vec{\alpha}_{21}$ are the three parameters completely describing the transducer, which for lossless transducers, are real numbers.

9. Equivalent Circuit Theory ★ 9.1 *The Equivalent Circuit:* From time to time in the discussion thus far, reference has been made to a lumped constant circuit or circuits which can be considered equivalent to the resonator system, output circuit, and load of the magnetron oscillator. One is now in a position to appreciate the justification for the use of such a simple, singly-resonant circuit to represent as complex a device as the magnetron. As has been pointed out, this justification lies in the ability to separate the mode frequencies and to diminish sufficiently well the excitation of all modes except the π mode. Further, in the discussion of the equivalent circuit shown in Fig. 2, it was pointed out how the output circuit and the electronics can be treated by circuit analysis. This particular equivalent circuit will now be discussed in some detail. From an analysis of this circuit it will be explained how the power which the magnetron delivers and the frequency at which it oscillates depend upon the load attached to it.

Consider now the equivalent circuit shown in Fig. 2, or as repeated in Fig. 31 (a). Since the N cavities of which the magnetron resonator system is composed are essentially in parallel for the π mode, the C of the equivalent circuit is N times the capacitance and the L is $1/N$ times the inductance of a single cavity. G_c is the shunt conductance representing the series resistance in the copper walls of the resonator system L_0, the inductance of the output loop which is coupled by the mutual inductance M to the lumped inductance of the equivalent resonating circuit. Z_L represents the impedance of the load at the loop terminals. Thus it represents the load impedance to which the magnetron is attached, transformed through the output circuit to the loop terminals.

The first step in understanding the circuit of Fig. 31 (a) is to reduce it to a simpler form. This is done in two steps as shown in Fig. 31. The inductances L and L_0, with mutual inductance M between them, form a transformer through which the impedances in the secondary circuit $j\omega L_0$ and Z_L are reflected into the primary circuit. It can be shown[21] that the circuit of Fig. 31 (b) is the equivalent of that of Fig. 31 (a). The coupling into the primary circuit is represented by an ideal transformer connected across the primary inductance L to the secondary winding of which are connected the load impedance Z_L and a reduced loop reactance

$$X_0 = j\omega L_0\left(1 - \frac{M^2}{LL_0}\right).$$

The ideal transformer effects a voltage transformation of L/M:1 or an admittance transformation of $(M/L)^2$:1 from its secondary to its primary terminals. Thus, the admittance Y''_L, presented at the primary terminals of the ideal transformer, is

$$\begin{aligned} Y''_L &= G''_L + jB''_L \\ &= (M/L)^2\,(1/X_0 + Z_L) = (M/L)^2\, Y'_L \\ &= (M/L)^2\,(G'_L + jB'_L) \qquad (32) \end{aligned}$$

in terms of the admittance Y'_L at the secondary terminals.

The equivalent circuit has now been reduced to that of Fig. 31 (c) used earlier in the discussion of a single resonator of the magnetron resonator system. Each of the quantities defined or derived for this circuit is now to be applied to the magnetron resonator system as a whole. These include the characteristic admittance of the resonator Y_0, the unloaded, loaded, and external Qs given by the relations (21), (22), and (23), and the circuit efficiency η_c of equation (25).

Looking to the left at the terminals AB into the electron stream, one sees the electronic admittance $Y_e = G_e + jB_e$. This is defined in terms of the current I_{RF} induced in the anode segments by the electrons moving in the interaction space, and the RF voltage V_{RF} appearing across the resonators, that is, across the terminals AB of Fig. 31 (c). Looking into the circuit at the terminals AB one sees the admittance Y_s.

This admittance by equations (19) and (32) is

$$\begin{aligned} Y_s &= G_c + j2Y_{0c}\frac{\omega - \omega_0}{\omega_0} + Y''_L \\ &= G_c + j2Y_{0c}\frac{\omega - \omega_0}{\omega_0} + \left(\frac{M}{L}\right)^2 (G'_L + jB'_L). \qquad (33) \end{aligned}$$

The condition for oscillation stated earlier requires that:

$$Y_e + Y_s = 0,$$

or:

$$G_e + jB_e + G_c + j2Y_{0c}\frac{\omega - \omega_0}{\omega_0} + \left(\frac{M}{L}\right)^2 (G'_L + jB'_L) = 0. \qquad (34)$$

Separating real and imaginary parts, this reduces to the pair of equations:

$$\left.\begin{aligned} &G_e + G_s = 0, \text{ or, } G_e + G_c + \left(\frac{M}{L}\right)^2 G'_L = 0, \\ &B_e + B_s = 0, \text{ or, } B_e + 2Y_{0c}\frac{\omega - \omega_0}{\omega_0} + \left(\frac{M}{L}\right)^2 B'_L = 0. \end{aligned}\right\} \qquad (35)$$

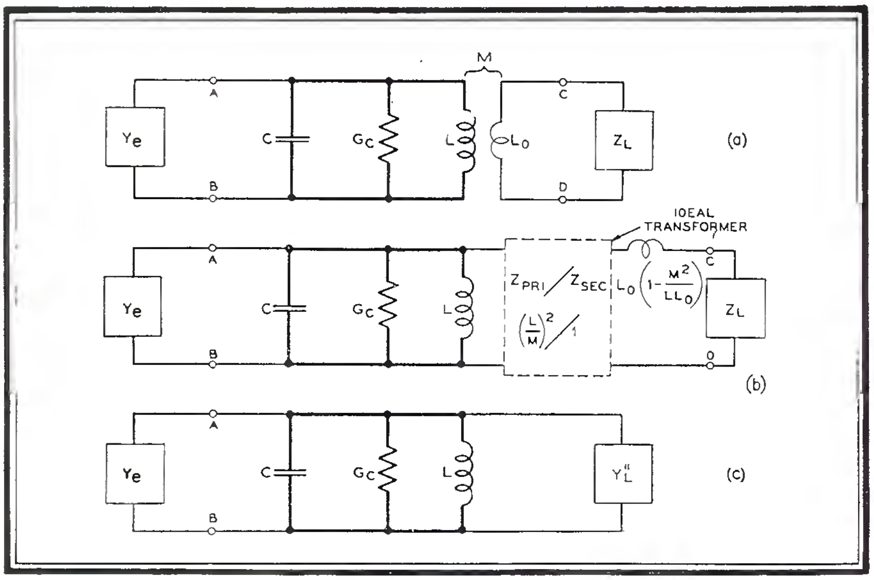

FIG. 31. A diagram showing an equivalent RF circuit for the magnetron oscillator, (*a*), and how this circuit may be reduced in two steps, (*b*) and (*c*), to a simpler form.

[21] See Guillemin, Communications Networks, Vol. II, p. 154.

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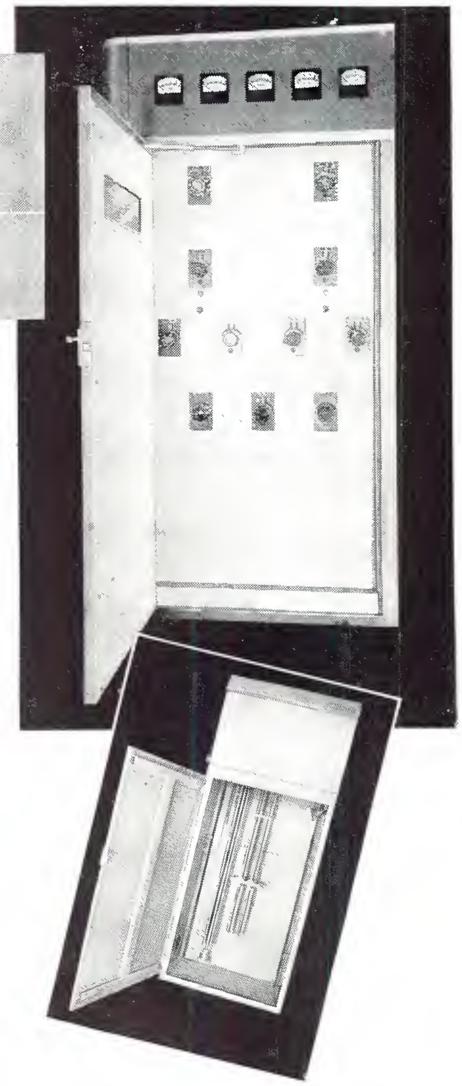

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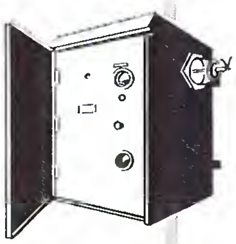

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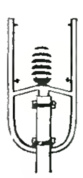

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Since $(M/L)^2\, G'_L$ is equal to G''_L, one can write the first of equations (35) in terms of the Qs defined by (21), (22), (23) and (24) thus:

$$-G_e = G_s = Y_{0c}\left(\frac{1}{Q_0} + \frac{1}{Q_{ext}}\right) = \sqrt{\frac{C}{L}}\,\frac{1}{Q_L}. \qquad (36)$$

9.2 *The Rieke Diagram:* The electronic conductance and susceptance, being functions of the parameters such as V_{RF}, V, and B which govern the electronic behavior of the magnetron, are not known *a priori* except for the fact that they are undoubtedly slowly varying functions of frequency. The circuit conductance and susceptance are given by equation (33). Equations (35) state that the circuit conductance and susceptance must be the negative of the electronic conductance and susceptance respectively. It is from these relations that the behavior of the oscillator under changes of load is to be inferred.

Suppose now that one were to vary the load in such a way that only B'_L changes, G'_L remaining constant. Then, by the first of equations (35), G_s and hence G_e would not change. If, further, the frequency of oscillation changes such that

$$2Y_{0c}\frac{\Delta\omega}{\omega_0} + \left(\frac{M}{L}\right)^2 \Delta B'_L = 0, \qquad (37)$$

by equations (35) B_s and hence B_e remain constant as well, and the electronic operation of the magnetron involving the RF voltage V_{RF} is undisturbed. Since the power delivered by the magnetron is

$$P = -\,G_e V_{RF}^2 = G_s V_{RF}^2, \qquad (38)$$

contours of constant G'_L on a plot of performance versus load, Fig. 32 (a), are thus contours of constant output power. Along any such constant power contour the frequency of the magnetron varies linearly with B'_L as equation (37) indicates. Hence any constant frequency contour on the diagram is obtainable from a neighboring contour of different frequency through translation in the direction of B'_L by an amount given by equation (37). The form of the contours of constant frequency depends upon the interdependence of the electronic parameters G_e and B_e. The fundamental electronic performance as a function of load is specified by the conductance G_s presented to the electrons at the anode slots, changes in load susceptance being compensated for by frequency changes and hence susceptance changes in the resonator. As G'_L is varied G_s, G_e, and the output power must vary as well. If B_e is independent of these changes, the constant frequency contours will correspond to lines of constant B'_L. Actually it is found that B_e does depend to some extent on G_e, resulting in the constant frequency contours on the $G'_L - B'_L$ plot being approximately straight lines inclined to the constant B'_L lines at a small angle α as shown in Fig. 32 (a).

If the $G'_L - B'_L$ plane is transformed to the reflection coefficient or $\vec{r}$ plane on which the load characteristic is usually plotted, contours of constant G'_L or power become circles tangent to the circle $\rho = 1$ at the same point. Constant B'_L contours form the set of circles orthogonal to these. The contour of constant frequency of Fig. 32 (a) transforms to a circle which intersects all the contours of constant power at the angle α.

Fig. 32 (b) is thus the form of the characteristic depicting the dependence of magnetron performance on load, called the Rieke diagram, plotted for that point in the equivalent circuit where the admittance looking out into the load is $Y'_L = G'_L + jB'_L$. Between this point and a point in the smooth output line, with respect to which the load admittance is usually measured, there is the series reactance X_o and the output circuit of the magnetron, forming a transducer through which the reflection coefficient defining the load admittance can be transformed by the expression (31). In undergoing such a transformation, the contours of constant power and frequency plotted on the $\vec{r}$ plane retain their general form, although they may be rotated and expanded or contracted. Thus the general form of the Rieke diagram shown in Fig. 32 (b) should be the same as that experimentally determined and plotted on a reflection coefficient plane for a point in the output line. Fig. 33 is such a Rieke diagram, and its resemblance to that of Fig. 32 (b) is apparent.

9.3 *Magnetron Circuit Parameters:* The fact that the circuit theory of the magnetron based on the simple equivalent circuit of Fig. 31 (a) explains the nature of the Rieke diagram so well is ample

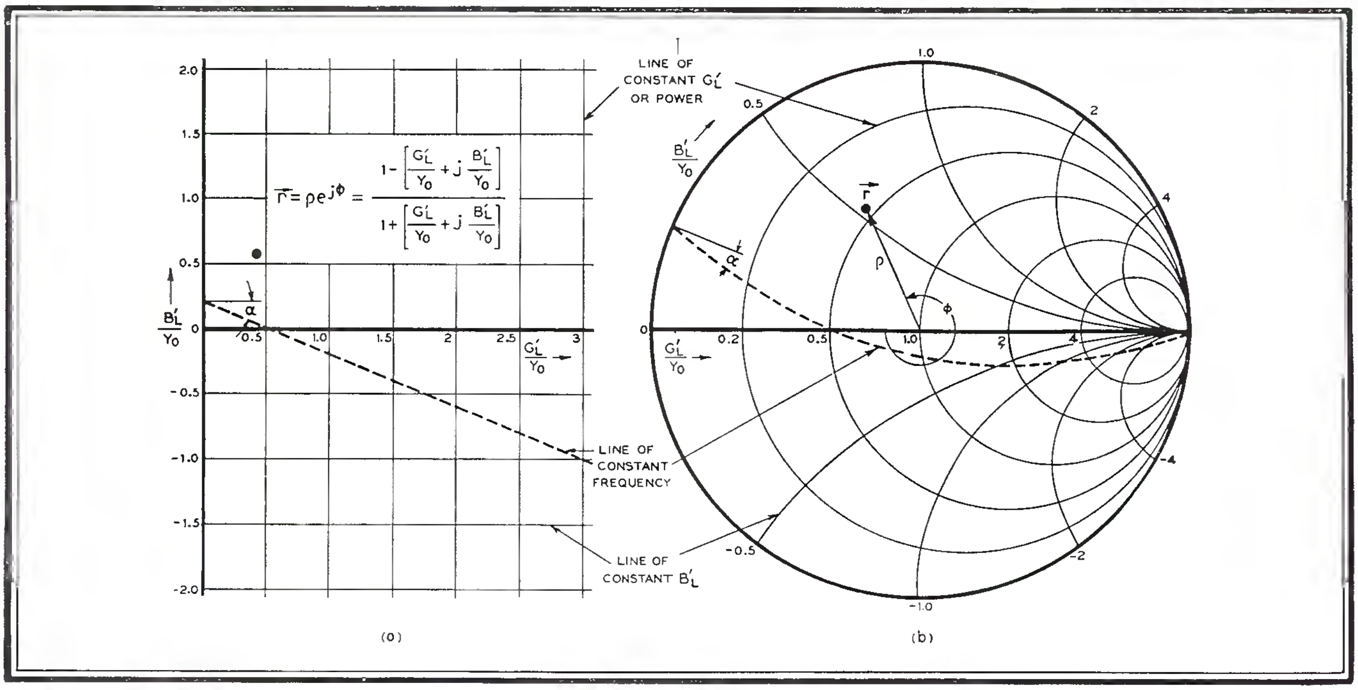

FIG. 32. Charts showing how the G'_L–B'_L plane of (*a*) transforms to the $\vec{r}$ plane of (*b*) under the bilinear transformation written out in the upper half of chart (*a*). A line of constant magnetron frequency is shown plotted on chart (*a*) and in its transformed position on chart (*b*). Note that all the straight lines of (*a*) become circles in (*b*) with angles of intersection preserved. Note also the transformation of the admittance point represented by the filled circle. The configuration of constant G'_L lines, corresponding to constant output power, and constant f lines shown on chart (*b*) is to be compared with the experimental Rieke diagram of Fig. 33.

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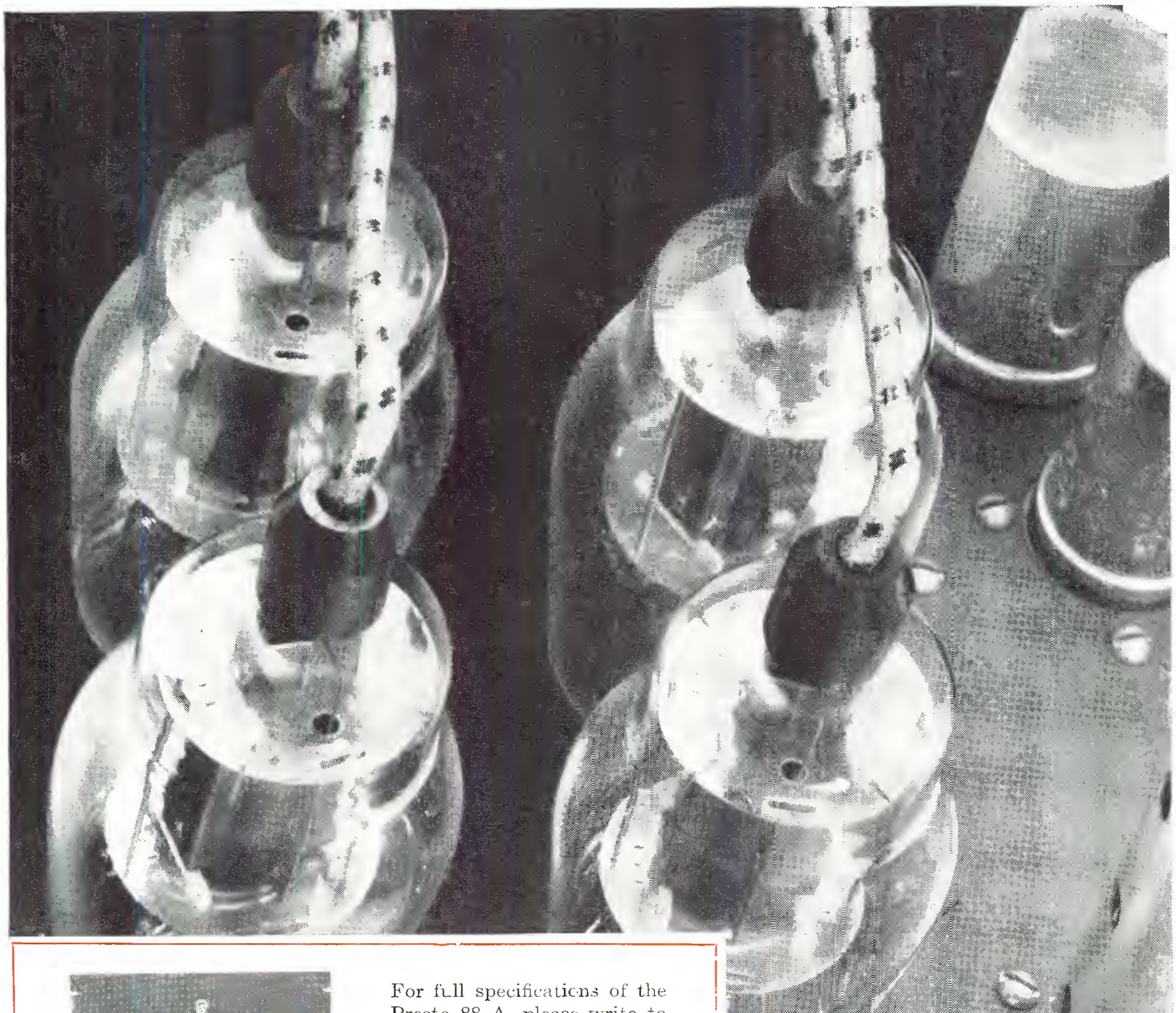

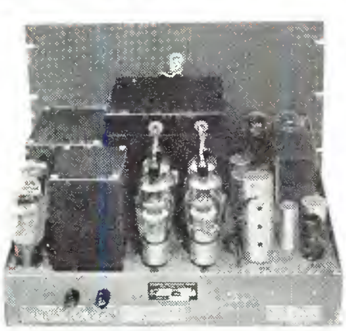

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WORLD'S LARGEST MANUFACTURER OF INSTANTANEOUS SOUND RECORDING EQUIPMENT & DISCS justification for its use. The parameters which specify the equivalent magnetron circuit can be determined as a function of frequency by a measurement of the impedance Z_c looking into a non-oscillating magnetron through its output circuit and an independent measurement or calculation of one of the parameters such as C or Y_{0c}. The impedance Z_c in terms of the equivalent circuit is the impedance across the terminals CD in Fig. 31 (a), looking to the left with the terminals AB open-circuited. From the circuit of Fig. 31 (b), this is seen to be

$$Z_c = j\omega L_0\left(1 - \frac{M^2}{LL_0}\right) + \left(\frac{M}{L}\right)^2\left[\frac{1}{G_c + j2Y_{0c}\dfrac{\omega - \omega_0}{\omega_0}}\right] \quad (39)$$

which, using equation (21), becomes

$$Z_c = jX_0 + \left(\frac{M}{L}\right)^2 \frac{1}{Y_{0c}}\left[\frac{1}{\dfrac{1}{Q_0} + j2\dfrac{\omega - \omega_0}{\omega_0}}\right] = R_c + jX_c. \quad (40)$$

The experimental data can be given in terms of the values of R_c and X_c, plotted as functions of ω as shown in Fig. 34. The value of X_0 is determined by the fact that the reactance curve is antisymmetric about the point (X_0, ω_0). When X_0 has been determined, one can determine the admittance $1/Z_c - jX_0$ at the terminals of the ideal transformer of Fig. 31 (b). In terms of the circuit parameters this admittance is

$$\frac{1}{Z_c - jX_0} = \left(\frac{L}{M}\right)^2 Y_{0c}Q_0 + j2Y_{0c}\left(\frac{L}{M}\right)^2\frac{\omega - \omega_0}{\omega_0} \quad (41)$$

The conductance term $(L/M)^2\ Y_{0c}Q_0$ is independent of frequency, and the susceptance term $2Y_{0c}\ (L/M)^2\ \frac{\omega - \omega_0}{\omega_0}$ varies linearly with frequency. If these quantities are plotted from experimental data as functions of ω, the values of Q_0 and $(L/M)^2\ Y_{0c}$ can be determined. To determine the individual values of the factors in $(L/M)^2\ Y_{0c}$ for a given magnetron, it is necessary to calculate or somehow to measure a value for $Y_{0c} = \sqrt{C/L} = \omega_0 C = 1/\omega_0 L$. When used with ω_0, this yields values for L, C, and M. How this is done will not be explicitly discussed here. From the values of Q_0 and Y_{0c}, values of Q_L, Q_{ext}, and η_c can be calculated for any magnetron load G''_L by the relations (21), (22), (23), and (25). There are other methods of extracting the Q values from the experimental data than that presented above.

When values of the circuit parameters are available, one can calculate the values of G_s and B_s from which G_e and B_e are obtained. From the output power, the RF voltage is then calculable by equation (38), and from this and the electronic admittance the in-phase and quadrature components of the RF current can be obtained. Using the circuit efficiency η_c, now determined as a function of load, one can obtain the dependence of the electronic efficiency η_e as a function of load conductance from experimental values of the over-all efficiency η, measured along a constant frequency contour of a Rieke diagram ($\eta = \eta_e\eta_c$).

To be continued next month

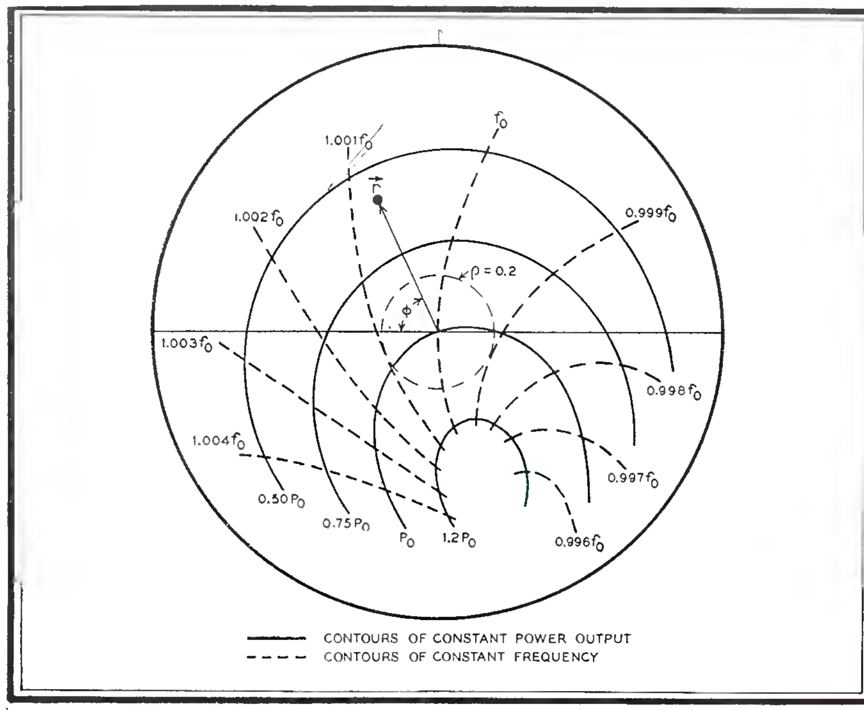


FIG. 33. A typical experimental Rieke diagram for magnetrons in the centimeter wavelength range. The $\rho = 0.2$ circle indicates a pulling figure of $0.02\,f_o$ *mc/s* for this example. Present practice is to couple long wavelength magnetrons more tightly to the load and short wavelength magnetrons less tightly to the load than this. The rotation of the diagram from the position of the contours of chart (*b*) of Fig. 32 is attributable to the transformer action between the terminals of the ideal transformer of the circuit of Fig. 31 (*b*) and the point in the output line to which the experimental diagram is referred.

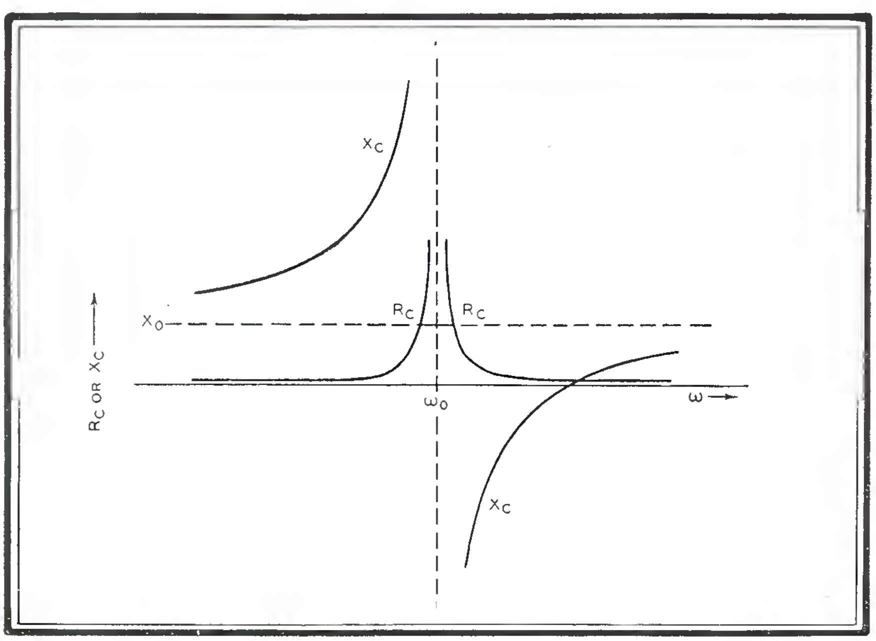
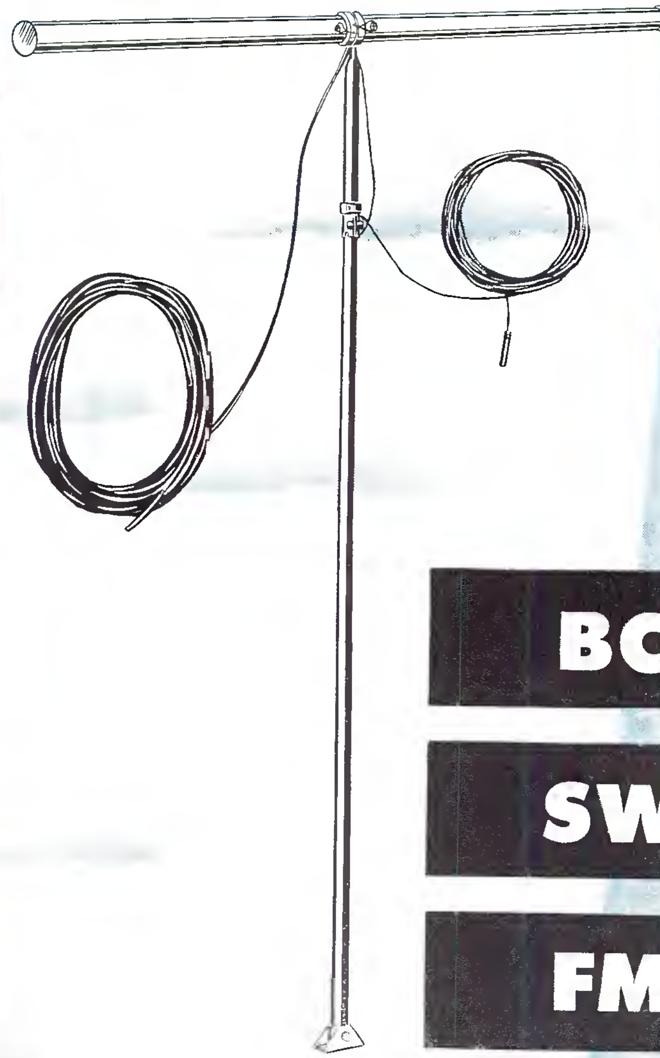


FIG. 34. A plot of the resistive and reactive components of the impedance $Z_c = R_c + jX_c$, looking into a non-oscillating magnetron through its output circuit [terminals CD of Fig. 31 (*a*)]. Note the symmetry of the reactance about the point (ω_o, X_o) determining the value of X_o, the loop reactance.

Amphenol

ALL-WAVE ANTENNA

GETS ALL THREE!



BC

SW

FM

Purchasers of modern radios deserve good reception on all three bands—standard broadcast, short wave and frequency modulation. Until Amphenol engineers perfected this new all-wave unit, the only way to achieve this was to install three separate antennas, a costly and unsightly solution.

The FM section of this new 3-way antenna is a horizontally polarized dipole. It operates most efficiently between 88 and 108 mc.

A 65-foot length of Amphenol Polyethylene covered copper wire serves as the standard broadcast and short wave antenna. The polyethylene covering minimizes precipitation static and assures long life.

A specially designed series M derived low-pass filter automatically switches the energy from the proper antenna to receiver input.

Installation is simple. The mounting is a 1-inch steel mast 5-feet in length. All hardware is included. A guy clamp bolted to the mast provides for tripod guying.

Vinyl-jacketed Amphenol 52 ohm coaxial transmission line serves as a low-loss lead in and eliminates interference from transmission line pickup. Noisy areas are not a problem with this antenna.

In a comparative test with the best available standard double doublet (with matching transformer) the Amphenol All-Wave Antenna proved far superior in gain—as well as being interference free.

Write for complete technical data, or see your jobber for full information.

AMPHENOL ALL-WAVE ANTENNA UNIT INCLUDES:

- ★ FM dipole with molded phenolic weatherproof filter housing
- ★ Steel mast 5-feet long with guy clamp and adjustable insulator
- ★ 50-feet Amphenol RG-5/U 52 ohm coaxial cable
- ★ Antenna wire polyethylene covered
- ★ Built-in M derived network

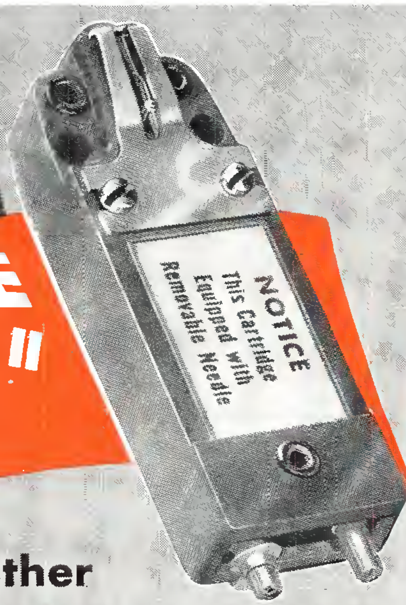
AMPHENOL

AMERICAN PHENOLIC CORPORATION
CHICAGO 50, ILLINOIS

COAXIAL CABLES AND CONNECTORS • INDUSTRIAL CONNECTORS, FITTINGS AND CONDUIT • ANTENNAS • RF COMPONENTS • PLASTICS FOR ELECTRONICS

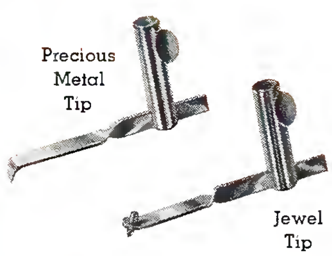
One for the Record

"ON THE QT"



Astatic introduces another entirely NEW and improved PHONOGRAPH CARTRIDGE... the Model "QT."

THIS "QUIET TALK" CARTRIDGE IS DESIGNED ESPECIALLY FOR HOME USE AND IS EQUIPPED WITH A *REPLACEABLE* NEEDLE OF THE MOST ADVANCED TYPE.



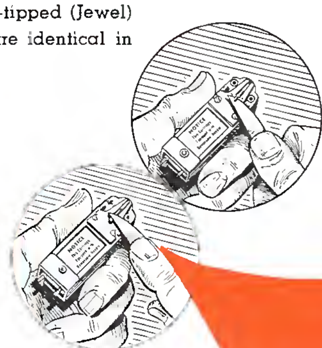
THE improved design of this needle, allowing appreciably more vertical compliance than has heretofore been possible, results in a VAST REDUCTION in the amount of surface noise which is ordinarily radiated directly from the needle. Pleasing reproduction and the absence of acoustic noise, together with low order of distortion, make the "QT" Cartridge ideally suited for home use.

TYPE "QT" AVAILABLE IN TWO MODELS

Model "QT-M" is supplied with precious metal-tipped stylus; Model "QT-J" with sapphire-tipped (Jewel) stylus. Both models are identical in every other respect.

Simple Method Devised for the Removal and Insertion of Needles

Needles in the "QT" Cartridge may be removed quickly by placing knife blade beneath needle and prying gently upward. Replacements are made by inserting shank of needle in socket and pressing down gently.



WE'LL SEE YOU AT THE CONVENTION!

Astatic's complete line of products will be on display at the National I.R.E. Convention, at Grand Central Palace, New York City, March 3 to 6, inclusive.

"QT" Literature is Available

THE **Astatic** CORPORATION
CONNEAUT, OHIO
IN CANADA CANADIAN ASTATIC LTD. TORONTO ONTARIO

Astatic Crystal Devices Manufactured under Brush Development Co. patents.

It is deplorable, but it's no less true, that 9 out of every 10 radio dealers and servicemen are so thick and dumb that they'll starve to death before they will exert any more mental energy than is required to sell and service cheap AM table models.

Manufacturers of FM receivers, high-quality amplifiers and speakers, and associated components are finding that broadside sales effort and trade-paper advertising is not more than 10% effective.

Our experience checks with that figure. For 7 years, we have been seeking out those 1-out-of-10 men as subscribers to *FM* AND TELEVISION.

Today, our 2,400 paid subscribers in this group comprise the leaders of the U.S. radio trade. They are the men who have set their sights on the profits to be realized from the enormous high-quality market opened up by Frequency Modulation.

We don't know what other magazines these 1-out-of-10 men read, but we can tell you that the cheapest way to reach them with advertising is through *FM* AND TELEVISION. You can check this statement to your own satisfaction by comparing the contents, the ABC reports, and the advertising rates of the different radio publications.

WHAT'S NEW THIS MONTH

(CONTINUED FROM PAGE 42)

of comparable quality sold in 1940 and in 1946. A fair estimate of the increase is 75 per cent. While sets are still offered at $24.95, for example, the performance of prewar sets in that price bracket is only obtainable now in $42.50 models. About the same ratio applies to expensive phonograph combinations.

The difference in price has not been taken out as profit by radio manufacturers. Published financial reports show that. No, the difference lies in increased labor costs. However, and here is a point of information that has not been emphasized sufficiently, only a part of the increased labor cost is due to higher wages. The remainder, and perhaps the major part, is due to disruptions resulting from strikes and to substantially lower production per man-hour, both within and without the radio industry.

BROWNING FM-AM TUNER

(CONTINUED FROM PAGE 38)

expected that at the high frequencies involved the drift will be appreciable for the first five minutes after the set is turned on. Following this initial period, however, the stability should be such that retuning is unnecessary. Through the use of components having thermal characteristics with the correct sign and magnitude, an excellent degree of compensation can be achieved. Fig. 10 shows the actual curve of frequency versus time made on the oscillator after an initial warmup of five minutes. The amount of drift previous to final stabilization is sufficiently small to eliminate the need of retuning.

The correct tuning on the AM section is always indicated by maximum closing of the eye. On the FM section, however, maximum eye closure is only an approximate indication of correct tuning, which is best determined by carefully adjusting for minimum background noise.

The output of the tuner should be hum-free under all conditions of operation. Therefore, if trouble with hum is experienced, look for the cause in the method of connection to auxiliary equipment. A common cause of hum is the lack of a good ground bond between the tuner and the audio amplifier. Heavy shield braid is excellent for this purpose if both ends are connected securely. The shielded audio lead to the amplifier must be solidly connected to the amplifier input and the shield grounded to the amplifier chassis. Tunable hum in the AM section is not experienced when using the power supply designed for the tuner. The transformer in this supply has an electrostatic shield which has been shown necessary to prevent this effect. If this difficulty is experienced when powering the tuner from an amplifier, connection of a .1 mfd. condenser from one or both sides of the AC line to ground may assist in removing this annoyance.

HOW THE FCC VIEWS FM

(CONTINUED FROM PAGE 24)

ease the growing pains of FM and assist it to mature in the shortest possible time.

Now let's see what the manufacturers are doing to promote FM. In the latter part of 1945 we made a survey to learn how many FM receivers would be produced in 1946. The estimate was that 9% of all sets produced would be FM. If that estimate had held up, we would have had 1,350,000 sets. Actually, only 1% of the total production was FM and we got only 163,000 sets. In January of last year, exactly 27 sets were produced. By July, production had climbed to 19,000. The figure for December was 25,000[1] but was still only about 2% of total set production.

One industry leader has predicted that the percentage of sets produced in 1947 which will contain FM will be between 15 and 20%, with the production curve getting up to 30% toward the end of the year. Let us hope that his prediction proves too conservative. I am sure that this [FM] Association will do everything in its power to break this critical FM bottleneck.

Also, I know that many of you have encountered difficulties in obtaining transmitting equipment. But that picture, too, promises to become brighter as the year wears on.

Every new application for FM is an additional incentive for the manufacturer to turn his energies to FM transmitting equipment. And every new station on the air is an added incentive for the receiver manufacturer to make more sets and to put them on sale in the area of the new station.

As to the public, it is the American way of life to seek the best there is. And the best there is in aural radio is FM. The American people will insist on having FM in their new radios once they have had an opportunity to hear it.

We complete the circle by coming back to the broadcaster, and relying upon him to be the mainspring of FM. It is upon him that we must depend to give the people their chance to hear and know FM.

To date, the Commission has received almost one thousand applications. I think that is a most encouraging demonstration of the interest of broadcasters in FM, especially when we realize that that figure almost equals the number of AM stations on the air.

Seventy percent of these applications have been from AM stations. Eleven percent were from non-AM newspaper interests. The remaining 19 percent were from applicants without either AM or newspaper interests. I was interested to learn that in this group the most numerous applicants were engineers, lawyers and doctors. I don't know why.

[1] This was only for the first 2 weeks of December. RMA estimates showed about 42,000 for the entire month. — *Editor's Note.*

I would suggest the following 7-point program to the FM broadcasters of America to speed the growth of FM:

1. Set your sights for interim operation just as high as you can. See that your listeners understand the limitations of your interim operation, and keep them informed of your plans to go on full power.
2. Go on full power as soon as you can get equipment.
3. Coöperate with the other FM applicants, permittees, or licensees in your area to promote FM.
4. Inform the listeners in your community on the merits of FM by means of demonstrations in theatres, schools, civic clubs and county fairs, by means of radio and newspaper advertising and all other forms of publicity.
5. Work with your dealers to obtain FM sets.
6. Conduct schools for radio servicemen on the proper servicing of FM sets, and on the proper installation of antennas.
7. Schedule programs worthy of FM's fullest potentialities.

Your association has a great opportunity. By combining your talents, your energies and your resources in an all-out effort of broadcasters, manufacturers, and dealers you can move the FM time schedule months ahead, perhaps even years. Your program will result in more radio and better radio for the American people. You have not combined to withhold but to give. This course of action to get the benefits of a great technological discovery to the largest number of consumers in the shortest possible time is in accord with the highest traditions of enlightened free American enterprise.

All the good wishes of the Federal Communications Commission go with you.

HOW TIME BUYERS VIEW FM

(CONTINUED FROM PAGE 25)

agency[1] already has a television director and a skeleton staff, working on a show or two a week — just to get the feel of the medium.

Everyone in the agency field is familiar with the pros and cons of color versus black-and-white television. They speak with authority about mechanical and electronic color, about program costs, and all other problems television faces in its current embryo state.

Television organizations draw big crowds for luncheon meetings, and the mildest pronouncements about television rate full treatment in the trade press.

Already, some 24 sponsors are using commercial television programs regularly in New York City alone. They are spending at an estimated rate of $2,015,858 per year for these programs for station time or

[1] See "Why the Other Five Letters Weren't Mailed" by Samuel H. Cuff, *FM* AND TELEVISION, Nov. 1944 for explanation of the methods used by Du Mont to interest advertisers in television.

NEW . . . Simpson Model 305RC Tube-Tester with "No Backlash"* Roll Chart

With the addition of the new Simpson "No Backlash"* Roll Chart to the 1947 version of our Model 305, this famous instrument becomes beyond question the finest tube-tester on the market in its price range. Read the description of this new Roll Chart in the panel below.

Model 305RC provides for filament voltages from .5 volts to and including 120 volts. It tests loctalc, single ended tubes, bantams, midgets, miniatures, ballast tubes, gaseous rectifiers, acorn tubes, Christmas tree bulbs, and all popular radio receiver tubes.

Like other Simpson tube-testers, the Model 305RC incorporates 3-way switching which makes it possible to test any tube regardless of its base connections or the internal connections of its elements. This method, the result of exhaustive research and expensive construction, protects the Model 305RC against obsolesence to a degree not enjoyed by competitive testers. No adapters or special sockets are required. In addition to having a complete set of sockets for every tube now on the market, this tester has a spare socket, to provide for future tube developments.

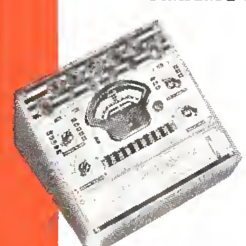
The Model 305RC has provision for testing pilot lamps of various voltages as well as Christmas tree bulbs. It tests gaseous rectifiers of the OZ4 type—also tests ballast tubes direct in socket for burnouts and opens. Has neon bulb of proper sensitivity for checking shorts. This tube-tester is fused, and has the latest improved circuit. It provides for line adjustment from 100 to 130 volts, with smooth vernier control.

Model 305RC is distinguished for its beautiful exterior. It has a two-tone metal panel in red and black on a satin-finished background. Sockets and controls are symmetrically arranged for quick operation. The large, modern, fan-shaped instrument has an exceptionally long scale. It has "good" and "bad" English markings, also a percentage scale for matching and comparing tubes. Cases, both portable† and counter style, are made of strongly built hardwood, durably and beautifully finished.

Size, 11"x11"x6". Wt. 10 lbs. Shipping wt., 15 lbs.
Dealer's net price, portable or counter model......**$59.50**
For 60 cycle 115 volt current only.
For 220 volt or 60 cycle, add................................ **7.50**
Standard Model 305, with book-type speed chart **49.50**

*6 Exclusive Features Make This the Finest Roll Chart Ever Designed for Tube-Testers . . . . . .

- "No Backlash" feature of this Roll Chart automatically takes up all slack in the paper chart and, by keeping it in constant tension, makes it impossible to turn the selector wheel without turning chart. Gives precision selection at all times. Also prevents chart from tearing or getting out of alignment.
- Gearing is such that only 6 turns of selector wheel will run the entire length of the 12½ ft. chart.
- Easy to read. The clear Lucite window is just wide enough to show 2 tube settings, or both settings on a multi-purpose tube.
- Entire unit removable by taking out four screws. Just lift from receptacle to make new entries or install new chart.
- Chart ingeniously fastened to rollers, affording easy replacement and constant alignment.
- Rigid, light-weight construction. Gear driving mechanism incorporates heavy-duty precision brass gears and parts.



Counter Model 305RC. Same instrument as portable model, but set in fine walnut finished hardwood case, with tilted, easy-to-use panel.

†Finished hardwood cases are standard on portable models. When these are not available, the instrument is housed in attractive simulated-leather covered case.

Simpson

INSTRUMENTS THAT STAY ACCURATE

SIMPSON ELECTRIC COMPANY
5200-5218 W. Kinzie Street, Chicago 44, Illinois
In Canada, Bach-Simpson, Ltd., London, Ont.

SEE *the newest facsimile equipment*

. . . operating on both FM Radio and wire circuits!

BOOTH 7C MAIN FLOOR

I. R. E. SHOW

GRAND CENTRAL PALACE • NEW YORK CITY

March 3—6 Inclusive

FINCH TELECOMMUNICATIONS, INC.

10 EAST 40th STREET, NEW YORK 16, N. Y. • Factory: PASSAIC, N. J.

HOW TIME-BUYERS VIEW FM

(CONTINUED FROM PAGE 54)

use of facilities, and production of programs.

These advertisers and agencies fully realize that no more than a few hundred receivers are tuned in to their programs. But they are so impressed with the enormity and the imminence of the future that the backers of television have painted that they are willing to invest real money now in order to gain franchises for desirable time spots.

This is in no sense intended to belittle television. We all realize that television will eventually prove a great medium of entertainment, of culture, and, incidentally, of advertising.

We realize that, some day, television will take its place beside radio, both AM and FM, as a companion service, each doing some jobs better and more economically than the other.

This is only intended to stress that, despite the many times more FM receivers in use than television receivers, despite the fifteen times as many FM receivers being delivered each month, despite the fact that FM faces no basic technical problems, and no program problems you can't wipe out by making peace with Petrillo — which, incidentally, you should do somehow quickly, and I don't presume to tell you how — despite all these advantages FM enjoys over television, advertisers are scrambling to get into television and overlooking FM altogether.

So much for the picture as it stands. Now for the constructive suggestions.

First, FM broadcasting should discard any outward appearance of an inferiority complex. Ladies and gentlemen of FM, you have an advertising medium to sell. There are already several hundred thousand FM receivers in use and the number will multiply in the coming months as more receiver makers swing into full production.

You are entitled to consideration now by any radio advertiser, and don't forget, you have several advantages over AM radio for many advertising prospects. Here are just five:

First: you have choice time spots to sell — a condition long since forgotten in AM network radio.

Second: your advertisers now will have less competition than they face on AM.

Third: you have, generally, audiences of higher income and cultural levels than AM stations.

Fourth: FM can be used to test radio advertising and specific programs at low cost.

Fifth: the technical differences in FM broadcasting should permit interesting new program techniques not yet fully developed.

Continuing on the constructive side, I should like to give you five suggestions from these advertising people, to help you build FM as a commercial medium.

First: build up your audience by pushing the sale of FM receivers in your areas, by programming your air-time carefully, and by promoting your programs to the full.

Second: learn the real facts about your market and your audience. See that these facts get into the hands of advertisers, agencies, and local dealers and distributors as well.

Third: establish fair rates and stick to them. Especially, don't have a rate for the agency, or the advertiser, and then give the time away to the advertiser's local distributor. (This practice cooled one agency's interest in FM some time ago.) Drive the chiselers out of FM at the beginning.

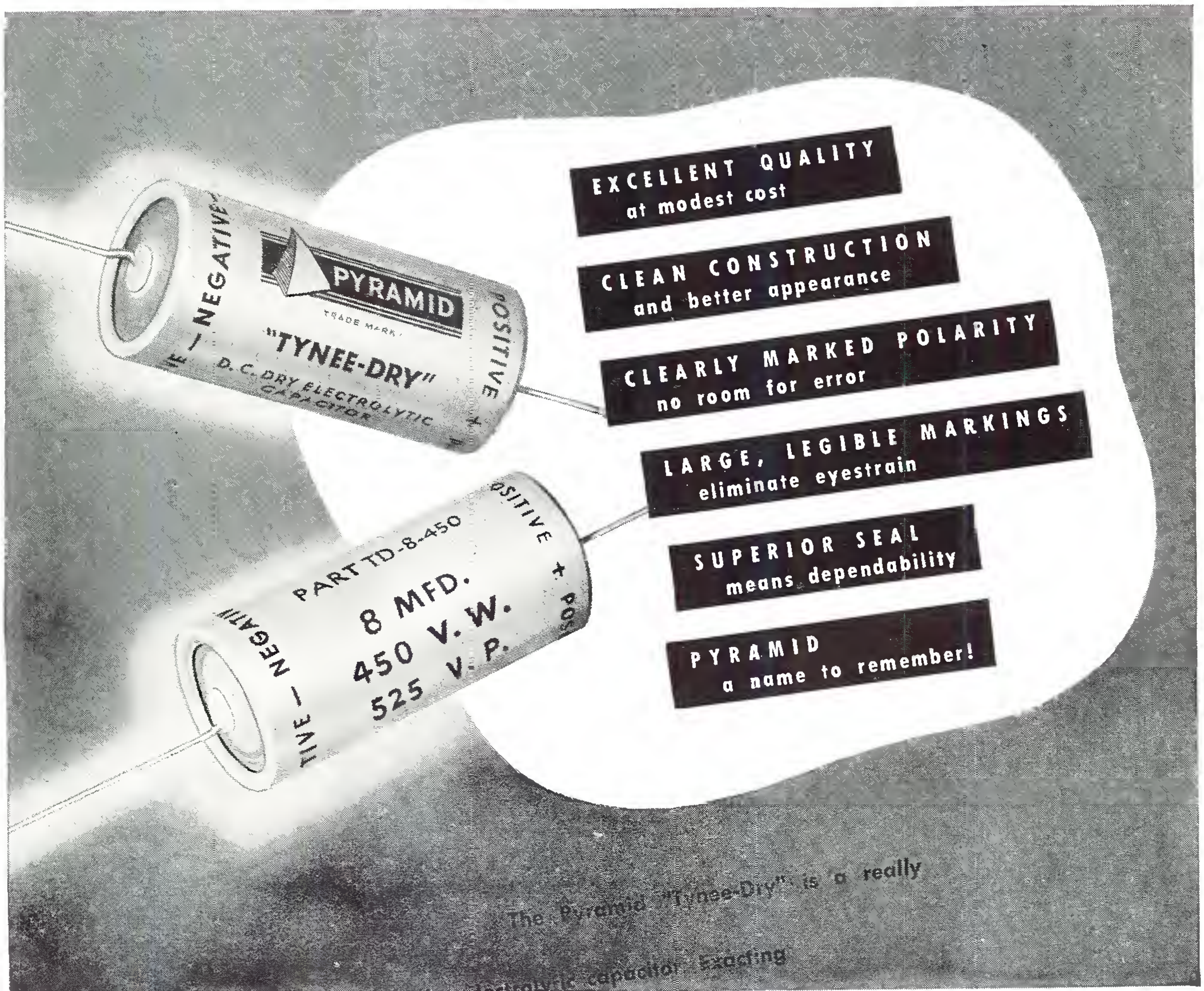
Fourth: give your advertisers every legitimate merchandising support — not only to make their advertising as productive as possible, but to make the advertiser, and his local dealers and distributors conscious that advertising through your station is working for them.

Fifth: don't dissipate your efforts in competitive selling. If you have a competitor, don't try to switch all of his clients over to your station. High pressure, competitive selling has made newspaper advertising unpopular with many advertisers. Right now, FM can set itself to avoid this mistake. Let every FM station get its own accounts and don't worry about accounts your competitors have.

(CONCLUDED ON PAGE 62)

Save SPACE, TIME and MONEY!

with the PYRAMID "TYNEE-DRY"



The Pyramid "Tynee-Dry" is a really tiny dry electrolytic capacitor. Exacting engineering and production controls provide maximum quality within minimum space—and at modest cost! Write for literature.

PYRAMID ELECTRIC COMPANY

JERSEY CITY 6, N. J.

PYRAMID "LONG-LIFE" Dry Electrolytic Capacitors

FM ASSOCIATION MOVES FAST

(CONTINUED FROM PAGE 23)

Liaison Committee ★ During the luncheon, FCC Chairman Denny said: "I think you ought to have an FMA liaison committee representing all your members to meet with the Commission informally to discuss any problems you might have. It would be helpful to us, and I'm sure we could be of some assistance to you."

Accordingly, a liaison committee was appointed by FMA president Hofheinz. The members are Gordon Gray, Wayne Coy, Everett L. Dillard, C. M. Jansky, Jr., and Leonard Marks, who is general counsel to the Association. This is an effective group for such a purpose, combining experience in broadcasting, broadcast engineering, and legal problems related to this field.

Although no announcement has beeu made concerning an agenda for this committee, it is obvious that it will perform a highly useful service in representing broadcast members of FMA before the FCC, and in exploring present and future problems.

FM Receiver Standards ★ One of the extremely important matters to which both the FCC and the FMA must give attention is that of FM receiver performance standards.

The need for such standards comes about as a result of the fact that the FCC, in setting up FM broadcast station allocations, assumed certain standards of receiver performance. This has nothing to do with AF characteristics, but only with sensitivity and selectivity, etc.

That is, the FCC has set up a frequency allocation plan under which stations on the same channel are repeated at certain intervals of distance, while stations on adjacent channels and those separated by one channel are distributed in such a way as to eliminate interference at receiving sets. But what degree of selectivity does this imply? Also, in specifying coverage areas, what degree of limiting does the FCC consider adequate?

The FCC has ruled that, if an FM transmitter is located in a residential area, the station management will be held responsible for any blanketing of reception at receivers in that area. Does that apply to sets that are without limiters?

We have claims and counter-claims from set manufacturers that limiting is necessary, or not necessary, to give "adequate" selectivity in FM receivers. What is "adequate" selectivity? The only basis for determining adequacy is the degree of selectivity assumed by the FCC in working out its allocation plan.

Now, although the FCC sets the standards for transmitting equipment, and issues type approvals, it has no authority whatever over receivers or receiver designs. In the case of FM broadcasting, however, unless manufacturers and the public have some information on minimal performance of receivers in relation to frequency allocations, FM set designs may be debased to the point where the allocations plan will be ineffective.

For example, in planning our national highways, certain assumptions are made as to the hill-climbing capabilities of automobiles. If, to reduce prices, car manufacturers omitted gear-shifts, many of our roads could not be used by the owners of such cars.

In the case of FM receivers, we need an official statement from the FCC as to the characteristics which sets must have in order to operate satisfactorily within the limitations of the frequency allocation plan. This would enable manufacturers of sets which afford such protection to owners to guarantee that their receivers meet or exceed the minimum FM receiver standards established by the FCC.

While there would be no requirement that sets should meet such standards, this protection would be made available to the public because manufacturers would feature that assurance in advertising models which provide it. Dealers, too, would be certain to sell their customers up to date models which meet FCC standards, and to discourage the purchase of sub-standard models.

No announcement has come from FMA on this subject, but it is certain that it must have early consideration as one of the progressive steps in the expansion of FM broadcast service.

NEXT MONTH:

REVIEW OF FM AND TELEVISION RECEIVERS NOW IN PRODUCTION

HOW TIME-BUYERS VIEW FM

(CONTINUED FROM PAGE 58)

So much for the findings of the survey. Following the usual pattern, I should like to close these remarks with a brief interpretation of what they seem to indicate to me:

In summary, the advertising agencies and their clients are only dimly conscious of the existence of FM as an advertising medium.

They are favorably inclined toward FM itself, but they need to be convinced that you have a new and growing market which can be increasingly productive for them.

Someone must convince them that dollars spent in FM radio will be better spent than in something else. You have a real selling job on your hands. You will be fighting the stiffest competition in the scrap for the advertising dollar.

You will have to conduct an extensive research and promotion. This will take money and people — more than any single station can well afford. But together, with a single FM promotional organization such as FMA to match the Magazine Advertising Bureau, the Bureau of Advertising of the ANPA, and the vast selling organizations of the networks and the major publishers. FM can be made a commercial success years sooner than it will by individual station effort.

In short, ladies and gentlemen of FM, the advertiser's door is open. Come in and start telling your story.

"FREE RADIO" THROUGH FM

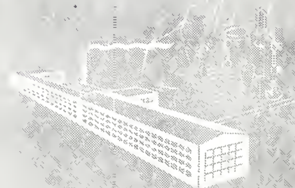
(CONTINUED FROM PAGE 29)

is permitted to have interference-free coverage only out to about 30 miles.

There are restrictive regulations prohibiting dual ownership of FM stations with overlapping coverage areas practically identical with those which apply to the ownership of AM stations. In short, the difference between the congestion which exists in the present AM and FM bands, and the regulations resulting from that congestion, are entirely a matter of *degree* and not of *kind*.

For years, the potentialities of broadcasting have been severely restricted by the technical limitations of AM. The invention of FM has effectively removed these. Except for the invention of FM, the opportunity to establish a truly free radio in this country would not exist. However, FM cannot of itself create a free radio. Radio will become free only if the American people sanction and insist upon a regulatory policy resulting in 1) the assignment of a sufficient number of 200-kc. channels to FM broadcasting to take care of all comers, and 2) the removal of the rules, regulations and standards now existent which have evolved from the philosophy of scarcity of facilities, and will have no justification for their existence once that scarcity has been removed.

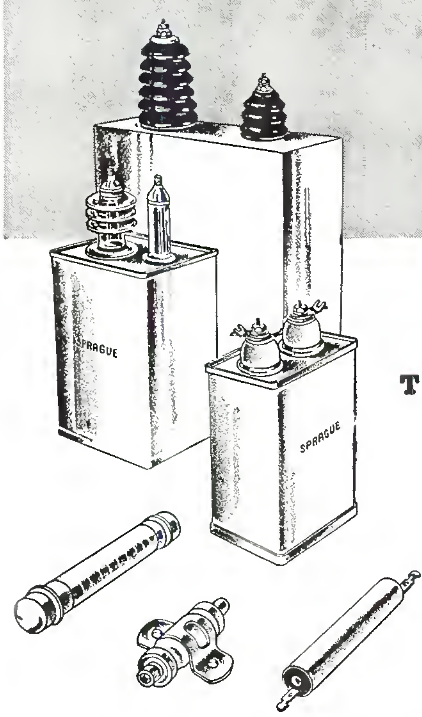
• PIONEERS OF ELECTRIC AND ELECTRONIC PROGRESS •



THE MAJOR CAPACITOR AND WIRE-WOUND RESISTOR DEVELOPMENTS OF THE PAST 5 YEARS HAVE BEEN ENGINEERED

by

SPRAGUE



THEY INCLUDE:

***VITAMIN Q** impregnated capacitors for higher voltages, higher temperatures and higher insulation resistance.

●

***HYPASS 3-TERMINAL NETWORKS** that set new standards of performance in solving anti-resonant frequency problems at frequencies as high as 150 megacycles or more.

●

GLASS-TO-METAL hermetically-sealed capacitors fully proofed against leakage, moisture, fungus, corrosion and shock.

ENERGY STORAGE capacitors of greatly increased capacity in smaller physical sizes.

●

MEGOMAX high-resistance, high-voltage resistors. Megohms of resistance operated at thousands of volts.

●

SPRAGUE *KOOLOHM RESISTORS with glazed ceramic coating and new type end seals in one standard type for use under any climatic condition.

●

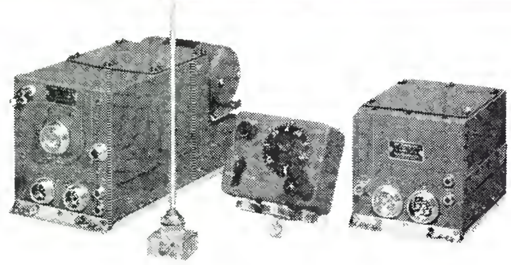
Catalog of any type on request

**Trademarks Reg. U. S. Pat. Off.*

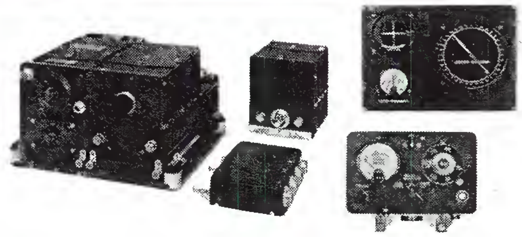
SPRAGUE ELECTRIC CO., NORTH ADAMS, MASS.

AIRCRAFT RADIO CORPORATION

Among the A.R.C. RADIO COMMUNICATION AND NAVIGATION SYSTEMS are



TYPE 11 SYSTEM
Range Receiver and VHF Transmitter
or **TYPE 17 SYSTEM**
VHF Receiver and VHF Transmitter.

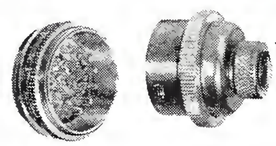


TYPE 15
VHF Omni-Directional
Range Receiving Equipment.

Among the A.R.C. ELECTRONIC COMPONENTS AND ACCESSORIES are

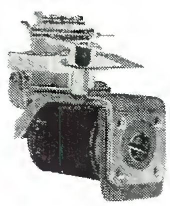
"MUSIC-BOX" TYPE SELECTOR SWITCHES →

For low-voltage control circuits.
Unusually positive detent action.
Lever-type control handle.



← **CERAMIC-INSULATED PLUGS AND RECEPTACLES**

- 24 combinations.
- 2 to 19 contacts.

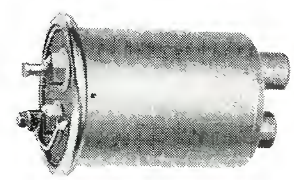


← **CERAMIC-INSULATED MINIATURE DC RELAYS**

1¼" long.
SPST, SPDT, DPST, SPST-SPDT, and DPDT.

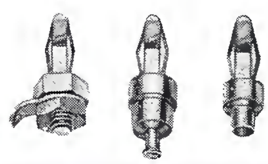
DRY ELECTROLYTIC SEALED CONDENSERS →

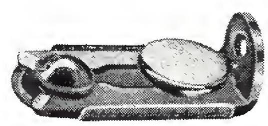
Terminals mounted on mica.
No bakelite-rubber seals.



MINIATURE PIN-PLUG CONNECTORS →

Specially designed to minimize spring fatigue.

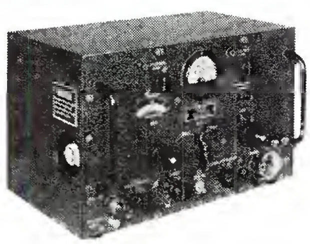




← **SNAPSLIDE FASTENERS**

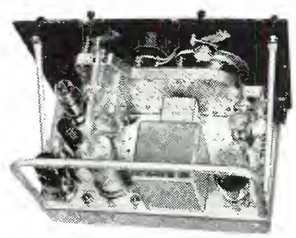
7/16" wide size, for heavy loads.
¼" wide size, for light loads.

Among the A.R.C. MICROWAVE UNITS AND ACCESSORIES are



TYPE H-10 TEST SET
for the 1.2 cm band

and various assemblies for the 10 cm, 3.3 cm, and 1.2 cm bands.



A.R.C.

Aircraft Radio Corporation

DEPENDABLE COMMUNICATION AND NAVIGATION EQUIPMENT

Boonton, N. J.

NEW
NEW
NEW

NEW COLLINS 213A
TRANSCRIPTION TURNTABLE

Designed for Better Recorded Programs

Yes, the Collins 213A turntable is designed for those who insist that their recorded programs be given every opportunity for success. This new table, shown for the first time at the 1946 NAB convention, reflects the careful attention given to its general appearance, operating performance, and functional convenience.

The 213A gives you faultless, professional turntable performance. Use it for better recorded programs. Available with or without cabinet and pick-up assembly. Write for complete details.

1 Designed for recording as well as playback.

2 Maximum difference of five seconds between recording and playback time in a 15-minute program.

3 Quick lever shift of speed, with turntable either running or stopped.

4 Rim driven by two rubber idlers, self-aligning to compensate for wear. Constant peripheral speed.

5 Speed regulation of 0.07% r.m.s. at 78.26 r.p.m., 0.13% r.m.s. at 33⅓ r.p.m.

6 Three-point support eliminates levelling adjustments on ordinary floors.

7 Hardened, ground, and polished stainless steel shafts running in oilite bearings reduce maintenance problems.

8 Driving mechanism is mounted on rubber shock-mounts. Rumble is held to a negligible level.

9 Black and gray baked enamel finish provides an attractive, long wearing appearance. Other colors available on special order.

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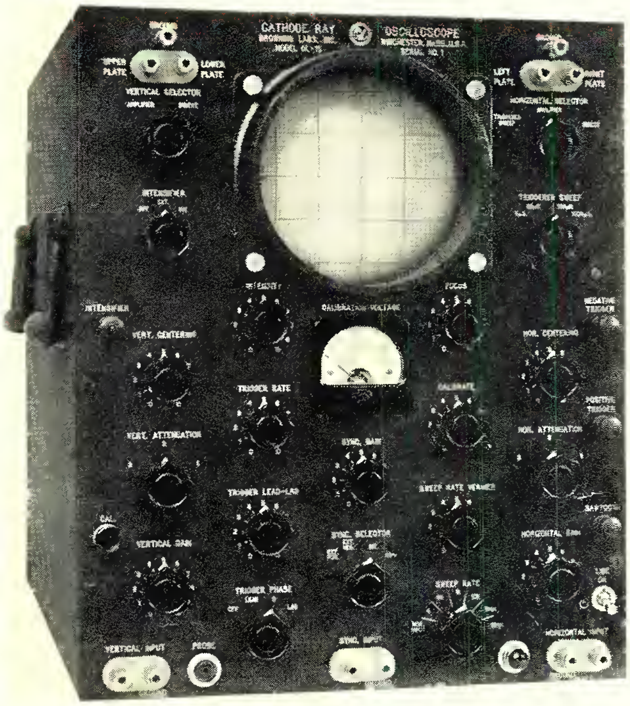

MODEL OL-15

A Wartime Development, Redesigned for Peacetime Applications. Price $1275.

The Improved BROWNING Oscilloscope

A Superior Design, Engineered for Engineers

The BROWNING model OL-15 oscilloscope is equipped with a 5-in. tube operated with an accelerating voltage of 3,000 to give increased intensity and definition of images. Among the operational features of the associated circuits are:

1. Sawtooth sweep for frequencies of 5 cycles to 500 kc.

2. Single sweep-triggered time base for transient phenomena of varying rate of repetition.

3. Internal trigger generator and built-in phasing circuit for single-sweep time base.

4. Vertical amplifier flat to ±10% of average value from 20 cycles to 4 mc. Input deflection sensitivity .05 RMS volts per inch.

5. Horizontal amplifier flat to ±10% of average value from 20 cycles to 1 mc. Deflection sensitivity .1 RMS volts per inch.

Other advantages are described in detail in the descriptive folder which will be sent on request.

THE BROWNING model OL-15 oscilloscope affords advantages over other laboratory types in two essential respects. First, the range of flat frequency response has been extended. Second, measurements and observations can be made with this instrument, because of added facilities, that are impossible with other oscilloscopes.

To these operational advantages BROWNING LABORATORIES have added another reason for choosing this instrument: It costs no more than oscilloscopes of relatively limited capabilities.

For measurements on AM and FM broadcast and communications equipment, or television, radar, and facsimile apparatus, we suggest that you give careful consideration to advantages of the BROWNING model OL-15 when you purchase a new oscilloscope.

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