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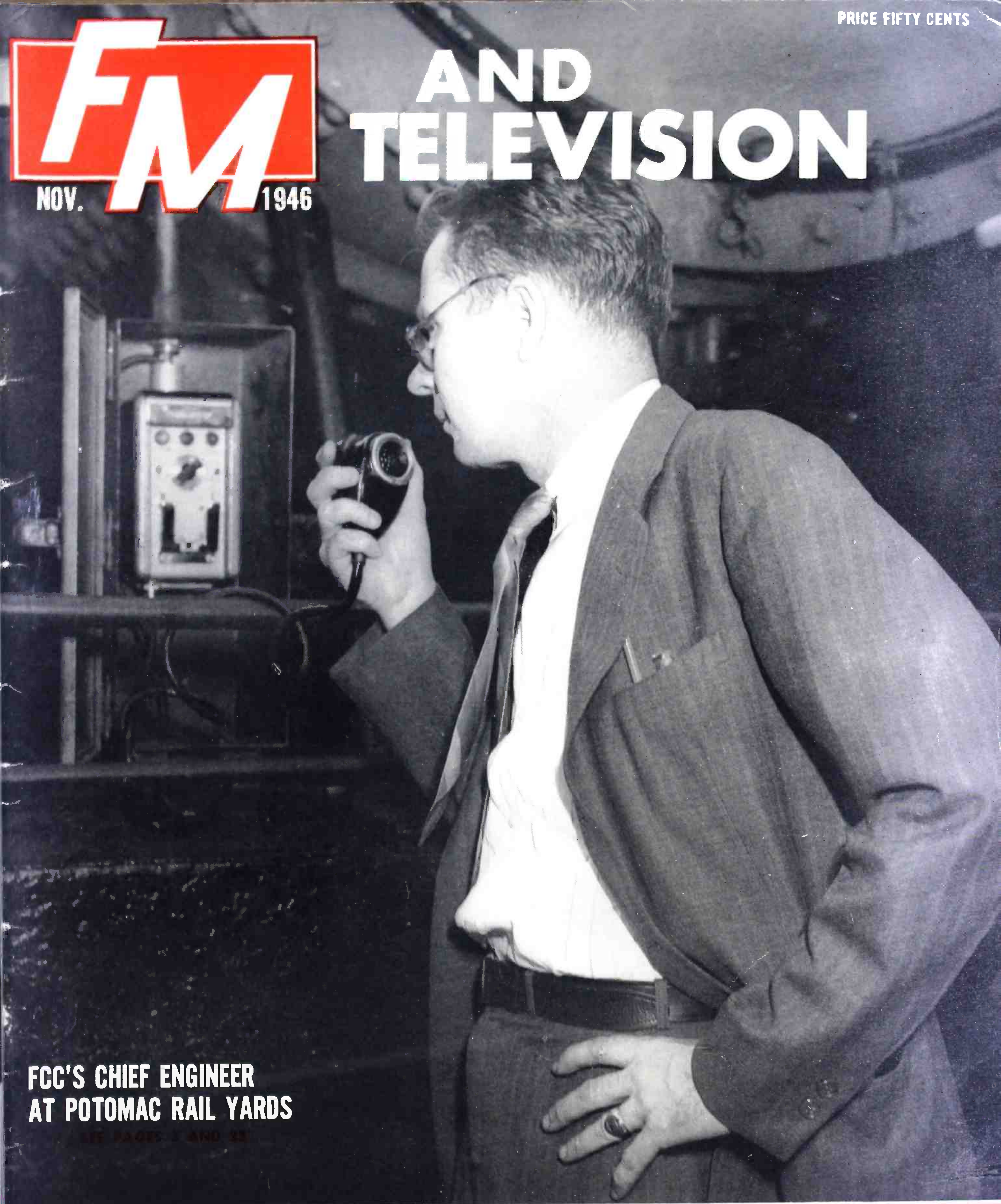
FM AND TELEVISION

NOV. 1946



FCC'S CHIEF ENGINEER
AT POTOMAC RAIL YARDS

★ ★ *Edited by Milton B. Sleeper* ★ ★

REG.U.S.PAT.OFF.

FM AND TELEVISION

FORMERLY: FM MAGAZINE and FM RADIO-ELECTRONICS

VOL. 6 | NOVEMBER, 1946 | NO. 11

CONTENTS

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THIS MONTH'S COVER

There's hardly anything going on in the radio industry that isn't known to George R. Adair, Chief Engineer of the FCC. The reason is that before any new development can proceed very far, arrangements must be made to give it a place in the frequency spectrum. Before that can be done, the FCC must be convinced that, among other things, the purpose is sound, and the means adequate. That's where George Adair comes in, since all engineering information at the FCC clears through his office. He usually has first-hand knowledge, too. This accounts for his presence on the platform of a Potomac Freight Yards locomotive, where this month's cover picture was taken, during the test of Farnsworth's FM railroad radio installation.

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MEMBER, AUDIT BUREAU OF CIRCULATIONS (ABC)

WHAT'S NEW THIS MONTH

1. FCC Chairman Denny's Address Before the NAB

1. The address by FCC Chairman Charles R. Denny, presented at the Chicago Conference of the National Association of Broadcasters on October 23rd, sets up the pattern of activities for broadcasters and for manufacturers of transmitters and home receivers, and for the radio trade.

Because of its great significance and its broad application to the radio industry, the full text is presented here. It should be read with care and thoughtfulness:

This afternoon, I would like to discuss a number of current topics — the first being the Blue Book, the affectionate term by which the radio industry knows the March 7, 1945 report of the Federal Communications Commission, entitled "Public Service Responsibility of Broadcast Licensees."

Before beginning, I am pleased to state that the remarks which I am about to make have the approval of all of the members of the Commission. In fact, the approval which I have is so definite that I am not at all sure that this speech is not subject to judicial review under the new provisions of the Administrative Procedure Act of 1946. I should add that Commissioner Durr, who is in Moscow attending the Five-Power Telecommunications Conference, did not participate in the consideration of my remarks but I have no reason to believe that he would dissent.

Now, I understand that some people are expecting a fight on the Blue Book issue. They expect this because of certain language used by my host in discussing this report. I am expected to reply in purple words. Many have said that they hope I will. They are doomed to disappointment.

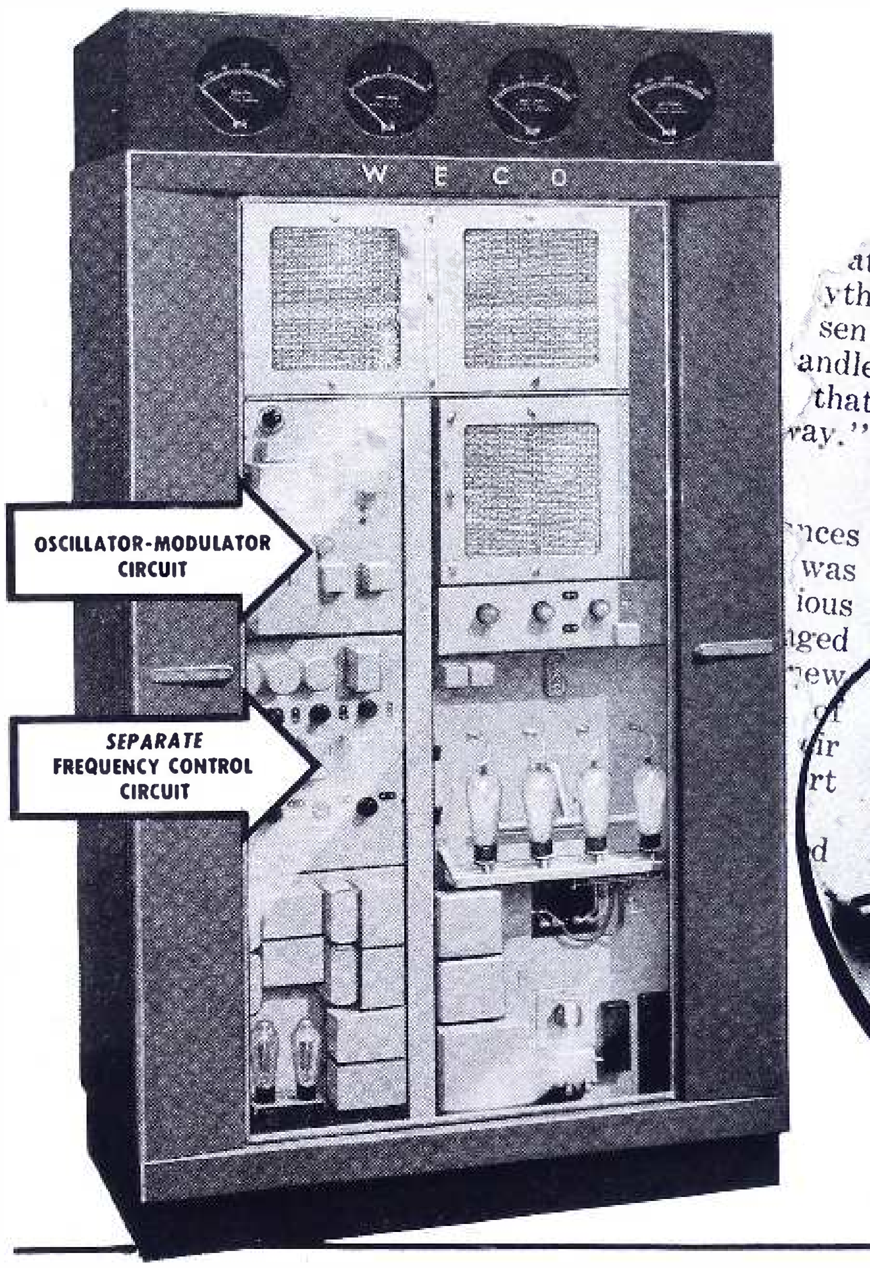
This is not going to be a fight. A quarrel would serve no purpose. Instead, it would divert attention from the real issues of the Blue Book. And it would hinder the closer coöperation between the industry and the Federal Communications Commission which is necessary for the solution of this and other important problems.

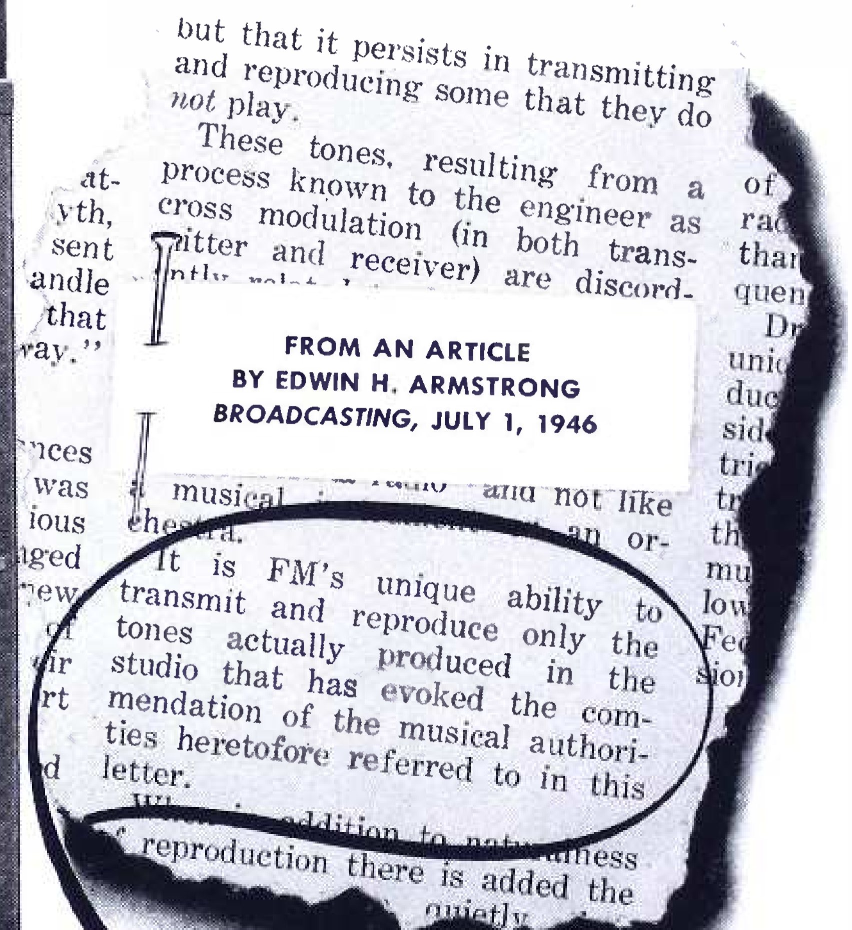
I have felt that we have been moving closer and closer toward a healthy but proper arm's-length working relationship between Government and industry in the communications field. We, at the FCC,

(CONTINUED ON PAGE 46)

Important FM news

for Broadcast Managers . . . Engineers . . . Listeners





but that it persists in transmitting and reproducing some that they do *not* play.

These tones, resulting from a process known to the engineer as cross modulation (in both transmitter and receiver) are discord-

It is FM's unique ability to transmit and reproduce only the tones actually produced in the studio that has evoked the commendation of the musical authorities heretofore referred to in this letter.

reproduction there is added the

FROM AN ARTICLE
BY EDWIN H. ARMSTRONG
BROADCASTING, JULY 1, 1946

IT is low cross modulation (intermodulation), as Major Armstrong points out, which allows FM to reproduce only the notes actually played and thus achieve such naturalness of tone.

Western Electric's Synchronized FM transmitters are unique in FM broadcasting because of their *unusually low intermodulation products*—achieved by a complete separation of the oscillator-modulator circuit from the frequency control circuit.

For other important features of Western Electric's complete new line of FM transmitters, contact your nearest Graybar Broadcast Equipment Representative, or write to Graybar Electric Company, 420 Lexington Avenue, New York 17, N.Y.

Unexcelled Performance of Western Electric FM Transmitters

Audio Frequency Response		±0.25 DB from 30 to 15,000 cycles
Harmonic distortion — for	±75 KC swing	Less than 0.5% from 30 to 15,000 cycles
— for	±100 KC swing	Less than 0.75% from 30 to 15,000 cycles
Intermodulation — — — for	*±75 KC swing*	*Less than 0.5% for 80% 50 cycles and 20% 1000 cycles; less than 1.0% for 80% 50 cycles and 20% 7000 cycles*
FM noise level		65 DB below ±75 KC swing
AM noise level		50 DB below 100% amplitude modulation
Carrier Frequency stability		Less than 2000 cycles deviation (no crystal heater)

Western Electric

— QUALITY COUNTS —

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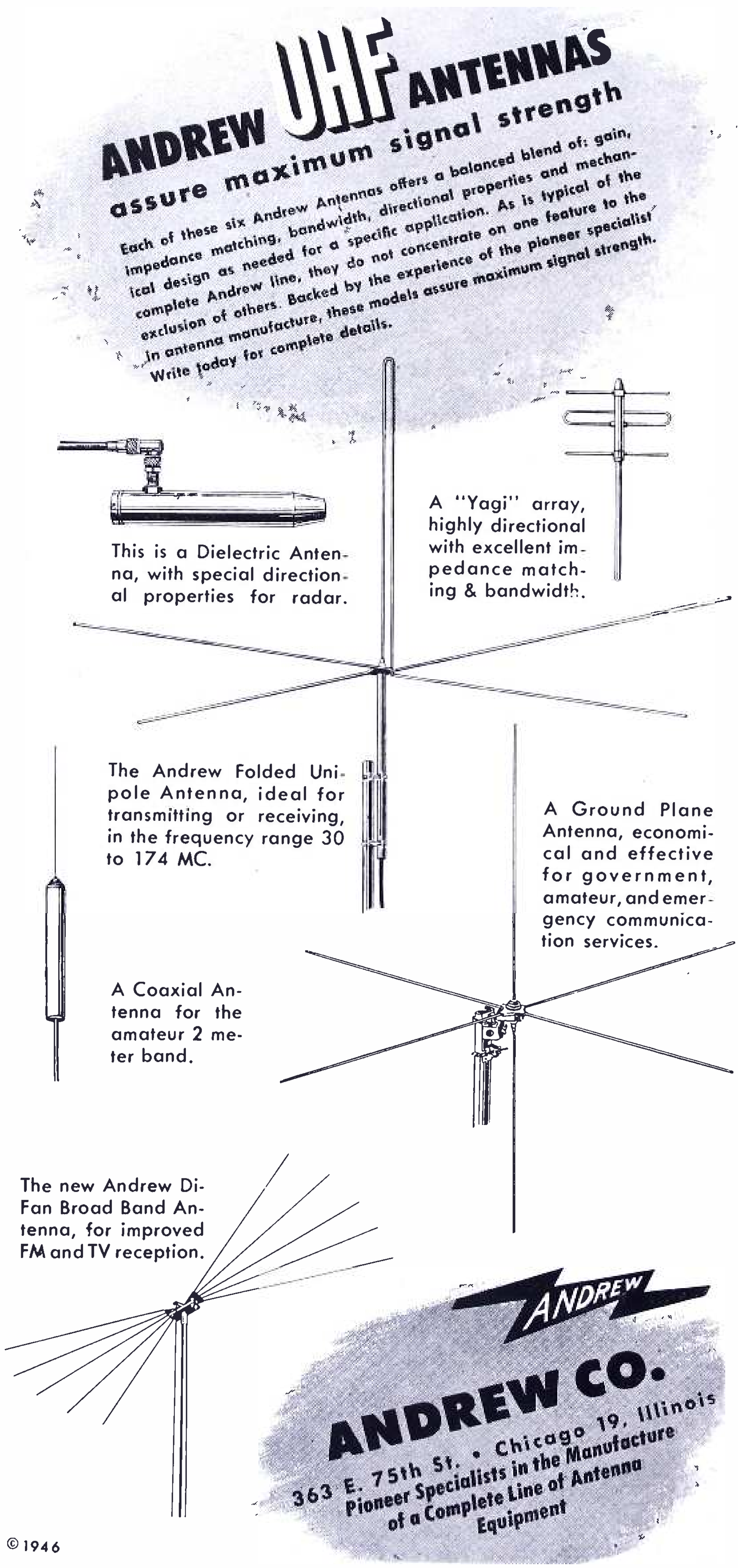
OFFICES IN 92 PRINCIPAL CITIES

ADVERTISERS INDEX



ENGINEERING SALES

Collins Radio: J. H. Boekhoff, formerly director of sales and service engineering, has been appointed manager of broadcast sales; William Graham, formerly manager of the sales engineering department, is now manager of the sales service department; new manager of amateur sales is John V. Murphy.

Stromberg-Carlson: William C. Lewis, who joined S-C in 1929, has been advanced to position of assistant sales manager.

Sprague Electric: Added to the field engineering department is Samuel Lubin, who will be in charge of relations with Government departments in Washington.

New York City: Newark Electric has acquired space for more office and warehouse facilities at 240 W. 55th Street.

Cannon Electric: Don A. Davis, formerly chief engineering representative, had replaced William V. Brainard as sales manager. Brainard has resigned to form his own sales promotion service.

RCA: Victor Division has moved its eastern regional office to 36 W. 49th Street, New York City. Manager is M. F. Blakeslee.

Sylvania: Tubes and special equipment will be distributed in Canada by Stromberg-Carlson, Ltd.

DuMont: Has appointed Victor E. Olson as sales manager of the receiver sales department. Olson was previously eastern sales manager for Meissner.

Aerovox: Lou Alexander, better known in the industry as Alec, is completing his 30th year on condenser sales engineering, and his 20th year with Aerovox.

Providence, R.I.: John J. Moore Company, Stromberg-Carlson distributors, have set up new showrooms at 92 Broadway.

Lewyt: Distribution of radios and other consumer products will be handled by the newly-organized Lewyt Distributing Company, Inc., Brooklyn, in territories where no independent distributors have been appointed.

New York City: After three years in the Army, Ralph West is back at Sun Radio & Electronics Company, in charge of the sound department.

that out-gains them all...

NO DIPOLES, NO LOOPS, no appendages of any kind—just a single, self-supporting structure that's simplicity itself . . . that, for its height, breaks all previous performance records.

This pace-setting FM antenna is the result of entirely new concepts of high frequency radiation—proved by RCA's wartime research and engineering.

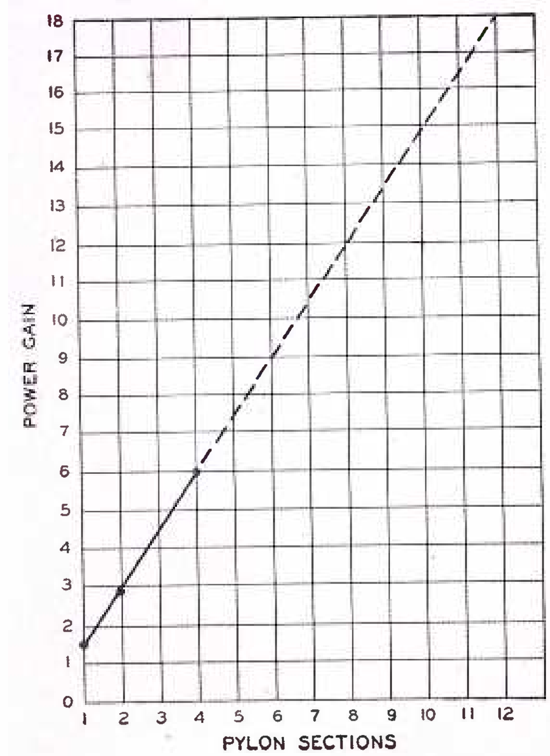
Each antenna section is rolled from a single sheet of aluminum approximately 13 feet high, making a cylinder about 19 inches in diameter. A narrow slot is left from top to bottom. Both ends of each section are capped with a cast flange which adds unusual rigidity and strength and provides a means of connecting and mounting.

A helpful way to visualize the principle of operation is to think of the cylinder as being made up of a large number of half-wave circular elements (*see cylindrical diagram on left page*). With voltage impressed across such elements, current flows in them and radiation takes place. Actually, however, since voltage is impressed at every point along the cylinder slot, the entire structure acts as a radiator.

Most important, the Pylon antenna is easy to erect. A single section weighs only 350 pounds. When two sections are used, they can be joined on the ground and the feed line interconnected. Only *one* connection has to be made in the air; only *two* when four sections are used—as compared with the 10 to 50 connections required by other types.

The simplicity of the feed lines (which run along the slot inside the cylinder) and the absence of external antenna elements have reduced wind, ice, and maintenance problems to the vanishing point. Provision has been made to mount a beacon lamp.

We believe the extra coverage promised by this new antenna—and the ease with which it can be erected—will make it *the* antenna for most FM installations. We'll be glad to send you complete "specs" immediately. Write Dept. 35-K, RCA, Camden, New Jersey.



As many as four, possibly more, cylindrical sections can be stacked to provide a remarkably simple FM antenna with record-breaking gain for its height.

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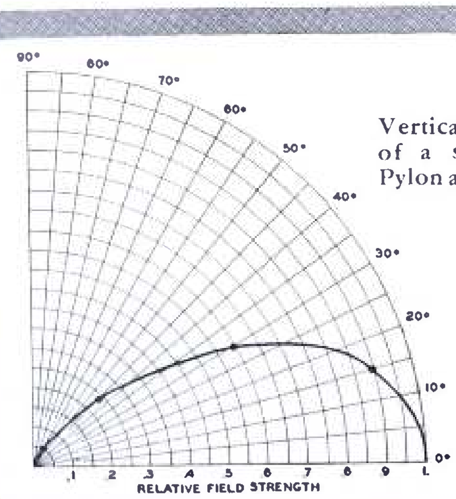
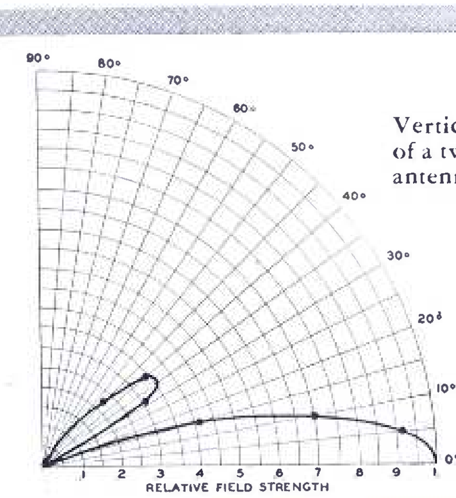
RADIO CORPORATION of AMERICA
ENGINEERING PRODUCTS DEPARTMENT, CAMDEN, N.J.

In Canada: RCA VICTOR Company Limited, Montreal



Vertical field pattern of a single-section Pylon antenna (98 mc).

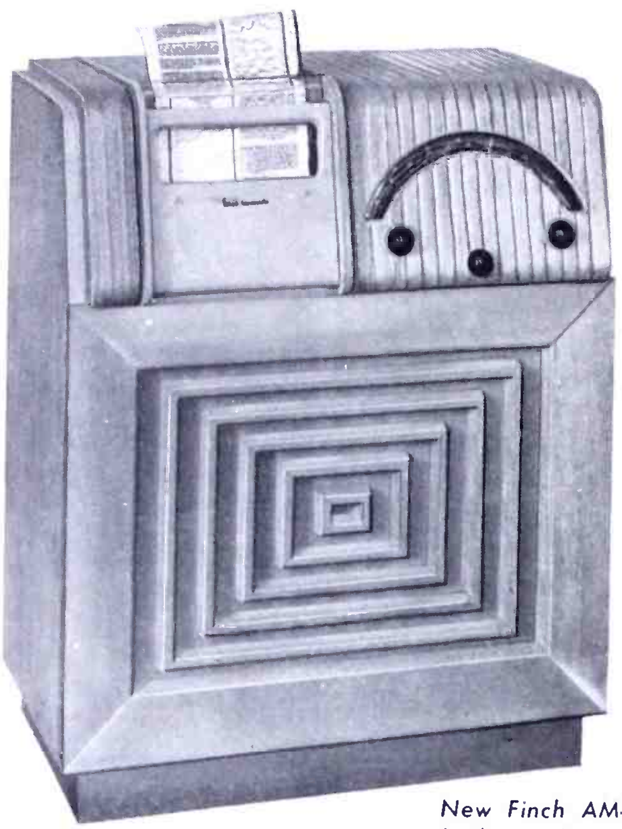


Vertical field pattern of a two-section Pylon antenna (98 mc).

NEWEST

FACSIMILE Broadcasting Equipment

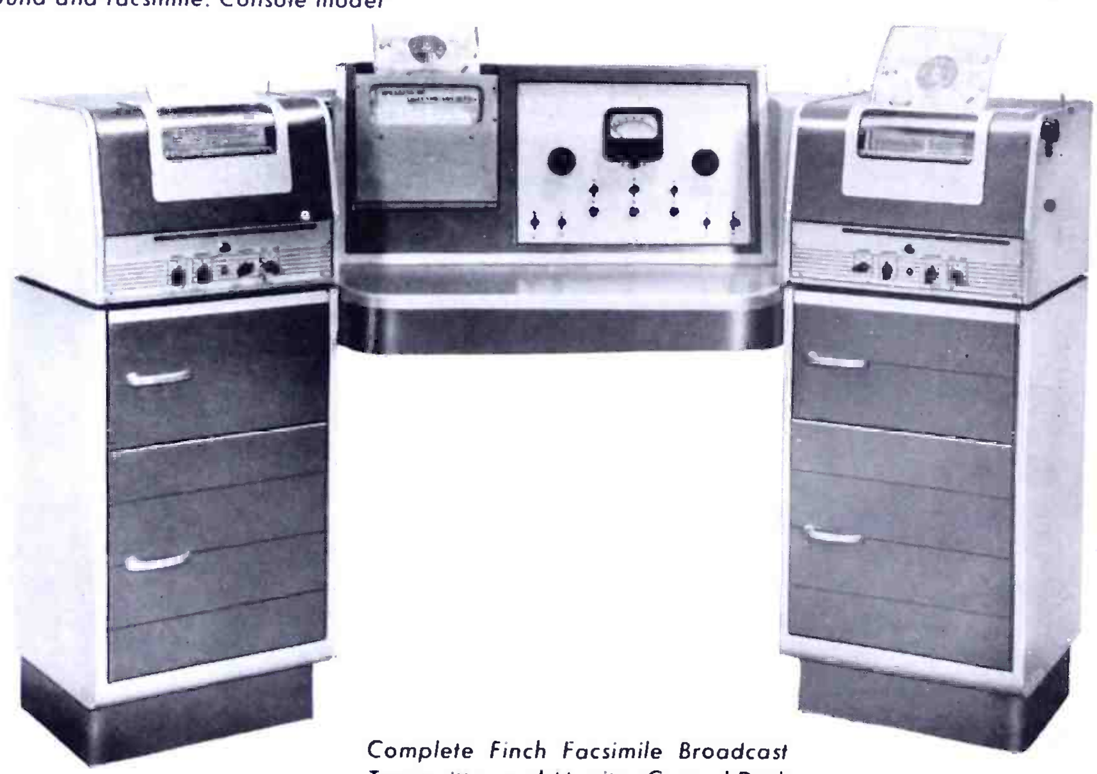
finch



New Finch AM-FM Radio for receiving both sound and facsimile. Console model

New Finch AM-FM Radio for receiving both sound and facsimile. Table model

ORDERS PLACED NOW WILL BE GIVEN PRIORITY



Complete Finch Facsimile Broadcast Transmitter and Monitor Control Desk

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Makers of Facsimile Broadcast Transmitting Equipment, Facsimile Home Recorders, Facsimile Duplicating Machines, and Finch Rocket Antenna for FM stations.

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1. **SEVEN** built-in pre-amplifiers—*more than any other console*—making possible 5 microphones and 2 turntables, or 7 microphones, on the air simultaneously.
2. **NINE** mixer positions—*more than any other console*—leading to 5 microphones, two turntables, one remote line and one network line.
3. **NINE** remote and two network lines—*more than any other console*—may be wired permanently.
4. **TELEPHONE-TYPE** lever-action key switches used throughout — most dependable, trouble-free switches available. *No push buttons.*
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6. **DISTORTION** less than 1%, from 50 to 10,000 cycles.
7. **NOISE LEVEL** minus 65 db's or better. Airplane-type four-way rubber shock mounting eliminates outside noise and operational "clicks."
8. **ALL FCC REQUIREMENTS** for FM transmission are met.
9. **DUAL POWER SUPPLY** provides standby circuit instantly available for emergency use.
10. **POWER SUPPLY** designed for mounting on desk, wall or relay rack.
11. **INSTANT ACCESS** to all wiring and components. Top hinged panel opens at a touch. Entire cabinet tilts back on sturdy full-length rear hinge.

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RC-11 STUDIO CONSOLE

for AM or FM

The Most Versatile Unit of its Kind...Easily Controlling Two Studios, Announcer's Booth and Nine Remote and Two Network Lines.

FIRST UNVEILED at the I.R.E. Show last winter, this remarkable Raytheon Console has won a unique place in its field—commanding the attention of studio engineers and managers as few items of broadcast equipment ever have!

It provides *complete* high-fidelity speech-input facilities for the modern station—with all the control, amplifying and monitoring equipment contained in a single compact cabinet. It easily handles any combination of studios, remote lines or turntables—broadcasting and auditioning simultaneously, if desired, through two high quality main amplifier channels. It makes it a simple matter to cue an oncoming program and pre-set the volume while another program is on the air.

Note the sloping front and backward-sloping top panel, giving maximum visibility of controls and an unobstructed view into the studio. Note the telephone-type, lever action, three-position key switches, *eliminating nineteen controls* and reducing operational errors to a minimum.

The beauty of this console, in two-tone metallic tan . . . the efficient, functional look of it . . . will step up the appearance of any studio, and yet blend easily with other equipment. And the low price of this Raytheon Console will amaze you.

Inquire at once! Write or wire to:

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Broadcast Equipment Division **7517 N. Clark Street, Chicago 26, Ill.**

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★

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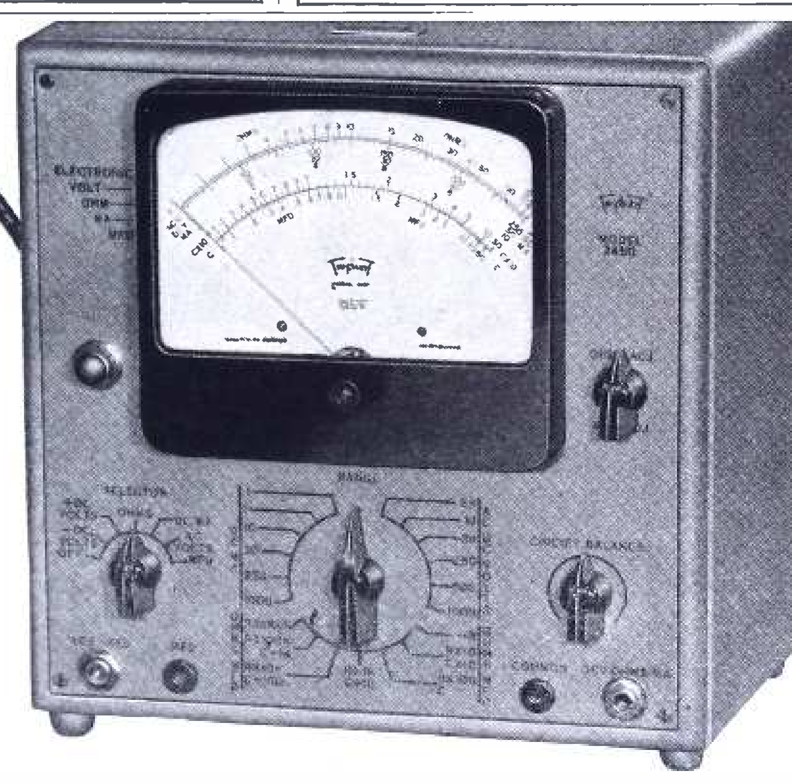
HIGHLIGHTS—42 ranges: DC and AC. Volts: 0-2.5-10-50-250-500-1000 • DC MILLIAMPS: 0-0.1-1.0-10-50-250-1000 • OHMS: 0-1000-10,000-100,000 • MEGOHMS: 0-1-10-100-1000 • CAPACITY IN MFD: 0-.005-.05-.5-5-50 • LOAD IMPEDANCE: 51 megohms on DC Volts • CIRCUIT LOADING: Low frequencies. Circuit loading equal to 8 megohms shunted by 35 mmfd. High frequency circuit loading equal to 8 megohms shunted by 5 mmfd.

Detailed catalog sheets on request.



Precision first ..to last

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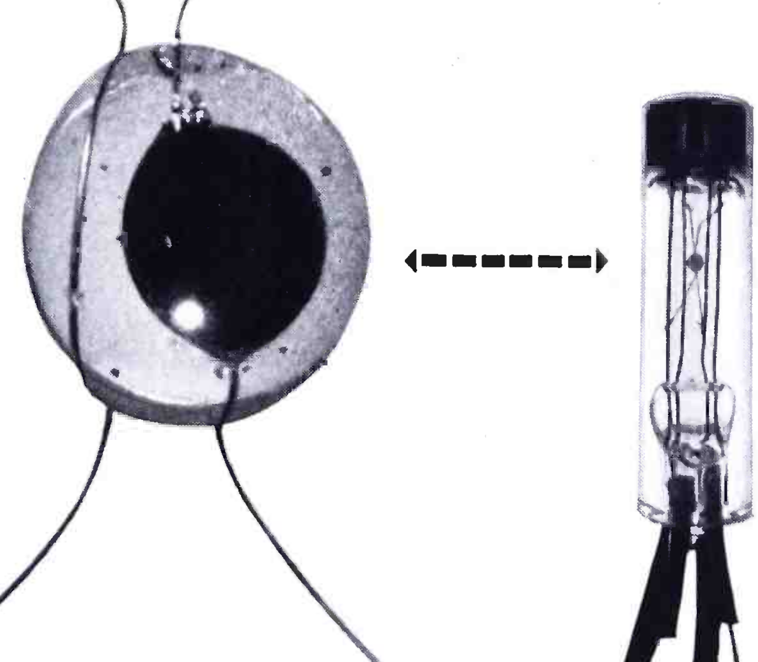
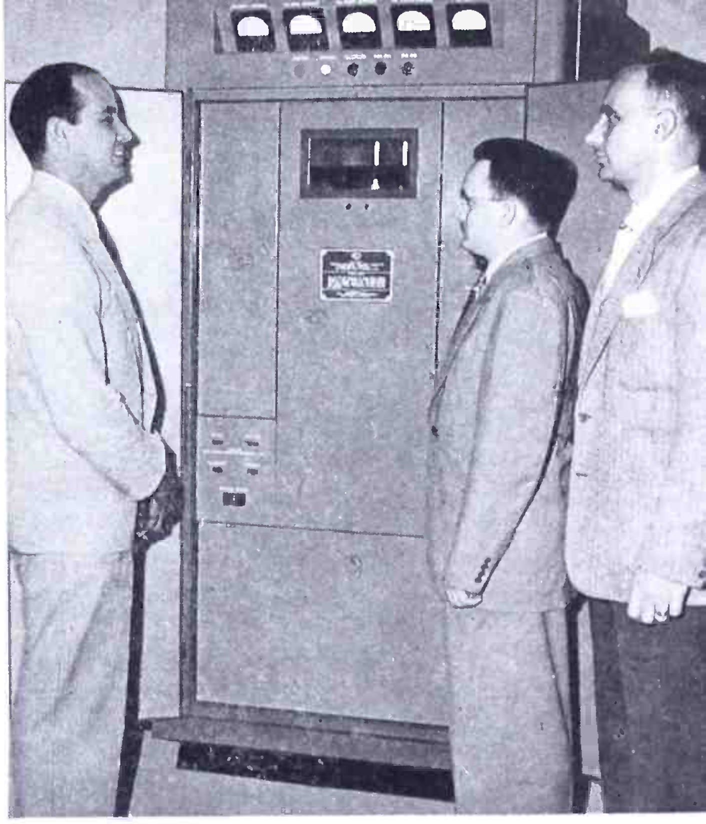
STANDARDS ARE SET BY Triplett



FM, FACSIMILE AND TELEVISION SHOW GAINS

New FM Association—Facsimile Standards Work Started—Communications Frequencies—Electronic Color Television Demonstrated

BY MILTON B. SLEEPER



NEW ORLEANS MAYOR AND FM ENTHUSIAST CHEP MORRISON, LEFT, AT WRCM WITH DR. GEORGE MAYORAL, TECHNICAL DIRECTOR, AND REL'S FRANK GUNTHER, RIGHT

FREQUENCY MODULATION

MOST encouraging FM news in October is that the efforts of FM broadcasters and equipment manufacturers are to be coördinated in a new trade association.

At the Chicago conference of the National Association of Broadcasters on October 21st, the AM avalanche which was to bury FM Broadcasters, Inc. for all time proved to be a dust cloud which blew back into the faces of the would-be grave-diggers.

Oddly enough, the anti-FM and the pro-FM forces joined in voting for the dissolution of FMBI. The former hoped that this would end any FM organization activities for all times. The latter wanted to get FMBI and its NAB contamination out of the way so as to set up a completely new FM association geared to the industry's postwar needs.

No sooner had FMBI been voted out of existence than the FM proponents, including both broadcasters and manufacturers, called for the formation of a new trade setup to advance and expand FM service to radio listeners.

NAB's Position ★ NAB officials stated frankly that their organization could not use its funds to promote any special segment of radio broadcasting. That was known in August, 1946, when FMBI directors accepted the proposal that FMBI become a department of NAB, but no public statement to members was made then.

While it is deplorable that so much time was lost in getting organized FM planning under way, at least the NAB smoke screen has been cleared away, and the line has been drawn sharply between those who want to give better reception to listeners and greater effectiveness to advertisers, and those who take the position that as long as they operate at a profit their service must be good enough for advertisers and listeners alike.

New FM Organization ★ On October 22nd, a steering committee met for breakfast as guests of Roy Hofheinz (KTHT Houston) who acted as chairman. Those present were:

Leonard Asche, WBCA Schenectady, N. Y.
Wayne Coy, WINX-FM Washington, D. C.
W. R. David, General Electric Co., Syracuse, N. Y.
Everett Dillard, KOZY Kansas City and WSDC Washington, D. C.
Theodore Granick, FM grantee, Washington, D. C.
Gordon Gray, WMIT Winston-Salem, N. C.
Frank M. Gunther, Radio Engineering Laboratories, Long Island City, N. Y.
Ira Hirschman, WBAF New York City
Roy Hofheinz, KTHT Houston, Texas
E. J. Hodel, WCFC Beckley, W. Va.
C. M. Jansky, Jansky & Bailey, Washington, D. C.
R. F. Kohn, WMFZ Allentown, Pa.
Leonard Marks, attorney, Washington, D. C.
Milton B. Sleeper, *FM* and Television, Great Barrington, Mass.
Jonas Weiland, WFTC Kinston, N. C.

From this group, three committees were appointed to set up the work of organizing the new FM association. These were:

Objectives Committee: comprising Messrs. Jansky, Coy, Hirschman, Asche, Hodel, and David, with Everett Dillard as chairman, and Leonard Marks as counsel.

Finance Committee: Messrs. David and Gunther, with Gordon Gray as chairman.

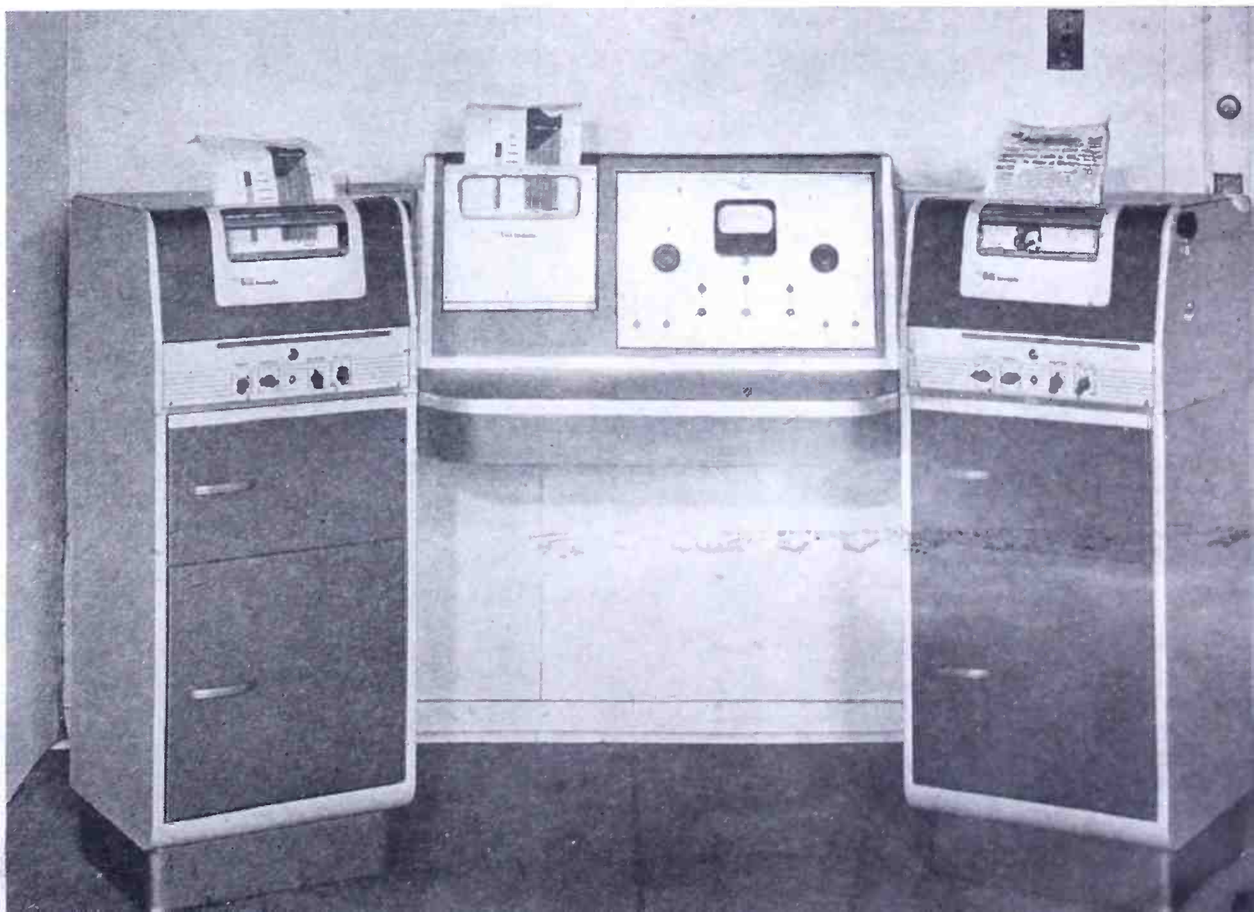
Nominations Committee: Messrs. Coy, Gunther, Kohn, and Ray, with Frank Gunther as chairman.

C. M. Jansky was appointed acting secretary, and Leonard Marks the acting treasurer.

First meetings of these committees were set for November 9th to 11th, at Washington. Judging from the interest and determination expressed during the NAB Convention, the new FM organization will be well under way by the first of the year, and it appears that ample financial support will be forthcoming. Preliminary plans call for headquarters in Washington, D. C., with a permanent staff.

In the preliminary discussion, it was proposed to set up a national organization of FM broadcasters and equipment manufacturers, but on a regional basis. This will permit coördination of geographical group activities, and provide regional representation on the national

FINCH FACSIMILE CONSOLE INCLUDES COMPLETE FACILITIES FOR BROADCAST STUDIO



ZENITH MODEL 8H032, PRICED UNDER $100, HAS 2 FM BANDS PLUS AM TUNING

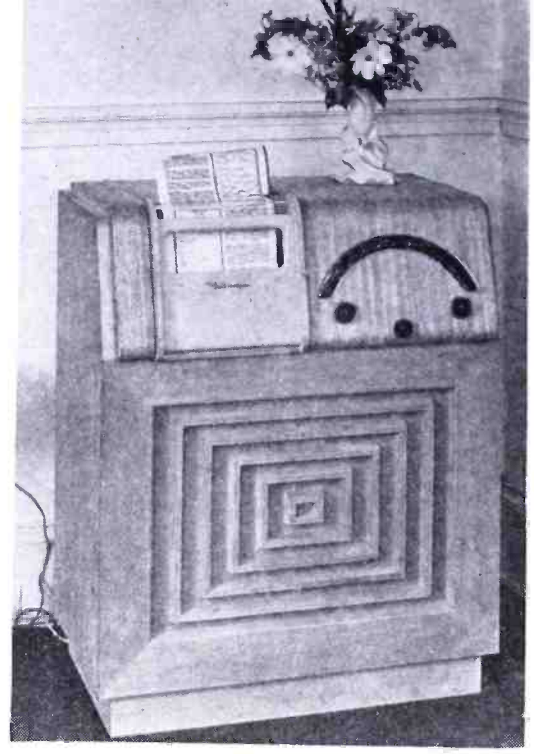
board of strategy, with a minimum amount of travel.

It is expected that we can report the work of the Committees in our December issue. Meanwhile, correspondence should be addressed to Acting Secretary C. M. Jansky, Jansky & Bailey, National Press Building, Washington, D. C.

More FM Receivers ★ Another important development in FM during October is the announcement of FM receiver models by Bendix, Motorola, Philco, and RCA. Reports on the performance of Philco's completely new single-stage FM detector, described elsewhere in this issue, are very favorable. No information has been received on the other makes, but it is reasonable to assume that they will do credit to FM broadcasting. Enough high-quality sets have been delivered to discourage any manufacturer from bringing out substandard designs.

Freed-Eisemann receivers, on which production has been limited by shortage of cabinets, are now coming through in greater volume. Zenith has added a larger table model of improved audio performance. Browning Laboratories have started delivery on the chassis which they announced last month.

Great significance is attached to FM set announcements by RCA and Philco, since the competitive situation among the manufacturers is such that, with these



FINCH CONSOLE SHOWS EASE WITH WHICH FACSIMILE CAN BE ADDED TO FM-AM SET

two companies in the FM field, all others must fall in line without delay.

The general situation has been further improved by the lifting of ceilings on radio equipment. High-quality parts, suitable for FM receivers, have been in short supply because they could not be produced profitably under OPA controls.

Altogether, it appears that the stage is now set to break the bottleneck on FM sets. The shift from cheap AM models to higher-priced FM-AM receivers will be marked by a general dumping of AM sets perhaps as early as Christmas, or directly after the first of the year.

As a result, even if there is something of a business recession in 1947, there should be an increase in dollar volume as compared to '46, with record profits for manufacturers, jobbers, dealers, and servicemen.

FACSIMILE

Most interesting news on facsimile is the conviction expressed by an increasing

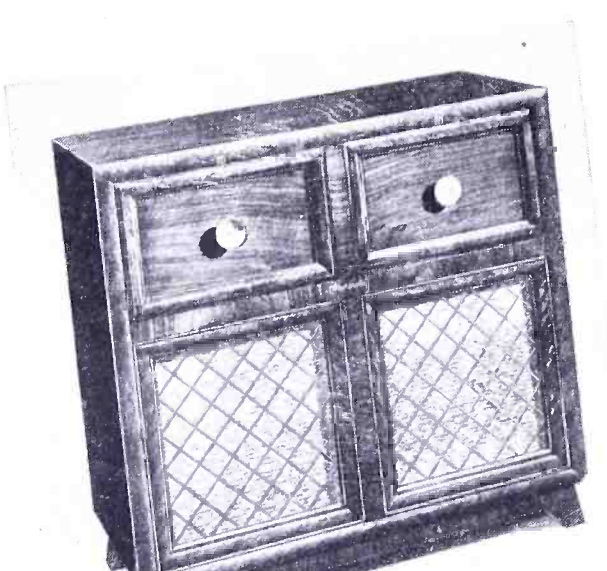
FIRST BENDIX FM-AM RECEIVER IS THIS TABLE MODEL WITH 1 FM BAND

number of radio executives that the time is coming when facsimile recorders will replace phonographs in combination models. Reasoning behind this is that better radio reception, afforded by FM broadcasting, will cut the demand for phonograph records, and that the completely new service rendered by facsimile will bring about this shift.

Another step in facsimile progress is the current discussion of standards. This is important because system standards must be adopted and approved by the FCC before there can be any large-scale expansion of facsimile broadcast service.

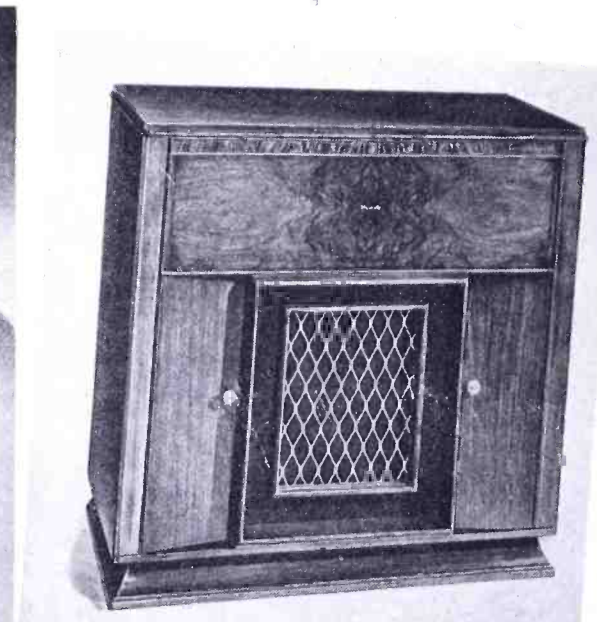
Although a definite start has been made, much work remains. With due respect for the RMA facsimile committee, it must be said that the members represent only a very limited understanding of the new art. There has been much emphasis placed on technical development and patents, but, as has been pointed out in *FM* AND TELEVISION, what the public will accept or reject is the programming.

Specifically, no intelligent decision can be reached on the width of the printed page until the format has been determined. First of all, a decision must be reached as to whether a single, wide column is to be used, or three or four narrow columns. The latter introduces serious complications, since it will be necessary to make up the text in individual pages of standard depth. That is because the foot



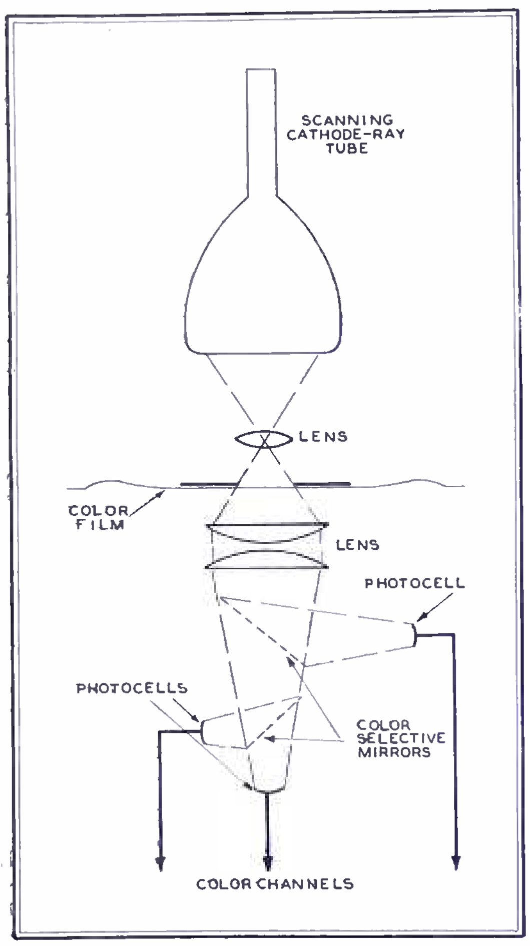
MOTOROLA PHONOGRAPH COMBINATION HAS 1 FM BAND, AM & SW.

FREED FM-AM PHONOGRAPHS ARE MOVING TO DEALERS AT ACCELERATED RATE



ANOTHER MODEL IN MOTOROLA'S NEW LINE OF FM-AM PHONO COMBINATIONS of the first column must carry over to the top of the second, and so on. Otherwise, the makeup will be hopelessly complicated. A single, wide column, with a paper width of perhaps 5 ins., would permit continuous reading. Illustrations and advertising might be of full column width, or one-half column wide, with the text run around them. Pictures requiring extra width could be run lengthwise on the paper, as is common practice in magazines.

Such RMA standards as were recently adopted are by no means complete, since they do not cover methods of phasing and synchronizing. On these points there is some jockeying for patent position. It would be unwise for the FCC to approve standards which involve patented methods until and unless some agreement has been brought about, perhaps by the RMA,



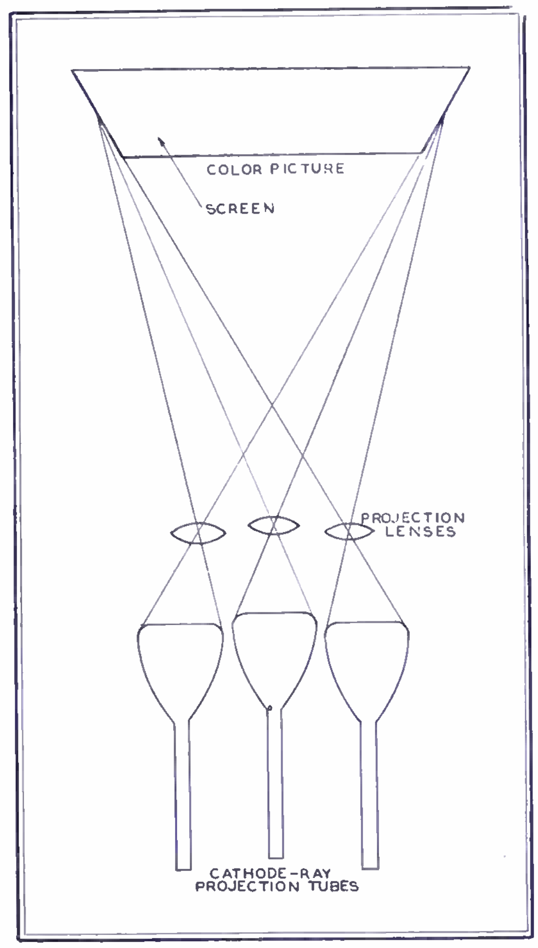
ELECTRON BEAM SCANS FILM OR SLIDES IN RCA COLOR TELEVISION TRANSMITTER

as to license policies on facsimile inventions. Otherwise, the standards may discriminate in favor of one patentee against the others.

All these problems must be brought to light, thrashed out, and settled before facsimile can get up its steam to go ahead at full speed. If, as it now appears, the FCC will not be able to tackle the standards problems until some time in 1947, the art will benefit by this reasonable delay.

Many broadcasters had their first opportunity to see just what sound-facsimile receivers may look like during the Finch demonstration at Chicago. Both table and console models were displayed. The latter, illustrated here, shows that cabinet dimensions are affected very little by the addition of the facsimile recorder.

RAY D. KELL, HEAD OF TELEVISION RESEARCH AT RCA LABORATORIES, AT THE SLIDE SCANNING EQUIPMENT



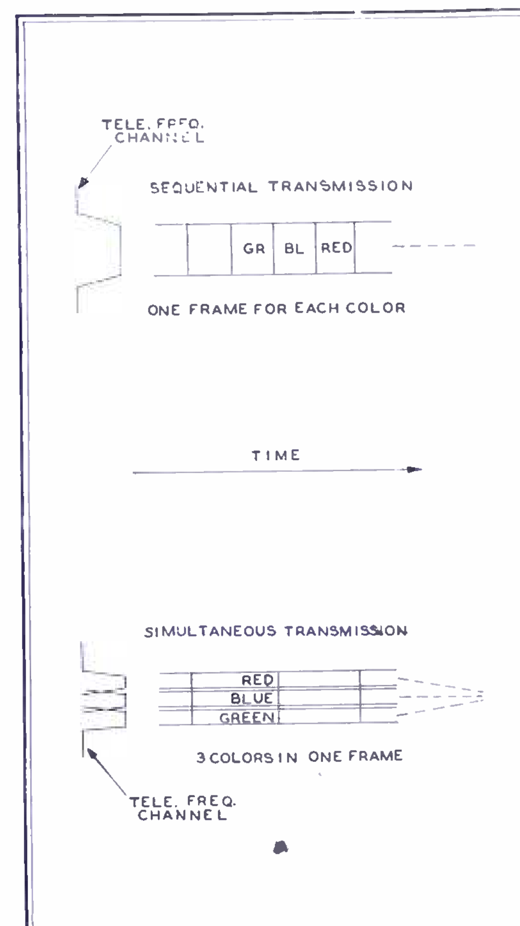
AT RECEIVER, RED, BLUE AND GREEN TUBES SUPPLY COLORS SIMULTANEOUSLY BELOW: RCA COLOR PROJECTION SYSTEM

COMMUNICATIONS

Principal subject of discussion at the Annual Conference of the Associated Police Communications Officers at Buffalo was the matter of choice between 30 to 40 mc. and 152 to 162 mc. In general, APCO has favored the higher band, while the Eastern States Police Radio League has generally voiced reluctance to shift from the lower band.

Now opinion is developing which would put all state police systems on the upper band, and municipal police on the lower!

Apparently the FCC has some ideas as to the future because a hearing on 30- to 40-mc. allocations has been set for December 16th. The FCC plans to set up this band with 20-kc. channels, instead of the 40-kc. channels now in use, by July 1, 1953.



COMPARISON OF CBS SEQUENTIAL SYSTEM WITH RCA'S ELECTRONIC COLOR SCANNING

The purpose of announcing the 20-kc. channel width now is "to encourage the design and manufacture of receivers which will have pass bands with selectivity characteristics such that the effective pass band is substantially less than 20-kc."

According to opinions expressed by manufacturers at the APCO Conference, neither they nor the FCC engineers know how practical FM equipment can be designed to operate within a 20-kc. band, since a swing of 15 kc. is now required to transmit 3,000-cycle modulation. Perhaps, for the present, the FCC expects

(CONTINUED ON PAGE 45)

ELEMENTS OF HOME FACSIMILE STANDARDS

Indicating That Questions of Format May Delay Determination of Standards

BY MILTON ALDEN*

THERE will come a day when facsimile will be important to everyone connected with the radio industry. That time is approaching rapidly.

If you are connected with engineering, manufacturing, distribution, broadcasting, or radio advertising, you must recognize that the industry has reached its present status because of the effectiveness of broadcasting as an advertising medium.

Competition for Attention ★ However, the effectiveness of any medium changes with the years. One factor is the competition for public attention. Broadcasters and newspaper and magazine publishers recognize this.

During the war, for example, gasoline rationing, blackouts, limited transportation, and long working hours tended to keep people in their homes at night. Then there was extra time to read and listen to the radio.

Now a new set of conditions must be faced by broadcasters and publishers. Transportation is available once more, taking people out of their homes. Working hours are shorter, affording leisure for many new activities. Sports are attracting more spectators and participants, as indicated by the 15,000,000 weekly attendance at bowling alleys.

All this means less listening and reading time. Radio surveys disclose this trend. Figures for magazine and newspaper circulation have taken on an altered significance because it is recognized that many publications are now read less thoroughly.

To meet the competition for attention, radio sponsors are upping expenditures for programs, and buyers of printed advertising are going to larger space and the use of color. At some not-distant point, the law of diminishing returns will become evident.

Offsetting this condition to some extent are readers and listeners whose standards of living have been raised, and added coverage of areas not reached previously. Also, the national economy may improve. It does not follow, however, that this would help broadcasting, magazines, and newspapers in their present form. Even television, while it may become big business in some areas, can only profit advertisers when people take time to give it their undivided attention.

Radio's Pot-Boiler ★ In manufacturing, many of us have what we call pot-boilers — staple products which carry the overhead, in contrast to specialties which make most of the profits.

Facsimile may prove to be the broadcasters' pot-boiler. The success of sound programs has been often attributed to the fact that it only requires the listener's presence, and not his undivided attention. Facsimile has the added advantage of unattended operation, since it provides a record of reception that is retained until the owner is ready to give it his undivided attention.

Thus, with every other advertising medium able to guarantee no more than transitory notice of its bound or folded pages, facsimile can offer advertising with top-rating assurance of visibility that guarantees attention for every square inch of space.

Facsimile gives further assurance to advertisers because, since people will pay for the paper, they will not fail to read what they have taken the trouble to record.

It is the writer's conclusion that facsimile advertising will meet the growing competition for public attention by introducing a new technique, a new convenience, and a new public service, and that it can give continuity to the growth of radio advertising at a time when a shot-in-the-arm is sorely needed.

As for the profitable operation of a broadcast station, the opinion is held in many quarters that the days of easy money may be brought to an end by the rise of rate wars. If that proves to be the case, facsimile may turn out to be the pot-boiler, producing a steady revenue to carry operating expense, so that lower rates for sound programs will still show a profit.

Limiting Facsimile ★ Having considered the possibilities of facsimile as a means to keep the dollar volume of broadcast advertising on the increase, let's consider how importunate friends of facsimile may, unintentionally, cramp its style.

Newspapers, both those already operating radio stations and those who look upon FM as a second opportunity, have been quickest to recognize the possibilities of facsimile. Perhaps that is because they understand its advantages, and the comparative merits of the two means of delivering printed news, pictures, and advertising.

These interests do not think of transmitting actual newspapers by facsimile, newspaper style and format, and with high-speed production. From their point of view, 4-column make-up on a roll 8½ ins. wide seems reasonable for facsimile. Also, they have favored a recording speed of 3.4 ins. per minute.

But let us look at the programming problems involved. The writer has discussed this matter at much length with prewar facsimile pioneers. They have found from actual experience that the production work involved in preparing interest-holding material for 15 minutes of transmission to be recorded on 8½-ins. paper is a big undertaking. To measure the magnitude of this task, paste four 8½- by 11-in. sheets end to end, and attempt to fill that area with material that you consider so important that Mr. and Mrs. John Q. Public and their children will feel compelled to read it.

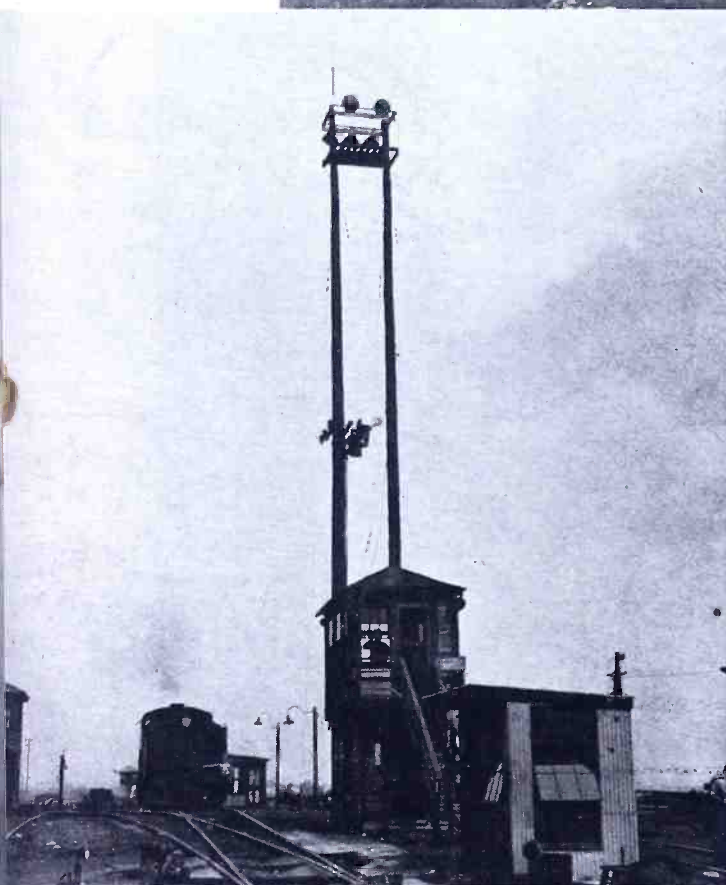
After several attempts, you'll probably come to the conclusion that what you have laid out will serve the interests of facsimile readers and advertisers much more effectively if it is boiled down sufficiently to be recorded on paper 4 or 5 ins. wide! Producers of sound broadcast programs will check with this, for they know how much more certainly a 15-minute variety program will click than a show that runs on for 30 minutes or an hour.

It would seem to be in the best interests of all concerned, therefore, to set up nothing more than tentative, experimental standards at this time, leaving ample latitude for not only engineering field tests but for an exhaustive study of facsimile format, since these two aspects are equally important in determining the eventual acceptance of this new radio service.

Technically, facsimile has already developed to the point of perfection where it might be possible to set up standards if that could be done without freezing the paper width. Unfortunately, that appears impossible. Pending the completion of format studies, if standards should be set, it would be necessary to settle on wide paper in order to take care of all eventualities. Then, if it is found that public opinion favors a single, wide column of type, the recorders will be extravagantly large in size, and a considerable part of the mechanism will require replacement, together with some modification, probably, in the electrical circuits.

It is the writer's opinion, based on extensive experience with facsimile programming techniques and with public

* President, Alden Products Company and Alfax



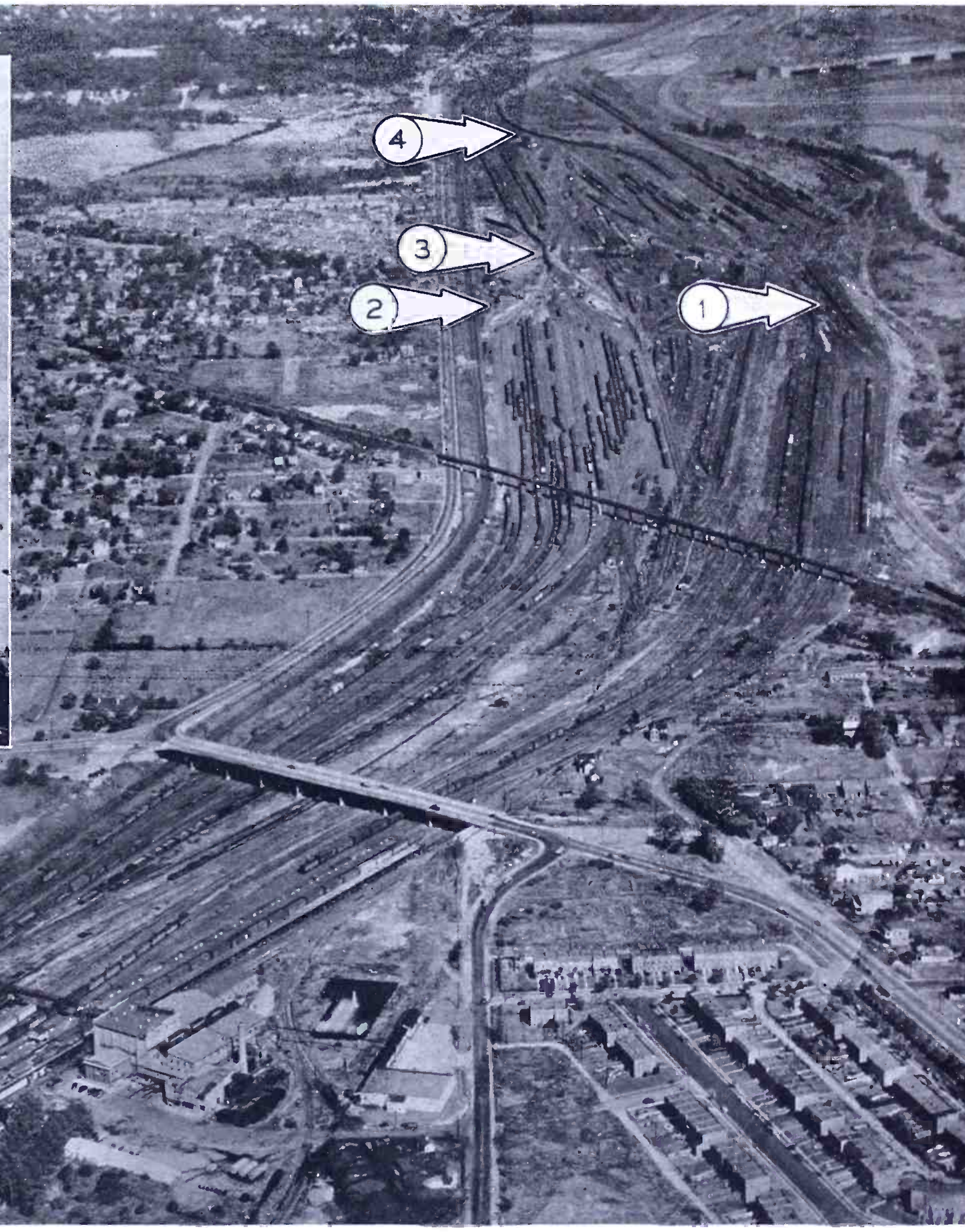


FIG. 1, ABOVE: THE POTOMAC FREIGHT YARD IS ONE OF THE LARGEST IN THE U. S. TRANSMITTER WAS INSTALLED AT POINT 1, WITH WIRE-CONNECTED CONTROLS AT POINTS 2 TO 5. FIG. 2, LEFT: TRANSMITTER AND ANTENNA INSTALLATION

FM FOR RAIL YARD MANAGERIAL CONTROL

Report on the Farnsworth Tests at the Richmond, Fredericksburg & Potomac Freight Yards

BY WILLIAM S. HALSTEAD*

1. INTRODUCTION

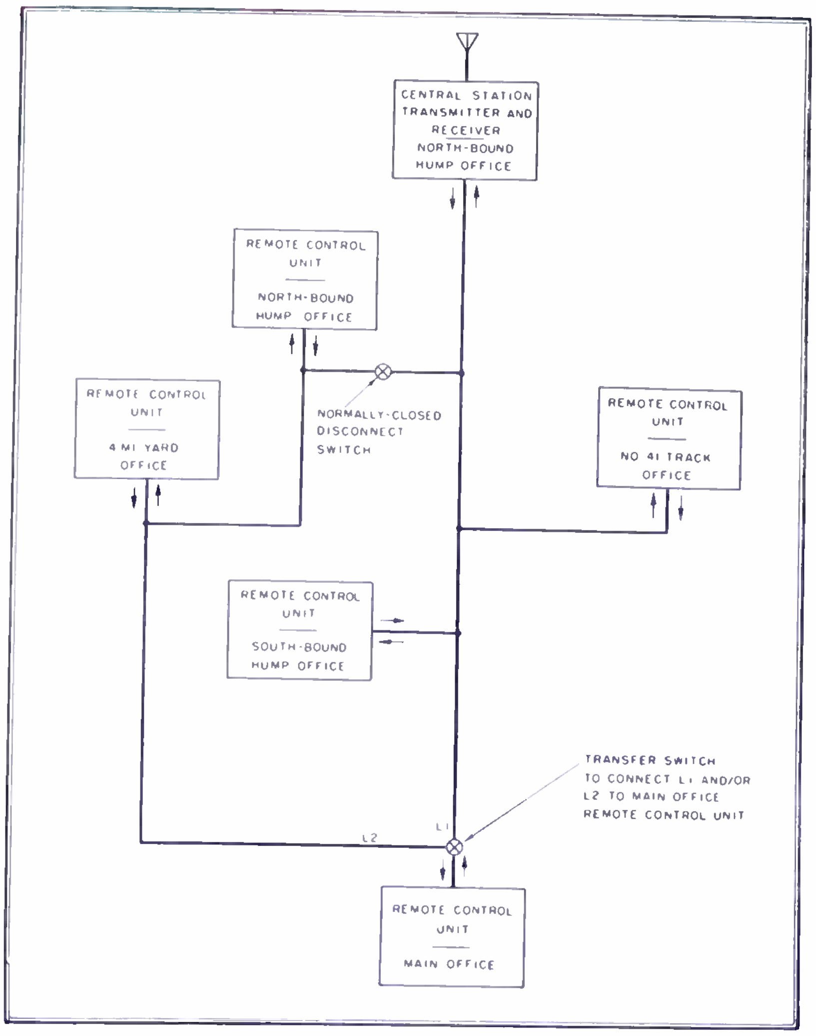
THE effectiveness of very high frequency FM radiotelephony in providing comprehensive managerial control of railroad yard areas was initially demonstrated during the war period at the U. S. Army's ordnance plants.[1] While a number of yard installations, using channels allocated to the railroads in the 152- to 162-mc. band, have been made since the end of the war, the majority of these have been of an exploratory nature, involving two-way radio communications between engineers or conductors in locomotive cabs and one or two control points within the yard areas.

A continuing study of the use of radiotelephony in railroad yard operations during the period from 1940 to date has indicated that, for the most effective use to be made of radio equipment, freedom of mobility by railroad personnel as well as centralized managerial control are important factors. Moreover, adequate pro-

normal working points of yard personnel including enginemen and those key men by whom the local movements of locomotives are directed — namely, the train conductors.

In normal yard service, conductors may spend considerable amounts of time riding on the footboards at the front or rear of yard engines, since it is from these points that the conductors can readily judge the distance between the engine and the cars toward which the locomotive is moving. From these favored vantage points, or on

* Consultant, Farnsworth Television & Radio Corp., Ft. Wayne, Ind.



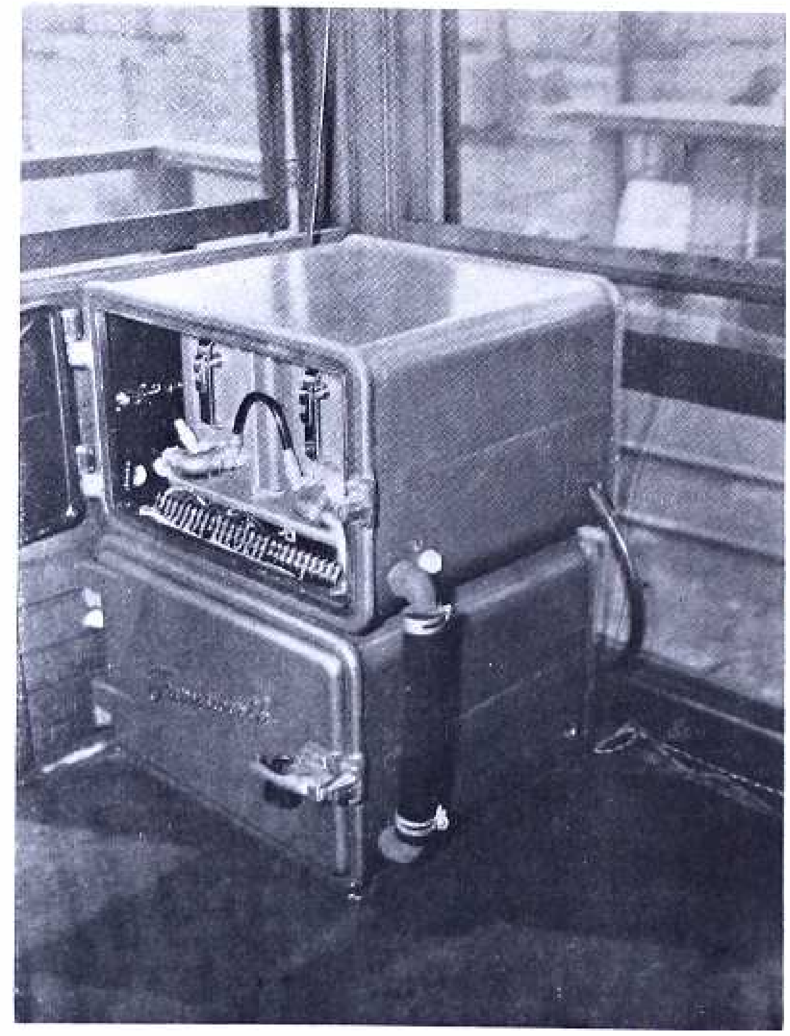


FIG. 3. NORTH BOUND HUMP OFFICE IS POINT 1 ON FIG. 1; MAIN OFFICE IS POINT 2; SOUTH BOUND HUMP OFFICE IS POINT 3; 4-MILE YARD OFFICE IS POINT 4; NO. 41 TRACK OFFICE IS POINT 5. FIG. 4. TRANSMITTER, RECEIVER, AND POWER SUPPLY UNITS

concerning engine movements in yard operations. Thus, communications directed to the conductor of a particular locomotive from a central control point should, under presently-accepted procedure, reach the conductor instantly at his normal work point, be acknowledged by him, and thence be relayed to the engineman who, in turn, will acknowledge receipt of the instructions. Such an operation can be handled effectively by the locomotive crew with a system which includes the following units on the locomotive:

1. Conductor's remote control equipment on the front and rear platforms of the yard locomotive, incorporating a microphone and loudspeaker and earphone.

2. Engineman's control unit in his cab, also provided with microphone, loudspeaker, and earphone.

3. An intercommunication circuit between control points 1 and 2 above, designed for both audio intercom connection between the two control points on the engine, and for controlling radio transmission from either of the two points. This requires means to select between the audio and radio circuits without interfering with the operation of the locomotive receiver, which must continue to respond to radio calls from the control point while the engine equipment is being employed in intercom service.

Similarly, in order to provide greater flexibility and increased scope of control under the varying conditions of yard operations, it is indicated that remote fixed-station control units of comparable functions should be located at points where supervisory yard personnel are normally posted. Usually, in the larger yards, there are at least three or four locations where these key men are situated. These may be the main yard office, various track offices, and hump offices. They should, it is believed, be provided with audio intercommunication connections which will function without interfering with radio reception during intercom use, and without need of going on the air when interoffice traffic is being handled through the control units.

To effect a further increase in the degree of mobility of communication and over-all efficiency of a yard radio system, experience has demonstrated the need for lightweight walkie-talkies. They should be of back-carried or other compact portable design which would not interfere with the normal, and often necessary, use of both hands. Such units will extend the use of the communications system to persons at any part of the yard.

In order to determine the general effectiveness of a comprehensive yard radio network, with remote control facilities at strategic locations in the yard area and on locomotives, a system of this sort was installed recently at the Potomac Yard in Alexandria, Va., just outside Washington, D. C. The system employed a 10-watt FM radiotelephone installation at the central

THE first published description of an FM railroad radio communication system, written by William S. Halstead, appeared in the July and August 1943 issues of "FM Radio-Electronics." At that time, it was considered a relatively obscure application of 2-way FM communications. However, unknown to most radio engineers, FM was used during the war for continuous day and night railroad operation to increase the efficiency and safety of yard operations at vital U. S. Army ordnance plants, where parts for shells and bombs were carried by rail between isolated assembly plants dispersed over many square miles.

The successful use of FM railroad radio during the war period is described in the records of Government hearings on the subject of railroad radio, conducted by the Senate Military Affairs Committee, and by the FCC in September 1944, when the case histories of railroad radio at ordnance plants were of great significance in appraising the value of railroad radio communications.

This series of articles by Mr. Halstead was an important contribution to stimulating interest in the use of radio to reduce railroad accidents, and provided the Senate Military Affairs Committee with valuable background data which would not otherwise have been available in correlated form. Subsequently, the articles were reprinted by the U. S. Government in its public record of the Senate hearings, and were entered as an exhibit by the FCC at its hearings on railroad radio.

The present article by Mr Halstead describes tests of an FM communications system, operating in the 152- to 162-mc. band, at one of the largest and most strategically-placed railroad yards in the country, handling the bulk of all rail freight traffic moving between the Southeastern states and the principal metropolitan centers of the northeast.

FIG. 5. C. E. MCCARTY, MANAGER OF THE POTOMAC YARD, TALKING FROM THE MAIN YARD OFFICE TO ONE OF THE LOCOMOTIVES. ONE OF THE STANDARD CONTROL UNITS IS SHOWN ON THE DESK

station, connected by wire to five remote control units, and 10-watt mobile stations on two yard locomotives, each equipped with two control positions. Extensive tests were conducted during the month of September, 1946, by the Potomac Yard, under the supervision of Mr. C. E. McCarty, Manager of the yard, in association with the Farnsworth Television & Radio Corporation. These tests also provided an opportunity for the FM railroad radio system to be observed in operation, during a special demonstration on September 11th, by a large group of railroad executives and government officials, including members of the Federal Communications Commission, Interstate Commerce Commission, and the top command of the Army Transportation Corps.

The type of communications network described above was used at Potomac Yard because the size of the yard and the traffic loads handled are of such magnitude as to require facilities for rapid intercommunications between all of the key control points, and between these points and radio-equipped locomotives.

2. POTOMAC YARD INSTALLATION

The Potomac Yard, one of the largest classification centers in the United States, is operated by the Richmond, Fredericksburg and Potomac Railroad Company. Six mainline railroads use the facilities of the yard. These are: the Baltimore and Ohio, Chesapeake and Ohio, Pennsylvania Railroad, Southern Railroad, Seaboard Airline Railroad, and the Atlantic Coast Line Railroad.

The yard handles 6,000 cars or more daily, since it serves as a main arterial gateway for the bulk of rail freight traffic moving along the Atlantic coast between the northern and southern sections of the Country. In order to expedite traffic flow through the yard areas, which are several miles in length, two separate classification yards are employed, each with its hump and hump office. Freight cars from the south are routed through the northbound yard, where a hump conductor directs local yard operations under the general supervision of the yardmaster, who is responsible to the Manager. Cars from the north are moved in similar manner through the southbound classification yard, under local direction of the hump conductor at the southbound hump office, with general supervision from the main yard office.

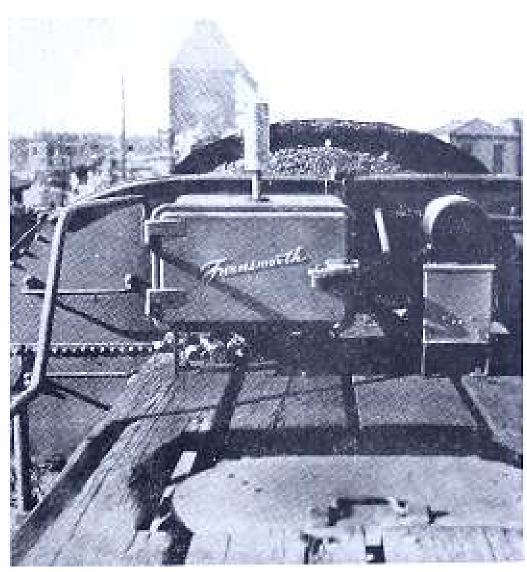


FIG. 6. ON LOCOMOTIVE NO. 3, THE RADIO AND ANTENNA WERE MOUNTED TOGETHER

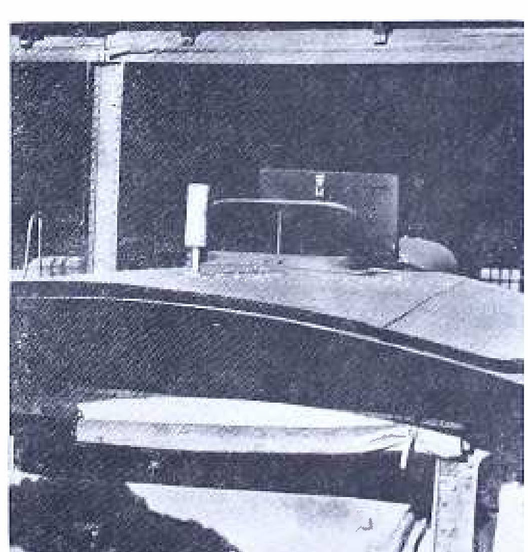


FIG. 7. LOCOMOTIVE NO. 45 CARRIED THE ANTENNA DIRECTLY ON THE ROOF

These operations require skillful coördination and constant intermeshing of control functions in order to keep a steady flow of traffic moving through the miles of tracks and switches within the yards.

Thus, because of the high traffic density, any increase in operating efficiency achieved through the use of radio communication is a matter of great economic importance.

Purposes of Radio Tests ★ The principal purpose of the tests, aside from the opportunity they afforded to observe the technical performance of the equipment, was to demonstrate that an integrated radiotelephone system, with a plurality of remote control units located at strategic points, would afford:

1. Improved managerial control in the operation of large rail yards, and

FIG. 8. CLOSE-UP OF THE RADIO EQUIPMENT INSTALLATION SHOWN IN FIG. 4

2. More effective coördination between the yardmaster and locomotive crews or yard personnel, by providing

3. Dependable two-way communications by radio throughout the entire yard area.

4. Direct two-way radio communications between the conductor or locomotive engineer and the supervisory personnel at any fixed point.

5. Direct two-way audio intercommunication between personnel at all fixed-station control points, in addition to radio control facilities at these points.

6. Direct two-way audio intercommunications between conductors on footboards of locomotives and enginemen in locomotive cabs, as well as radio control circuits at these locations.

7. Freedom from electrical noise in receivers on radio-equipped locomotives in portions of the yard where an 11,000-volt overhead catenary power system is installed.

Details of the System ★ The FM radio system used in the Potomac Yard employed a 10-watt central-station FM transmitter and a receiver, operating in the 152- to 162-mc. band. This equipment was installed at the northbound hump office, ndicated as 1 in Fig. 1. Wire lines were provided for remote control units at four other key points, indicated as 2, 3, 4, and 5 in Fig. 1. The complete system is illustrated diagrammatically in Fig. 3. Two steam locomotives were equipped with 10-watt transmitters and receivers, oper-

Central Station ★ The central station equipment, Fig. 4, was installed at the northbound hump office, Fig. 2. The transmitter was crystal-controlled for operation on any pre-determined frequency assigned to railroad radio service in the 152- to 162-mc. band. The transmitter was a pre-production version of a model manufactured by Farnsworth for railroad use, with nominal power output of 10 watts, in lieu of the 15-watt rating of the production unit, Fig. 15. Phase modulation was employed, with maximum frequency swing of ±15 kc. The effective audio-frequency range of the speech input circuits extended from approximately 150 cycles to 3,500 cycles, with a rise in audio-frequency response of approximately 6 db per octave between 300 and 3,000 cycles. Peak limiting prevented excessive frequency swing during modulation of the transmitter.

The FM receiver, also a Farnsworth pre-production model, was a crystal-controlled superheterodyne. The receiver had 0.5-microvolt sensitivity, with maximum power output of approximately 5 watts. The selectivity rating was approximately 80 db down at 120 kc. off resonance on each side. As in the transmitter, the effective audio frequency range extended from about 150 cycles to 3,500 cycles. The de-emphasis characteristic provided a response decreasing with increasing audio frequency between 300 and 3,000 cycles at the rate of 6 db per octave.

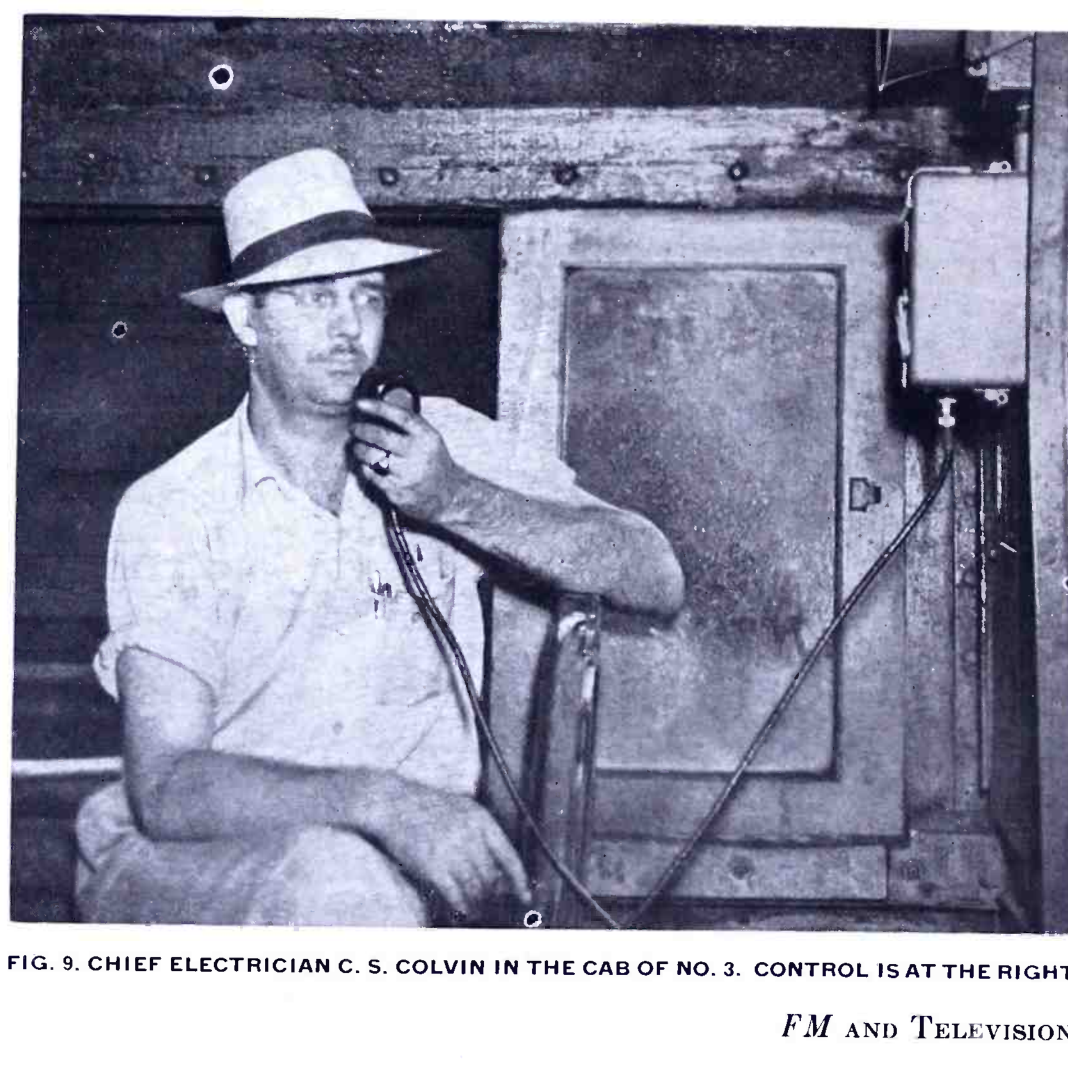


FIG. 9. CHIEF ELECTRICIAN C. S. COLVIN IN THE CAB OF NO. 3. CONTROL IS AT THE RIGHT

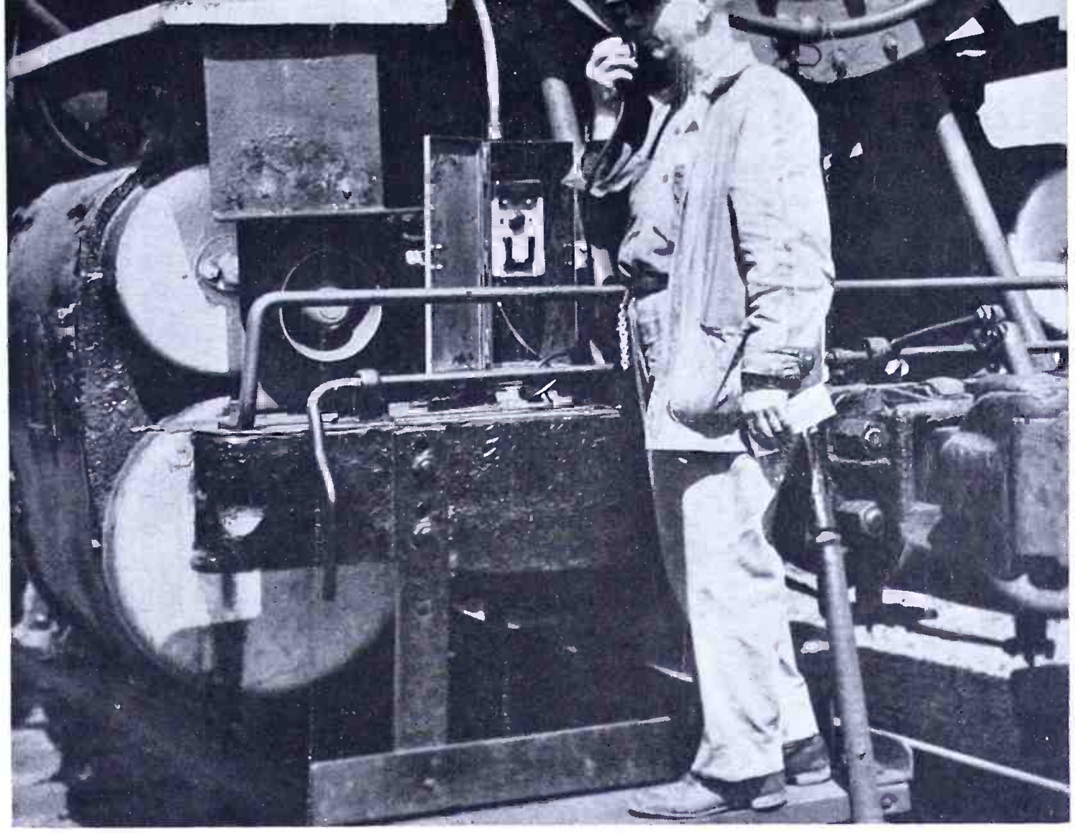


FIG. 10. CONTROL AND SPEAKER AT FRONT OF NO. 45. CONDUCTOR BAYLISS AT THE MIKE

Cascade limiters were used, with AVC action sufficient to hold the audio signal level within 4 db over a variation of RF input signal ranging from 1 microvolt to 1 volt or more. An electronic squelch circuit, of noise differential type, was incorporated in the receiver to suppress loudspeaker operation except during reception of a carrier signal.

A local control unit, consisting of the necessary relays to effect local or remote control of transfer switching between the transmitting and receiving circuits, was used at the central station.

Filament and plate power were derived from a conventional 115-volt 60-cycle power supply unit.

The transmitter, receiver, local control, and power supply sections were each assembled on chassis of uniform size, as shown in Fig. 4. The transmitter and receiver units were designed to be interchangeable with similar units on the locomotives. The transmitter and receiver chassis were held in tracks on metal racks provided with shock-mounts. The local control chassis and the AC power supply units were installed within a separate housing, located beneath the transmitter and receiver case, as illustrated in Fig. 4. The door of each housing was designed to close in pressure contact with a rubber gasket. This made the cases air-tight, sealing them against the entry of corrosive gases present in the smoke from steam locomotives.

The doors were also equipped with latches on which locks could be placed to prevent unauthorized access to the radio apparatus. Furthermore, the top and bottom of each chassis were provided with metal covers on which seals could be placed. This precluded the removal

service, which permit unlicensed railroad employees to operate and replace pre-adjusted transmitters and other radio equipment, but which require that all adjustments in transmitting apparatus be made only by personnel holding FCC licenses.

The antenna at the central station, Fig. 2, was a vertical collinear array developed by Farnsworth. It was mounted at an elevation of about 65 ft., at the top of a floodlight tower. This antenna somewhat resembles a coaxial antenna in external appearance, is approximately one wavelength long, and was designed to provide low-angle radiation of vertically-polarized waves in all horizontal directions about the antenna. The gain of the antenna is 3 db over that of a vertical dipole. Connection between the antenna and radio equipment in the hump office was made by a flexible Amphenol RG 17/U concentric cable, approximately 75 ft. in length.

Remote Control System ★ Remote control of the central station equipment was effected by means of AC-operated remote control units, located at the points designated in Figs. 1 and 3. Each unit consisted of

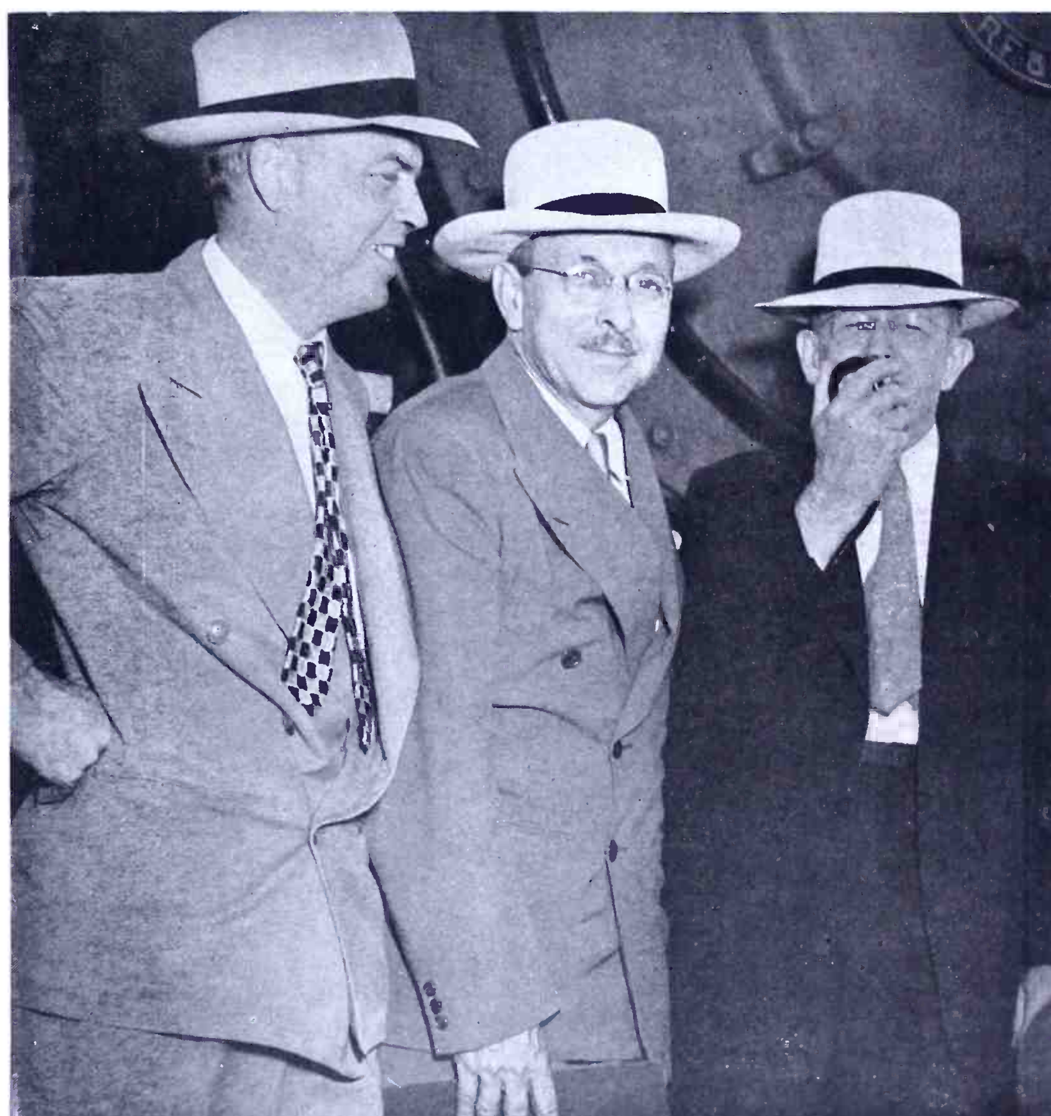


FIG. 11. FCC COMMISSIONERS E. K. JETT, RAY C. WAKEFIELD, AND PAUL WALKER (L. TO R.) TOOK PART IN THE FARNSWORTH DEMONSTRATION OF RAILROAD RADIO

FIG. 12. REMOTE CONTROL POSITION AT THE SOUTH HUMP OFFICE OF THE YARD

a small desk-mounting metal case, enclosing an audio amplifier to operate a built-in loudspeaker, AC-operated power-supply circuit, transmit-receive relays, indicating lights to show that power is applied to the remote control unit and to the transmitter during transmit periods, volume control for the loudspeaker, intercom switch for direct-line audio communication between all remote control points without causing operation of the radio transmitter, a channel selector switch for radio operation on either of two predetermined frequencies, and a telephone handset. Removing the handset from its hang-up switch transferred incoming signals from the loudspeaker to the earphone. All remote control points were interconnected by a single-pair telephone line with the radio installation at the Northbound Hump Office.

Line transfer switches, Fig. 3, permitted the use of the wire lines as two intercom systems. One of these connected the Northbound Hump Office, the associated Four-Mile Run Yard Office, and the Main Yard Office. The other connected the Southbound Hump Office and the associated Track 41 Yard Office to the Main Yard Office. These two systems were operated on a party line basis in nearly all instances, and enabled the yardmaster or manager to communicate with either or both north and south hump offices, or with the mobile units, depending upon the position of the intercom switch at the control point.

Locomotive Transmitter & Receiver ★ The mobile transmitter and receiver installed on steam locomotives Nos. 3 and 45 were of unit construction, interchangeable with the central station equipment. The transmitter and receiver units on engine No. 3 were installed on a shock-mounted rack

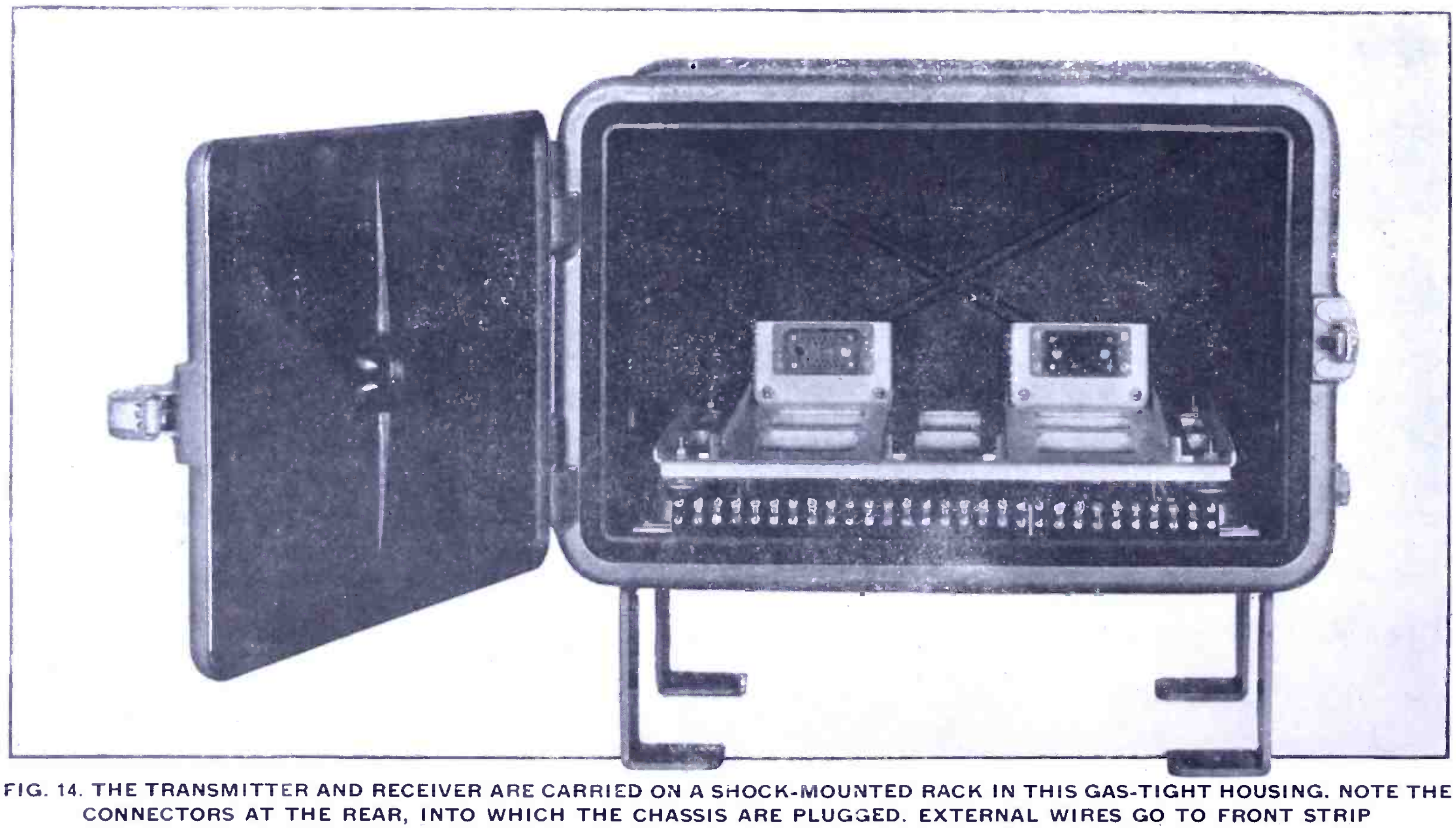


FIG. 14. THE TRANSMITTER AND RECEIVER ARE CARRIED ON A SHOCK-MOUNTED RACK IN THIS GAS-TIGHT HOUSING. NOTE THE CONNECTORS AT THE REAR, INTO WHICH THE CHASSIS ARE PLUGGED. EXTERNAL WIRES GO TO FRONT STRIP

FIG. 13. GUESTS AT THE DEMONSTRATION INSPECT THE FIXED RADIO INSTALLATION

within a mobile equipment housing, shown in Fig. 6. Supporting brackets on the bottom of this housing were bolted to a wooden platform on the tender at the rear of the coal bin. A 32-volt self-regulating motor generator set was used to provide 6 volts AC for the filaments and 350 volts DC for the plate supply. A Farnsworth "firecracker" antenna, mounted at the top of the equipment housing, made a compact transmitter-receiver-antenna assembly of extreme ruggedness.

Since there is no insulator at the base of this antenna, as is the case with conventional quarter-wave whips, it was bolted directly to the top of the equipment case. Projecting only 11¾ ins. above the top of the equipment case, such an antenna does not interfere with the coaling or watering operations on steam locomotives. Electrical performance of the firecracker is approximately that of a vertical dipole, with a substantially circular radiation pattern. The entire assembly is at common DC ground potential, providing a direct path to ground in the event of accidental contact with electric power lines.

Locomotive Control Units ★ The locomotive cab control unit consisted of a volume control, transmit-receive relay, on-off switch, indicating lights, intercom switch, channel selector switch, test switch for opening the squelch circuit, squelch control, and a noise reducing microphone. This is shown in Fig. 9.

A second control unit, identical in design to that used in the cab, was mounted in a metal case at the front of the locomotive a short distance above the footboard, as illustrated in Fig. 10.

A re-entrant type of loudspeaker was mounted in the cab, and a similar speaker was installed at the left of the remote control unit on the front platform of the engine. This can be seen in Fig. 10.

By means of the intercom circuit, a conductor on the ground or on the footboard at the front of the engine could carry on two-way conversation with the engineman in the cab, without operating the radio transmitter. However, during conductor-to-engineman communication, the radio receiver was kept in operation, and always responsive to a radio call.

the antenna was provided by means of a flexible Amphenol cable, type RG 8/U.

2-Frequency Operation ★ While not used in the Potomac Yard tests, the radio equipment at the fixed and mobile stations was designed to permit operation on either of two pre-determined carrier frequencies. Channel selector switches were provided for this purpose at each remote control. In this manner, if required, instructions addressed to northbound traffic could have been sent on one frequency, and instructions for southbound traffic on the second frequency. This would have divided the total communications load between two radio channels, preventing reception of messages intended for a locomotive in one area by locomotives in the other area.

3. RESULTS OF THE TESTS

Employment of the yard radio communications system was found to be beneficial in many respects including the following:

1. It was generally concluded that an appreciable increase in operating efficiency and safety was obtained throughout the yard area by the use of a comprehensive, coördinated radio system. With regard to the safety aspect, the comment was made that wild cars could be quickly reported to all control points and to crews operating at key locations within the yard area immediately after they were seen by crews operating near or on mobile units or at fixed control points. Accidents could also be reported immediately from mobile units or fixed-station remote control points.

Mr. C. E. McCarty, the Yard Manager, stated during a recorded interview with

FIG. 15. TRANSMITTER OR RECEIVER CAN BE REPLACED WITHOUT REMOVING COVERS

Equipment on steam locomotive No 45 was the same as that on engine No. 3, with the exception that the antenna was mounted on the roof of the cab, as shown in Fig. 7. Interconnection between the transmitter and receiver equipment and

an NBC field broadcast man that the radio system had been used day and night by the people to whom it had been made available, and that he was sure that with radio communication the yard

(CONTINUED ON PAGE 52)

SPOT NEWS NOTES

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

That Frequency Shift: With Republican Senator Tobey's hand strengthened by November elections, a Senate investigation will undoubtedly fix responsibility for the shift of FM frequencies under Paul Porter's administration. And before the battle smoke clears away, we may find the band from 50 to 88 mc. earmarked for FM broadcast expansion.

Important: By all means, read FCC Chairman Denny's address to the National Association of Broadcasters. It contains important information that has a bearing on the plans and future activities of everyone engaged in the radio industry. The complete text appears in "What's New This Month," starting on page 4.

Communications Systems: Wilcox Electric Company, Kansas City, Mo. is bringing out a complete line of FM communications equipment, including dial-operated selective calling devices. John H. VanHorn, previously design and project engineer at Automatic Electric, is chief engineer of the new division, with John O. Conway, former Bell System executive, in charge of sales.

In Case You've Forgotten: The man who told us that meat was scarce because we gobbled it all up when the ceiling was off for a few weeks last summer is the one who said on August 17, 1945, that 10-kw. new-band FM transmitters would be "immediately available." At this time of writing, latest reports are that stockyards are turning back truckloads of cattle, and the radio industry is still wondering who will get the first commercial 10-kw. new-band FM transmitter!

AFM: Broadcasters will soon receive new demands from American Federation of Musicians. With musicians' wages already pushed up to a disproportionately high level, prospect is for demand of 50% further increase, as recently accepted by transcription companies. It now comes out that the latter could have settled for much less if they had stuck together. Instead, they tried to make separate deals. Taking advantage of this lack of unity, AFM had no trouble in gouging the transcription concerns for the full amount.

If the networks present a united front, they can hold their line, and with public support. However, the feeling is that they do not trust one another to this extent. If that proves to be the case the musicians will get anything they ask.

Piscatorial Note: That dead mackerel seems to have been buried. In his Chicago address, FCC Chairman Denny, referring to NAB name-calling over the Blue Book, said: "This is not going to be a fight, . . . those comments haven't cooled our friendship because, you see, we believe in free speech."

Joseph L. Collins: Appointed chief engineer of Aerovox Corporation, New Bedford, Mass. Since 1938, he has been in charge of the electrolytic engineering division at Aerovox.

EXCEPTION, PLEASE!

CHARLES R. DENNY'S address before the NAB at Chicago on October 23rd, published elsewhere in this issue, is reassuring evidence of his grasp of industry needs, and the sincerity behind his offer, on behalf of the Commission, "to consult with you, to learn your problems, to advise you in any way and in every way we can."

However, there is one part of his speech to which broadcasters may well take exception—not as much as to what he said, as to his angle of reasoning. Referring to the rapid increase in the number of AM station licenses issued, Mr. Denny said that some broadcasters "fear that the Commission is introducing competition to their communities with 'irrational haste,'" adding that: "I don't believe they realize the degree of Federal regulation which they invite." Then he offered this reassurance: "Today's pie will not have to feed us tomorrow. As the newcomers take their place beside us, the pie will grow larger."

Now, the FCC's obligations are not primarily to broadcasters, but to listeners. If, therefore, he had thought in terms of coverage, and not competition, he could only conclude that, as new AM broadcasters go on the air, the number of stations which the average listener can hear without interference will grow smaller!

Protection of radio listeners in this respect does not involve economic determinations. What is required, and all that is required, is a determination of contour protection.

AM broadcasting is already broken down to the point where, as Mr. Denny pointed out, few operators of local stations can hear their own programs at night. But there is still time to make a thorough and complete study of 1) FM contour protection, 2) the increase in bandwidth which will be necessary to maintain that protection as more and more FM stations go on the air, and 3) the provisions which must be made now to assure the availability of more channels as they are needed.

This study is necessary not to protect broadcasters against competition, but in the service of public interest, convenience, and necessity

I.R.E. Radio Show: The engineering show scheduled for March 3rd to 7th, 1946, will be held in the Grand Central Palace, New York. Demand for space exceeded capacity of the 34th Armory, originally reserved.

FM Construction: Despite bearish attitude toward FM expressed by its officials, Crosley has begun construction on an FM and television transmitter at Warner and Chickasaw Streets in northern Cincinnati. The installation, including a 575-ft. tower, will cost $170,000.

Chicago Show: Final plans for the Radio Parts and Electronic Equipment show call for a 4-day session, instead of 3 days, from May 13th to 16th. Those who register in advance will be sent their badges by mail, thus eliminating lost time for registration after arrival.

Illinois State Police: Will spend $123,000 to bring their radio communications system up to date. Of this, $86,000 will be put into FM headquarters equipment to replace AM installation, and $37,000 into 50-watt unattended repeater stations, also FM, to pick up car transmissions and relay them to headquarters. Thus the range of the cars will be extended to about 100 miles.

New Address: Press Wireless Manufacturing Corporation has moved from Long Island City to Cantiague Road, Hicksville, Long Island. Executive and sales offices will remain at 1475 Broadway, New York City.

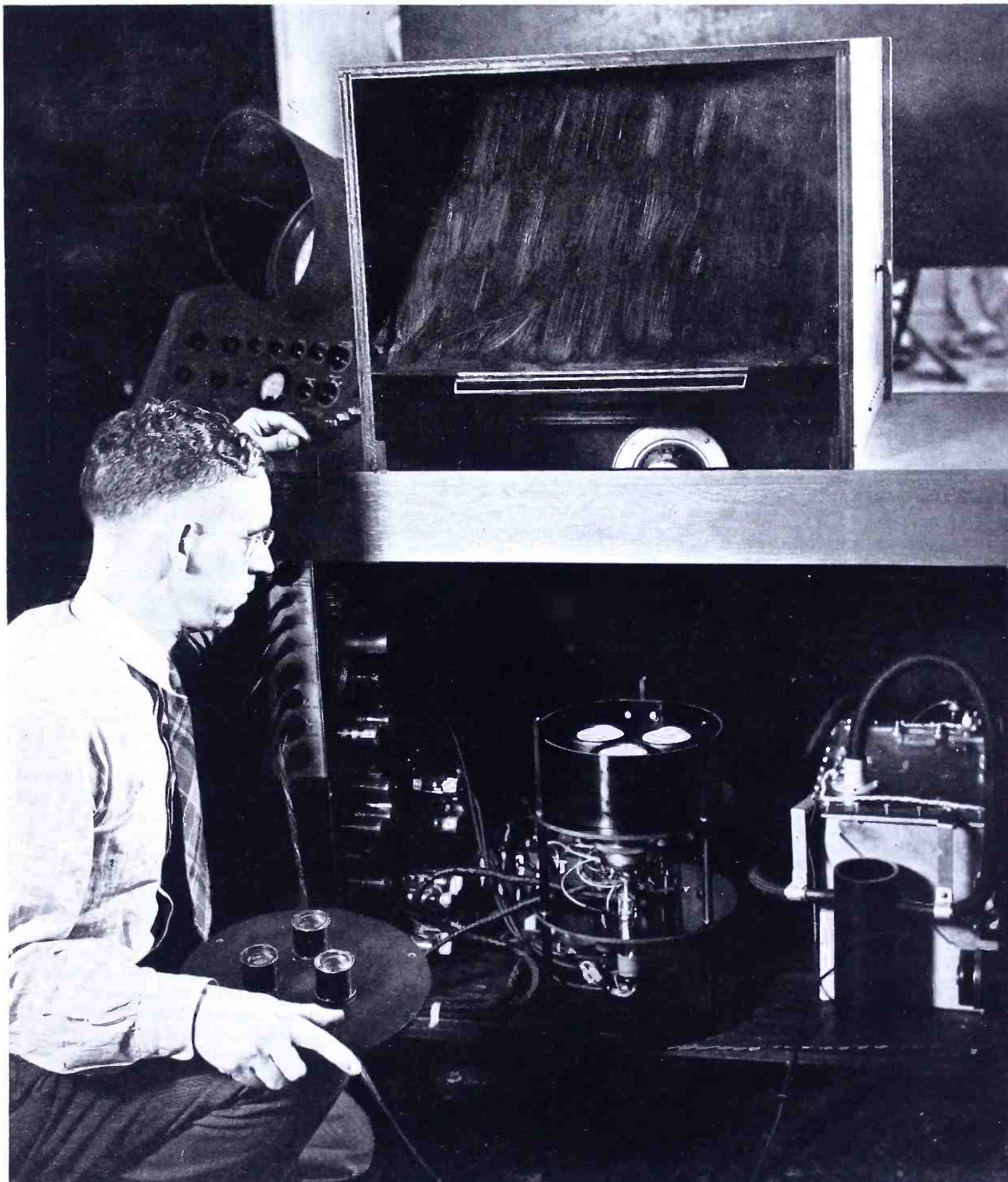
Dr. W. R. G. Baker: G.E.'s vice president in charge of electronics has been elected president of the Institute of Radio Engineers for 1947, succeeding Frederick B. Llewellyn of Bell Laboratories.

Set Production: RMA figures show 17,541 FM-AM receivers produced in September, compared to August figure of 13,892. Television sets produced in September totalled 3,242, against 225 for the previous 8 months of 1946. For FM sets, this was an increase of 27% over August, compared to a decrease of 9% in AM receivers during September as compared to August.

New Wire: U. S. Rubber Company is producing hook-up wire that has aluminum in place of copper for the conductor, and insulation comprising a layer of glass and a coating of fire-resistant synthetic rubber. One of the first applications was for wiring on the Vultee bomber B-36. Weight of wiring was reduced 200 lbs.

WFMZ Gets Action: Aggressive GI management of Penn-Allen Broadcasting Company, Allentown, Pa., has been lighting a fire under the FM set manufacturers. Now they have put out a very interesting report about it. If you ask them, they'll probably send you a copy.

New Sleeving: To meet new Underwriters' requirements, Bentley, Harris Mfg. Company is producing non-fraying Fiberglas sleeving which satisfies UL and saves considerable assembly time. Available in standard sizes and colors. You can get samples without charge if you address Dept. P-13.



NEWS PICTURE

THE first public demonstration of electronic color television, eliminating the whirling disc mechanism used by CBS, was given at RCA's Princeton Laboratories on October 30th. Using the large-screen projection receiver shown here, the performance on reception of colored slides was excellent, not only far superior to what was expected, but an improvement as to size and the elimination of flicker and eye strain. Moreover, as explained elsewhere in this issue, this seems to answer the problem of obsolescence.

The receiver shown here has three small cathode ray tubes which supply red, blue, and green simultaneously — not successively. In size and apparent simplicity, the equipment is truly remarkable. At the demonstration, two of these receivers worked perfectly, and without requiring readjustment, over a period of about an hour. Transmission was by cable from another part of the building.

It was all so perfect that no one in the audience inquired about the life of the new projection tubes, cost of the lens system, and other wrinkles which may remain to be ironed out.

B.B.C. FIELD TRIALS OF FM

An Evaluation of FM Broadcasting Made by the British Broadcasting Company

BY H. L. KIRKE*

1. INTRODUCTION

FREQUENCY MODULATION is not a new art or science. It has been known for many years — in fact a patent was taken out as early as 1902. It was not, however, until Major Edwin Armstrong[1] in America in 1936 pointed out the importance of wide-band frequency modulation on ultra-short waves using a noise-suppressing limiter, that the practical possibilities of the system for broadcasting were realised, although the use of a limiter had been proposed some years before.

One of the main factors influencing the desire to exploit such a system for broadcasting is the congestion in the medium and long wave broadcasting bands and the necessity of acquiring additional channels. The results of the congestion in the present broadcasting bands are the poor quality of reception and/or high interference level, except in areas of relatively high field strength, together with a severe limitation in the total coverage obtainable.

When the modern form of Frequency Modulation was first proposed, there was a tendency to imagine that this system was the panacea for all the ills of broadcasting. This is not the case, although there is no doubt that it does afford a valuable means of increasing total coverage and improving reception conditions. In assessing the advantages and disadvantages of frequency modulation, we have to make two comparisons. One is with medium- and long-wave broadcasting, and the other with Amplitude Modulation on ultra-short waves. It is also desirable to compare Frequency Modulation with other systems of modulation on ultra-short waves, as FM is but one of a number of possible methods of modulation.

Much publicity has been given to FM both in the technical and in the more popular press, particularly in America, and in some instances exaggerated claims have been made. A considerable amount of development work on FM took place in America before the war in the 40- to 50-mc. band, and a number of transmitting stations had been erected and were in use. The advent of the war reduced further development work a very great deal. The frequency band in America has recently been changed to 88 to 108 mc., despite a number of objections which have been raised.

It was not possible during the war to obtain much first-hand information as to the practical results obtained in America, as most of the engineers concerned were occupied in more important work. In view of the probable importance of FM to broadcasting as a means of improving overall coverage, as well as quality of reception, the B.B.C. decided just before the end of the war to carry out field trials in this country.

The first series of tests was planned in the 45 mc. band and two 1-kw. transmitters were built in the B.B.C. Research Department laboratories. One was installed at Alexandra Palace in London, and one near Oxford. One of the transmitters was later moved to Moorside Edge, near Huddersfield, for tests in hilly country. A number of receivers were obtained and, in addition, two receivers were built in the B.B.C. Research Department, these latter having special facilities provided for test purposes.

In view of the probability of a higher frequency band being allotted to FM in this country also, it was later decided to provide two additional transmitters to work in the 90-mc. band. One of these transmitters was installed at Alexandra Palace for field trials in the London area, the second at the B.B.C. Research Department premises near Oxford, for more detailed tests. The latter transmitter is now being installed at Moorside Edge for tests in that district. The following tests have been carried out or are in progress:

1. Propagation tests on 45 and 90 mc. (field strength versus distance, for both horizontal and vertical polarisation).
2. Fading measurements at various distances.
3. Comparative tests on FM and AM.
4. Signal-to-noise ratio tests.
5. Practical listening tests with different types of receivers at various distances and in the homes of ordinary listeners.

A considerable amount of information of practical value is available as a result of these tests, and it is the purpose of this article to summarise the results. It is not proposed to go into the details of the technical or theoretical aspects of Frequency Modulation, as this information is available in technical publications in this country and elsewhere.

2. FREQUENCY MODULATION

In FM, the carrier-wave is varied in frequency by an amount depending upon the amplitude of the modulating oscillation, and does so at the frequency of the modulation. The greater the amplitude of the modulating AF, the greater the change of carrier frequency, and this change is known as the *deviation*.

In contrast, in AM, which is used in normal broadcasting, the amplitude of the carrier wave is varied in accordance with the amplitude of the modulating oscillation, and at the frequency of the modulation. The amount by which the carrier wave amplitude is varied is called the *depth* of modulation, and is expressed as a percentage of the carrier amplitude. This process is obviously limited to a depth of 100 per cent, when the carrier amplitude varies from zero to twice its mean, unmodulated value. Any increase of modulation amplitude beyond this would result in distortion, both in the transmitter and in the receiver. It will be observed that there is no precisely defined point in FM, corresponding to 100 per cent AM, at which distortion sets in, so that if the transmitter and receiver circuits are suitably designed, a greater range of modulation can be achieved.

In order to render a frequency-modulated signal audible, the receiver uses a device known as a *discriminator*, which converts it into an amplitude-modulated signal, which may then be detected by any of the classical methods.

Since with FM any change of amplitude of the carrier wave is fortuitous and conveys no intelligence, it is practicable to use in the receiver a device called a *limiter*, which makes the receiver insensitive to amplitude changes. The function of the limiter is to reduce the effect of AM interference, but this cannot be eliminated entirely thereby, as in any case phase-modulated components remain and, since discriminators respond to phase modulation, produce a noise output at audio frequency. There is thus a limit to the degree of interference suppression which can be obtained. Interference can be of several types — receiver hiss, interference from ignition systems of motor vehicles, atmospherics, general electrical interference such as that from domestic appliances, and interference from other stations either using the same carrier frequency or on adjacent channels.

One rather interesting point to note in connection with FM is that since the receiver is sensitive only to variations in frequency, the audio output from the detector or discriminator is the same for a given deviation, whatever the field

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[1] *Proc. I.R.E.*, May 1936, Edwin H. Armstrong, "A Method of Reducing Disturbances in Radio Signalling by a System of Frequency Modulation." Also published with corrections in FM AND TELEVISION, June, July, and August, 1944.

strength of the signal, provided that the latter is greater than a certain minimum value. FM is therefore an *all or nothing* system as far as signal strength is concerned. The only result of changing the field strength is to change the amount of interference or noise which is heard. The effect is analogous to ideal A.G.C. (Automatic Gain Control).

Before the advantages of wide-band Frequency Modulation were appreciated, Frequency Modulation was compared with Amplitude Modulation on a basis of the same total bandwidth, and it was generally accepted that on this assumption there was no great advantage to be gained by the use of Frequency Modulation. It would not be worthwhile using Frequency Modulation on medium or long waves, largely because the band width is restricted. On ultra-short waves there is at present no such limitation, and wide-band Frequency Modulation can be used with advantage. An increase in the deviation in FM is the equivalent of increasing the modulation in AM, but without distortion.

Advantages of Frequency Modulation ★ The following advantages have been claimed for Frequency Modulation:

A. Reduced receiver noise (background hiss)

B. Reduced interference from car ignition systems, electrical machinery, domestic electrical appliances, and from atmospherics

C. Improved transmitter efficiency, cheaper transmitters, and low running costs

D. Increased dynamic range of modulation

E. Improved quality of reception and greater audio-frequency range

F. Pre-emphasis can be used at the transmitter and de-emphasis at the receiver, with greater advantage than with AM

G. Increased service area (for common-wave working)

H. Elimination of fading, particularly selective fading

The advantages claimed above will now be discussed, together with other matters and with the results of tests which have been carried out.

A. Signal-to-Noise Ratio ★ In Amplitude Modulation on medium or long waves, receiver noise, which takes the form of a continuous hissing sound, is not usually noticeable at the field strengths normally employed. On ultra-short waves, due to the lower field strengths obtained, receiver noise is a factor of importance. It would be one of the factors limiting the range of an amplitude-modulated ultra-short wave broadcasting service. In Frequency Modulation, a very considerable degree of suppression of this noise can be obtained by the combined use of a limiter and a balanced discriminator. In this way, using a sensitive receiver, a satisfactory service can be obtained with Frequency Modulation at a field strength as low as 50 μv/m from the point of view of receiver noise, whereas for the same amount of noise the field strength for AM would need to be at least 900 μv/m. The actual figure depends upon carrier frequency. The advantage of FM over AM for receiver noise is 25 db or 18:1 in amplitude ratio. For a high quality, very low noise service, a field strength of about 200 μv/m is required for FM, but this depends upon the design of the receiver.

B. Ignition Noise, Atmospherics & other Interference. ★ It is true that FM has a considerable advantage over AM in regard to ignition noise, as well as other types of interference. Interference from atmospherics is considerably reduced by the use of ultra-short waves in any case, and the use of FM makes such interference negligible.

It is noteworthy that the field strength required for the same degree of freedom from interference using horizontal polarisation is about one-third of that for vertical polarisation. This has also been confirmed on 90 mc. by a large number of observations, and confirms the general opinion in the United States that horizontal is better than vertical polarisation, although very little published data are available. The above figures are for substantially complete inaudibility of interference in a condition of low ambient acoustic noise. It is possible that occasional motor car interference which was perceptible under these conditions could be tolerated in practice. Using horizontal polarisation, a field of 1 mv/m could result in perceptible interference at 20 yards, while a field of 5 mv/m would give a barely perceptible interference level at that distance on 45 mc. For service in urban areas in the 40- to 50-mc. band, a

TABLE 1—RANGE OF IGNITION INTERFERENCE

Field Strength 45 Mc. ½-Wave Dipole 30 Ft. above Ground	EXTINCTION DISTANCE		
	FM		AM
	Hor. Polar	Vert. Polar	Hor. Polar
50 μv/m	200 yards	M200 yards	At 100 yards, ignition was very disturbing, but merged into the set noise, which was very high.
100	150	200	(as above)
300	80	120	As above, but less disturbing
500	60	120	Merging into set noise at 100 yards
1,000	40	80	190 yards
5,000	25	50	120

Furthermore, man-made interference, such as that from electrical machinery and domestic appliances, is considerably reduced by the use of FM.

The most serious factor in ultra short wave broadcasting is, however, car ignition noise which is not important in medium-wave reception. Ignition noise is not completely eliminated by the use of FM. It is much reduced, however, but the degree of improvement depends to a considerable extent upon the design of the receiver, as does the suppression of receiver noise. Suppression of noise of both types depends to some extent upon the accuracy of tuning of the receiver, and this is a practical point of some importance.

The actual audible improvement in ignition noise when using FM by comparison with AM is not quite as great as the figures would suggest. The improvement of FM over AM, as well as the degree of interference to be expected at various field strengths, can best be shown by quoting the distances of motor cars from the receiver at which the interference becomes negligible. The amount of interference depends upon the type of polarisation used, *i.e.* horizontal or vertical. The following Table 1 can be taken as typical for a fairly good receiver for 45 mc. This table shows the distance of cars for negligible interference on 45 mc. for vertical and horizontal polarisation. Figures for AM, for horizontal polarisation only, are given for comparison.

field strength of 5 mv/m would be required for a practically noise-free service, but a passable service would be given by a field of 1 mv/m. If vertical polarisation is used, however, about three times the field strength is required. For areas where the likelihood of motor car interference is small, a field of 50 μv/m would be adequate for a service on 45 mc.

It is to be noted, however, that during a very large number of observations alongside a main arterial road, it was extremely rare that any interference was caused by military vehicles, which have suppressors fitted. The universal fitting of suppressors to motor vehicles would therefore increase the service area of a transmitter very considerably. The interference tests on 90 mc. which have so far been made indicate that the field strength required for the same degree of interference as on 45 mc. is only about one-third. It is also to be noted, however, that the field strength on 90 mc. may be less due to higher attenuation and greater screening effects. The effective range on 90 mc. may not, therefore, be greater than on 45 mc. Horizontal polarisation is also preferable on 90 mc., and the improvement is about the same as on 45 mc., *e.g.* 10 db.

C. Transmitter Power ★ As there is no variation in amplitude in an FM carrier, the transmitter can be more economically designed. The output stage itself has only to cope with the carrier amplitude whereas in amplitude modulation the output stage has to be capable of handling a peak power of four times the carrier power. This results in a smaller, cheaper and more efficient transmitter for a given power for FM. Alternatively, of course, a greater power output can be obtained for a transmitter of given size, cost and input power.

D. Increased Dynamic Range ★ This is a factor which is intimately connected with signal-to-noise ratio. Due to the improved signal-to-noise ratio, it is possible to increase the dynamic range of modulation which results in a more realistic effect at the receiver provided, of course, that the receiver has adequate power-handling capacity for the peaks of modulation. If a greater dynamic range is used, however, the average modulation will be lower, and the actual signal-to-noise ratio reduced. There must, therefore, be a compromise between dynamic range and signal-to-noise ratio or range.

E. Improved Quality of Reception & Greater AF Range ★ In general, the use of ultra-short waves for broadcasting permits of a wider audio-frequency band being used. This results in an improvement in quality. From the point of view of audio bandwidth, there should be no difference between FM and AM. With AM on medium waves, high-fidelity, wide audio-band reception would be possible were it not for the close spacing (9 kc.) of adjacent channels, and the consequent interference from distant stations at night. The majority of receivers are designed for a bandwidth of ± 4½ kc. or less, in order to eliminate this interference. High-quality reception is still possible in the medium-wave bands, provided that the field strength is great enough and the interference small enough, but in general it must be admitted that high-quality reception is unusual. Another factor which affects the quality of reception is the noise level which, in FM, can be made exceedingly low. The reduction in noise level of FM, when compared with medium- and long-wave reception, has been noticed by many listeners.

The detectors commonly used in AM receivers cause distortion at modulation depths greater than about 50%. In FM, this distortion should not be present, although distortion can occur in FM due to misalignment of discriminators or due to insufficient bandwidth in the receiver.

Broadcasting on ultra-short waves, and particularly with FM, does provide the possibility of high-fidelity reception. The extent to which this can be made use of will depend upon advances in receiver and loudspeaker design.

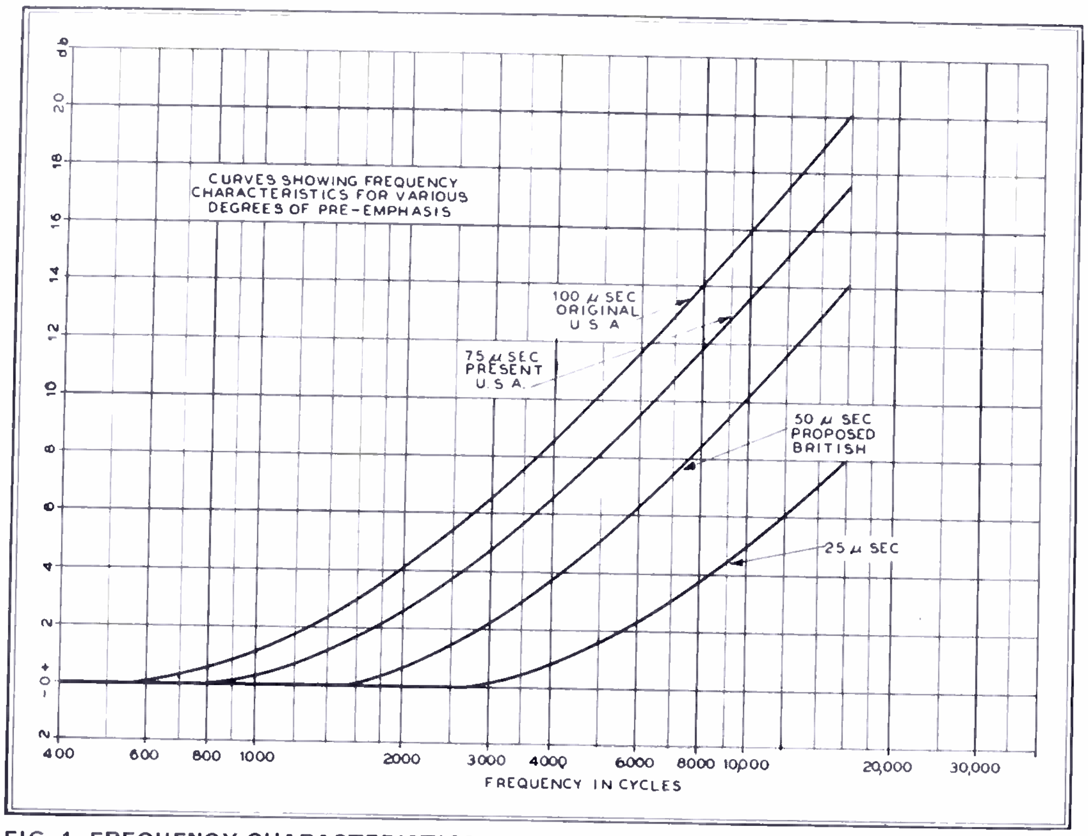


FIG. 1. FREQUENCY CHARACTERISTICS WITH VARIOUS PRE-EMPHASIS TIME CONSTANTS

F. AF Pre-Emphasis ★ This device merely means relatively greater modulation at the high audio frequencies. It has been proposed for FM partly because it had been assumed that in practice the peak levels at high frequencies were lower than at low frequencies, and the same could therefore apply to AM. The greater advantage in FM is that in the receiver, which would be correspondingly *de-emphasised*, the effect on noise suppression is greater than in AM. This is so to some extent, but not to the extent which has been assumed in most of the calculations regarding the resultant improvement. The effect of de-emphasis is naturally more noticeable on a high-quality loudspeaker, as the higher frequency components of the noise would be made more noticeable by such a loudspeaker, but the effect is less marked than might be expected because the ear is much less sensitive at the higher frequencies. Pre-emphasis is usually expressed as the time constant in micro-seconds of an electrical circuit giving the desired frequency characteristics. The frequency characteristics for various time constants are shown in Fig. 1.

Tests were carried out using various amounts of pre-emphasis and with a large number of different types of programme, with results as follows: With 100 micro-seconds pre-emphasis as originally proposed in America, a reduction in noise of 15 db has been claimed as the theoretical gain. In the tests carried out, a 12 db reduction in audible receiver noise and a 6.5 db reduction in ignition interference was obtained. But to avoid distortion, it was necessary to reduce the modulation in some cases as much as 12 db and generally by 6.5 db. The resulting gain in signal-to-noise ratio was 5.5 db in the case of set noise, and zero in the case of ignition noise. With 50 micro-seconds pre-emphasis, receiver hiss was reduced by 7.5 db and ignition noise by 4.5 db, while it was necessary to reduce modulation by 3 db. The resulting gain was then 4.5 db for set noise and 1.5 db for impulsive noise. This amount of pre-emphasis has been used in the tests described later. Further tests showed that provided some de-emphasis was used in the receiver, the audible noise did not in general increase markedly when wide-range high-fidelity loudspeakers were used. The judgment of the improvement in noise by the use of pre-emphasis differs considerably with different observers, and the above figures are average values. It is understood that in America the FCC has now standardised a value of 75 micro-seconds pre-emphasis. It is thought, however, that 50 micro-seconds is to be preferred.

G. Larger Service Area (for Common-Wave Working) ★ An FM receiver possesses a property known as *capture effect*, as a result of which an unwanted signal is suppressed by a wanted signal, provided that the former is weaker than the latter by a certain amount. A figure for that amount which has frequently been quoted is 6 db or 2:1 in amplitude.

The results of our tests show that when the stronger signal is about 3 times (10 db) the amplitude of the weaker signal, no intelligible break-through of unwanted modulation occurs, and the interference takes the form of an unintelligible rasping sound. A ratio of 10:1 (20 db) is required for a just tolerable reduction of this noise, while 30:1 (30 db) is required for its complete elimination.[2]

In amplitude modulation, using a common channel and different programmes, about 200:1 (46 db) is required for substantially no interference, but at a level of interference −46 db is not inaudable.

[2] This confirms the tests carried out in U.S.A. by Raymond Guy of NBC. See *RCA Review*, October, 1940, page 190.

So that for common-wave separate programme working, we can reckon on an improvement of about 16–20 db for a first-class service, and 20–26 db for a second-class or just tolerable service. There is very little difference between common programme working and separate programmes as far as FM is concerned; the same rasping noise would be heard due to the phase and time differences between the wanted and unwanted signals. For AM there is a considerable difference, however, when common programme is used. For a first-class service a ratio of about 5:1 (15 db) is required, while for a second-class service about 3:1 (10 db) would suffice. For common programme common-wave working, therefore, AM is better than FM by 10 db for a second-class service, and 15 db for a first-class service.

Deviation, Bandwidth & Channel Spacing ★ Tests have been carried out to determine the effect of different values of peak deviation and bandwidth. The deviation used in America is ± 75 kc. This means that peak modulation will swing the carrier ± 75 kc. from its mean frequency. For high field strengths, the greater the deviation the greater the signal-to-noise ratio for receiver noise, while for low field strength there is an optimum deviation for the best signal-to-noise ratio. The signal-to-noise ratio in the latter case is, of course, less than for high field strengths. For high signal-to-noise ratios, the improvement is proportional to the deviation. For impulsive noise, *e.g.* car ignition noise, the position is complicated by the very *peaky* nature of the interference, but the results are similar to those for receiver noise.

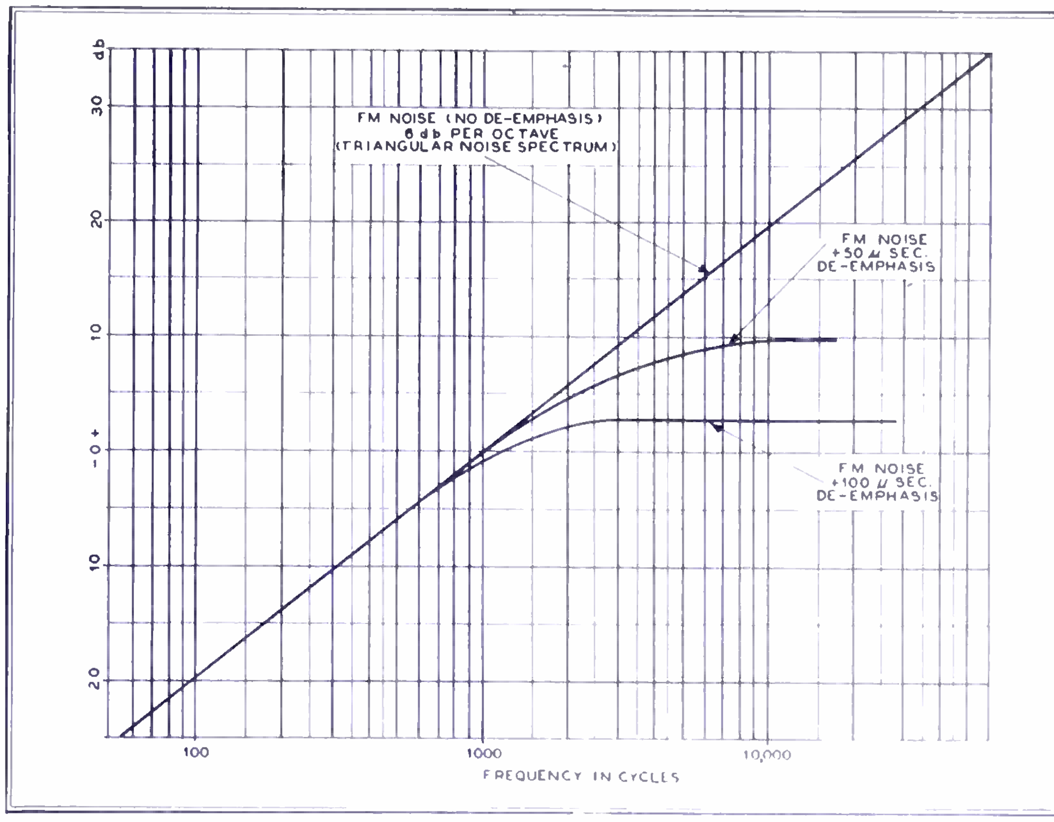


FIG. 2. EFFECT OF DE-EMPHASIS ON THE NOISE SPECTRUM AS DETERMINED BY THE B.B.C.

It would appear from our tests that there is not a great deal to choose between different deviations and bandwidths, and that for practical purposes there seems to be no object in changing from the value of ± 75 kc., at any rate from the point of view of noise and interference. There is, however, a point of importance in connection with oscillator frequency drift in the receiver. The less the deviation and bandwidth, the greater will be the effect of the oscillator drift which results, in effect, in the mistuning of the receiver, degrading its performance in regard to noise and interference, and also causing distortion.

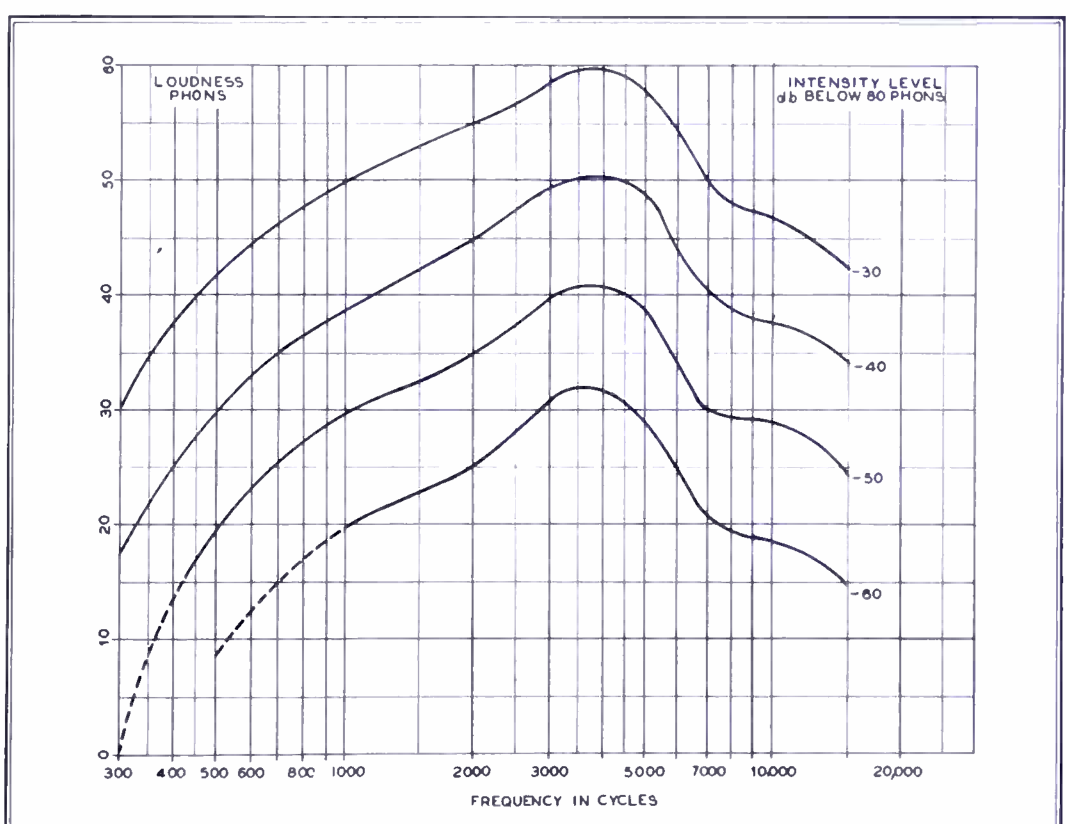


FIG. 3. LOUDNESS OF THE NOISE AT VARIOUS FREQUENCIES AND AT VARIOUS NOISE LEVELS

It is possible to argue almost any conclusion regarding bandwidth and oscillator drift, but in practice no clearly defined optimum appears to exist. A narrow deviation would permit more channels in a given band and *vice versa*, but again the position is complicated by many other factors; for example, the capture effect is a function of deviation and bandwidth.

A point of interest in connection with deviation is that it is customary to express this factor in terms of a deviation ratio which is the ratio of the peak deviation to the highest audio frequency transmitted. The reason for this is that the amount of noise is said to be a function of the audio bandwidth. The wider the audio band the greater the noise. This is true from the purely electrical standpoint, but not entirely true as far as the audible effect of the noise is concerned, at any rate for audio bandwidths greater than about 5,000 cycles. This is because the sensitivity of the ear decreases rapidly for frequencies above 5,000 cycles, and an increase in audio bandwidth of, say, from 8,000 to 12,000 cycles does not increase the audible noise markedly, particularly when the level of the noise is low, as is the case in an FM receiver. This has been confirmed by tests.

It may be preferable, therefore, to consider deviation independently of audio bandwidth.

Noise can be considered as a very large number of signals of random phase and frequency, and in the spectrum of noise all the components have equal amplitude. In AM, therefore, the electrical noise consists, in effect, of a large number of side bands of equal amplitude about the carrier frequency, producing an audio spectrum in which the amplitude at all frequencies is constant. In FM, the amplitude-modulated components are eliminated by the limiter and discriminator and the phase-modulated components remain. Equal phase modulation at all frequencies produces in an FM receiver an output proportional to frequency. Put in another way, in FM, as audio output is proportional to the frequency deviation or frequency difference, the noise components furthest from the carrier will produce in the detector the most noise. The noise spectrum in FM rises 6 db per octave, therefore. With de-emphasis, however, the output at the higher frequencies is reduced and above some frequency the noise spectrum will be uniform.

Fig. 2 shows the effect of de-emphasis on the noise spectrum in frequency modulation. The intensity vs. frequency characteristics of the sound waves in the air resulting from the reproduction of such signals have exactly the same shapes, assuming that a perfect loudspeaker is used, so the effect on the ear can now be deduced by the use of Harvey Fletcher loudness curves.[3] If it be assumed that the maximum listening level is 80 phons, the curves in Fig. 3 will give the loudness of the noise at various frequencies, the four curves corresponding respectively to electrical noise levels 30, 40, 50 and 60 decibels below the signal giving a sound intensity of 80 phons.

It will be seen that, for most practical conditions, the noise has maximum loudness between 3,000 and 4,000 cycles. The loudness falls off both above and below this frequency. Noise components above about 8 kc. are 12 db less than those around 4 kc. and contribute little to the total noise. These curves show clearly why noise sounds high-pitched and does not, to the ear, have a uniform spectrum.

Channel Separation ★ The normal channel separation proposed in America is 200 kc., although for stations serving the same geographical area a separation of 400 kc. (2 channels) is proposed. Our tests confirm that this is satisfactory.

EDITOR'S NOTE: *The second and concluding part of this survey will appear in December.*

[3] *Bell Technical Journal*, Vol. XII, No. 4.

FM AND TELEVISION PROGRESS REPORT

Construction Permits Issued by the FCC in September 1946

TELEVISION STATIONS

IOWA

AMES: Iowa State College A. & M. Arts
Non-commercial No. 4 66–72 mc. 13 kw. Video 506 ft.

KENTUCKY

LOUISVILLE: Louisville Times Co.
Commercial No. 9 186–192 mc. 9.6 kw. Video 529 ft.

MASSACHUSETTS

BOSTON: Continental Television Corp.
Experimental, frequencies to be assigned.

PENNSYLVANIA

LANCASTER: Conestogo Television Assn., Inc.
Experimental, frequencies to be assigned.

RHODE ISLAND

PROVIDENCE: Cherry & Webb Bcstg. Co.
Experimental, In 480 to 920 mc. band

FM BROADCAST STATIONS

CALIFORNIA

PASADENA: Rose Bow. Bcstrs., Inc.
Class A No. 286 105.1 mc. 180 w. 760 ft.

GEORGIA

SAVANNAH: Savannah Bcstg. Co. (WTOC)
Class B No. 253 98.5 mc. 45 kw. 510 ft.

IDAHO

NAMPA: KFXD—FM
Class B No. 267 101.3 mc. 2.5 kw. 340 ft.

ILLINOIS

HERRIN: Orville W. Lyerla (WJPF)
Class B No. 259 99.7 mc. 20 kw. 500 ft.
QUINCY: Quincy Newspapers, Inc.
Class B No. 249 97.9 mc. 13 kw. 490 ft.

MARYLAND

BALTIMORE: A. S. Abell Co.
Class B No. 257 99.3 mc. 20 kw. 440 ft.
BALTIMORE: Baltimore Radio Show (WFBR)
Class B No. 259 99.7 mc. 20 kw. 500 ft.

MASSACHUSETTS

FALL RIVER: Fall River Bcstg. Co. (WSAR)
Class B No. 243 96.5 mc. 20 kw. 500 ft.

MINNESOTA

WINONA: Winona Radio Service (KWNO)
Class B No. 229 93.7 mc. 55 kw. 610 ft.

MISSOURI

ST. LOUIS: Globe-Democrat Pub. Co.
Class B No. 225 92.9 mc. 53 kw. 490 ft.

NEW JERSEY

PATERSON: Passaic Daily News
Class A No. 287 105.3 mc. 190 kw. 540 ft.

NEW YORK

HORNELL: W. H. Greenhow Co.
Class B No. 260 99.9 mc. 10 kW. 580 ft.
NIAGARA FALLS: The Niagara Falls Gazette (WHLD)
Class B No. 239 95.7 mc. 20 kw. 415 ft.
ROCHESTER: Monroe Bcstg. Co. (AM grantee)
Class B No. 249 97.7 mc. 27 kw. 455 ft.

NORTH CAROLINA

ASHEVILLE: Skywave Bcstg. Corp.
Class B No. 232 94.3 mc. 8.8 kw. 130 ft.
ROANOKE RAPIDS: Telecast, Inc.
Class B No. 273 102.5 mc. 3 kw. 500 ft.
ROANOKE RAPIDS: WCBT, Inc. (WCBT)
Class B No. 275 102.9 mc. 10 kw. 390 ft

OKLAHOMA

TULSA: Tulsa Bcstg. Co. (KTUL)
Class B No. 233 94.5 mc. 170 kw. 630 ft

OREGON

MEDFORD: Mrs. W. J. Virgin (KMED)
Class B No. 276 103.1 mc. 950 w. 1000 ft.

PENNSYLVANIA

MCKEESPORT: Mon-Yough Bcstg. Co.
Class A No. 290 105.9 mc. 240 w. 350 ft.
MEADVILLE: H. C. Winslow
Class B No. 257 99.3 mc. 3.2 kw. 415 ft.
WILKES-BARRE: Scranton-Wilkes-Barre-Pittston Bcstg. Co.
Class B No. 277 103.3 mc. 2.5 kw. 1040 ft.

TENNESSEE

MEMPHIS: Memphis Publishing Co. (WMC)
Class B No. 228 93.5 mc. 136 kw. 530 ft

TEXAS

DALLAS: KRLD Radio Corp. (KRLD)
Class B No. 226 93.1 mc. 26 kw. 560 ft.
SAN ANTONIO: Walmac Co. (KMAC)
Class B No. 261 100.1 mc. 160 kw. 530 ft.

VIRGINIA

LYNCHBURG: Old Dominion Bcstg. Corp.
Class B No. 270 101.9 mc. 20 kw. 320 ft.
NEWPORT NEWS: Hampton Roads Bcstg. Corp. (WGH)
Class B No. 222 92.3 mc. 34 kw. 405 ft.
ROANOKE: Radio Roanoke, Inc.
Class B No. 299 93.7 mc. 3 kw. 1700 ft.

WASHINGTON

LONGVIEW: Twin City Bcstg. Corp. (KWLK)
Class A No. 282 104.3 mc. 270 kw. 390 ft.

WISCONSIN

GREENFIELD: Wm. C. Forrest
Class B No. 276 103.1 mc. 92 kw. 1030 ft.
MILWAUKEE: Midwest Bcstg. Co.
Class B No. 232 94.3 mc. 31 kw 430 ft
RACINE: Racine Bcstg. Corp. (WRJN)
Class B No. 267 101.3 mc. 2.9 kw. 300 ft.

NOTE: 65 FM stations are on the air
270 Construction Permits granted
261 Conditional grants issued
137 Applications designated for hearing
196 Applications awaiting action
929 TOTAL

NEW FM STATIONS ON THE AIR

Latest additions to FM stations on the air, reported by FCC since October 15th, are: Calif. — KRFM Fresno 102.3 mc.; KPOR Riverside 102.1; KANY Sacramento 102.5. D.C. — WINX-FM 92.9. Fla. — WQAM Miami 95.5; WIOD-FM Miami 97.5; WKAT-FM Miami Beach 96.7. Ga. — WJWW Columbus 96.7; WTOC-FM Savannah 98.5. Ill. — WFJS Freeport 102.1; WMIX Mt. Vernon 103.7. La. — KPDR-FM Alexandria 104.3; WWLH New Orleans 94.9. Md. — WITH-FM Baltimore 102.5. MO. — WMBH-FM Joplin 102.3; KWK-FM St. Louis 95.3. N.Y. — WBEN-FM Buffalo 92.1; WHCU-FM Ithaca 101.3; WSYR-FM Syracuse 93.5; WIBX-FM Utica 97.9; N.C. — WBBB-FM Burlington 101.3; WGBR-FM Goldsboro 99.7; WMFR-FM High Point 97.7. Okla. — KTOK-FM Oklahoma City 100.5; KOCY-FM Oklahoma City 98.5. Ore. — KPRA Portland 95.7. S.C. — WSPA-FM Spartanburg 92.1. Tenn. — WTJS-FM Jackson 95.1. Tex. — KERA Dallas 94.3; KTHT-FM Houston 98.5; KYFM San Antonio 101.5. Va. — WSAP-FM Portsmouth 94.7. W. Va. — WCFC Beckley 101.1. Practically all these stations, it should be noted, are operating on low power, pending delivery of final amplifiers.

PHILCO'S SINGLE-STAGE FM DETECTOR

Explaining the Operation of the Heptode Tube Circuit Used in New Philco FM Receivers

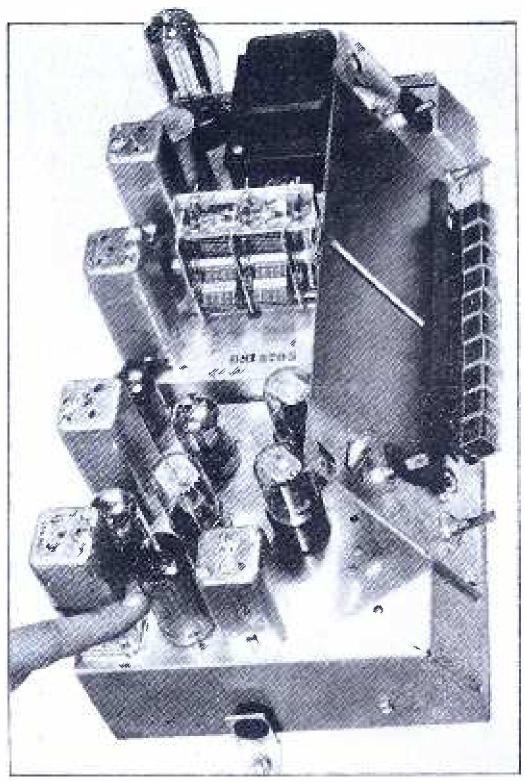
BY WILLIAM E. BRADLEY*

WHILE engineers working with Amplitude Modulation radio circuits have long had available several excellent circuits which approximate an ideal AM detector, highly responsive to variations in carrier-wave amplitude but not to carrier-frequency deviation, until recently there has been no corresponding circuit in the field of frequency modulation radio. Development of the new single-stage FM detector known as the "Philco Advanced FM System" began in our research laboratories with the aim of finding a more direct way to convert the frequency deviation of a carrier wave into an audio output voltage than by means of the conventional multi-stage limiter-discriminator system.

Our goal was to design an ideal Frequency Modulation detector, defining this as a carrier wave detector so constructed and arranged as to be highly responsive to carrier frequency deviation, but not at all responsive to carrier amplitude variations. The new single-stage FM detector developed by the Philco laboratories represents what we consider to be the successful result of this research program. This detector, as will be explained, responds directly and solely to the frequency deviation of the received carrier signal. Its practical application, to realize the full efficiency of the circuit, embodies the use of a special heptode tube, designated as the Philco FM 1000 tube, having high transconductance and sharp cut-off characteristics, plus shielding of the No. 3 grid from other tube elements.

In actual receiver design, it has been found that the minimum input signal, obtained from the last IF amplifier stage, required to operate the new single-stage detector is about 0.5 volt r.m.s. for full deviation. The voltage required varies linearly with deviation. Furthermore, the relation between the frequency deviation of the applied carrier wave and the audio output voltage is linear up to the limit of the detector characteristic, where a sharp break occurs. This linearity results in excellent reception of high-fidelity FM programs without distortion.

The audio output of the new detector, as used for example in the 1946 Philco Model 1213 radio-phonograph, is substantially independent of applied carrier amplitude. For any input signal beyond the minimum required for the detector to



CHASSIS OF THE PHILCO FM-AM SET USING THE HEPTODE TUBE CIRCUIT

operate, the audio output for full 75-kc. deviation is about 6 volts r.m.s. By contrast, the response of the circuit to amplitude variation, including the principal part of the interference produced by forms of natural and man-made AM static or electrical noise, is negligible. With attention to shielding, as may be seen in the construction of the model 1213 receiver, this AM response is normally 50-60 db less than the FM response.

Analysis of Single-Stage Detector ★ Fig. 1 is a circuit diagram of the Philco FM detector. Essentially the circuit comprises the heptode and two tuned circuits reactively coupled. With the input signal coming from the final IF amplifier stage and applied to grid 3 of the heptode, one of the two control grids, audio output is obtained directly from the plate current.

Quadrature circuit A is connected to the heptode plate, while the oscillator circuit B is tied in with grid 1 of the heptode, its other control grid. Both of these tuned circuits are tuned approximately to the intermediate frequency. The quadrature circuit is damped so as to have a bandwidth about six times that of the useful deviation band, in other words 1,000 kc.

A neutralizing circuit, indicated by dotted lines, may be used to remove the disturbing effects of capacity coupling between grid 3 and the heptode plate. However, in practice, in the case of the model 1213 receiver, good layout of wiring has made such a neutralizing circuit unnecessary.

Another consideration is feedback of energy from the electron stream in the tube to input grid 3. To avoid this feedback, it is desirable to drive the detector from a source of fairly low impedance. Hence a stepdown transformer, with an effective turns ratio of about 3.1, is ordinarily used at the input.

Together with tuned circuit B, the cathode and grids 1 and 2 of the heptode constitute an oscillator. Since screen grid 2 is bypassed to ground, oscillator voltage appears on grid 1 and the cathode. This oscillator operates Class C, so that the space current through the heptode consists of a series of pulses. For reasons explained below, it is important that the pulse duration be short compared to the time interval between pulses.

The action of grid 3, the second control grid of the heptode, causes the tube to function as a kind of phase detector. As we have seen, the space current of elec-

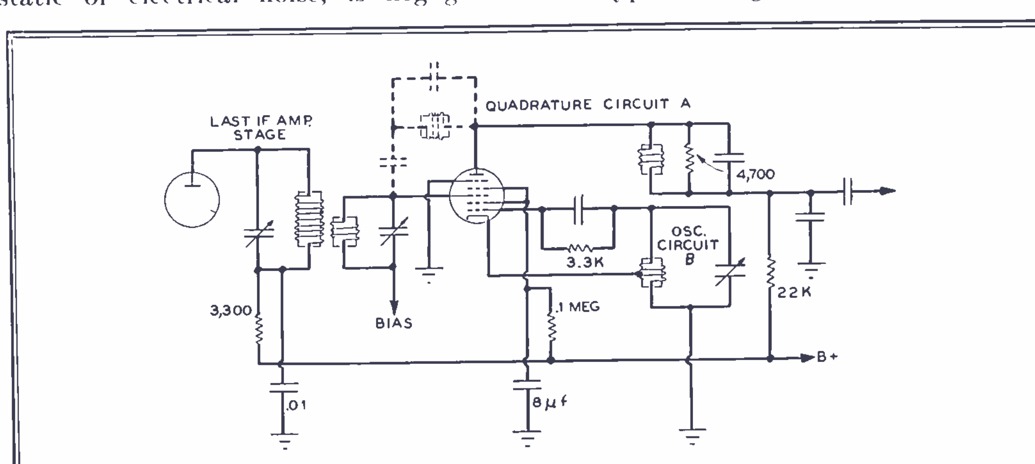


FIG. 1. ELEMENTARY CIRCUIT OF THE PHILCO SINGLE-STAGE FM DETECTOR

*Director of Research, Philco Corporation, Philadelphia, Pa.

plate, and the controlling factor is the potential of this grid at the instant the pulse arrives. This instantaneous control voltage, in turn, is the sum of the fixed grid bias and the varying input or signal voltage, which may add to or subtract from the bias, depending on the phase relation between the oscillator and the incoming IF signal.

The fundamental component of the resulting plate current is fed back to the oscillator through tuned phasing circuit A, reactively coupled to the oscillator tank circuit. This phasing circuit is so adjusted that the effect of feedback is reactive. When this is done, variations in plate current cause pure frequency modulation of the oscillator without any first order load deviation, that is, without any amplitude modulation of the oscillator.

A notable point is that the phase of feedback is unaffected by the incoming signal on grid 3. Provided that the pulses of plate current through the tube are short, the incoming signal can modify only their magnitude, not their phase.

In practice in the new model 1213, the oscillator circuit is carefully shielded from the direct action of the incoming IF signal, so that the frequency of the oscillator is determined wholly by its fixed constants and the fundamental component of the heptode plate current. The oscillator circuit is so adjusted that, with no input, the oscillation is at center frequency. If the phasing or quadrature circuit is damped, as described above, so as to be non-critical with respect to frequency, and the oscillator maintains a constant amplitude, then frequency variation as a function of plate current is linear.

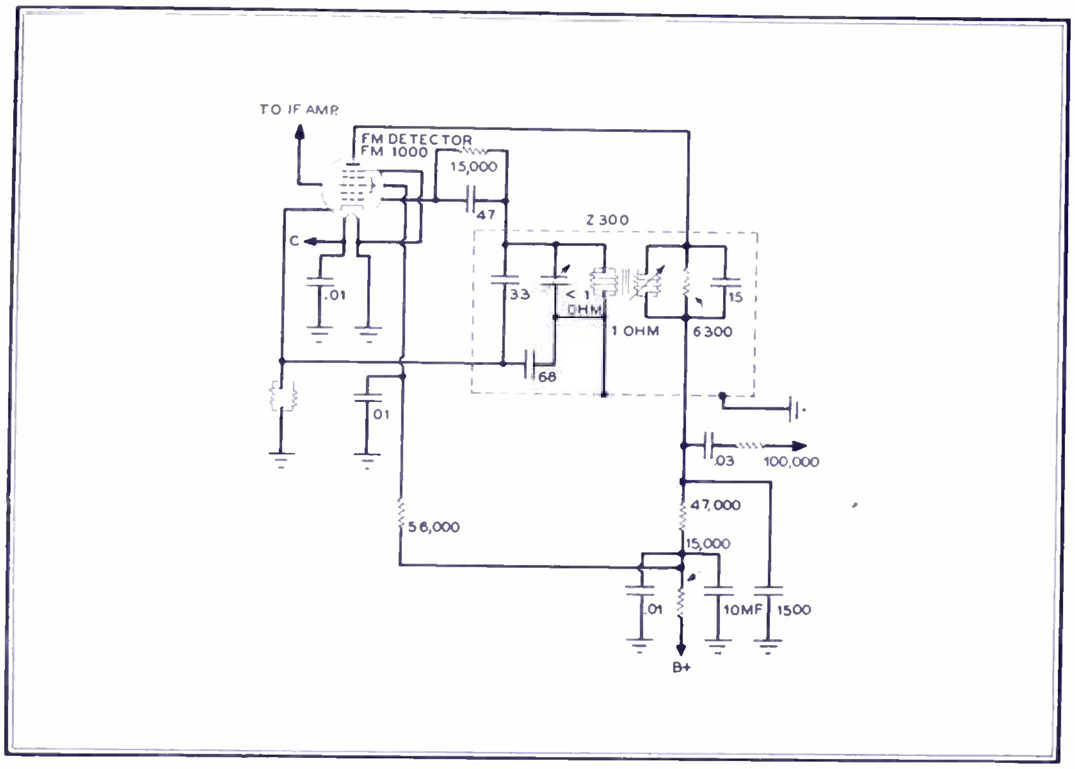


FIG. 4. FM DETECTOR CIRCUIT AS IT IS ARRANGED IN THE PHILCO MODEL 1213 SET

approximately one-half the peak value of

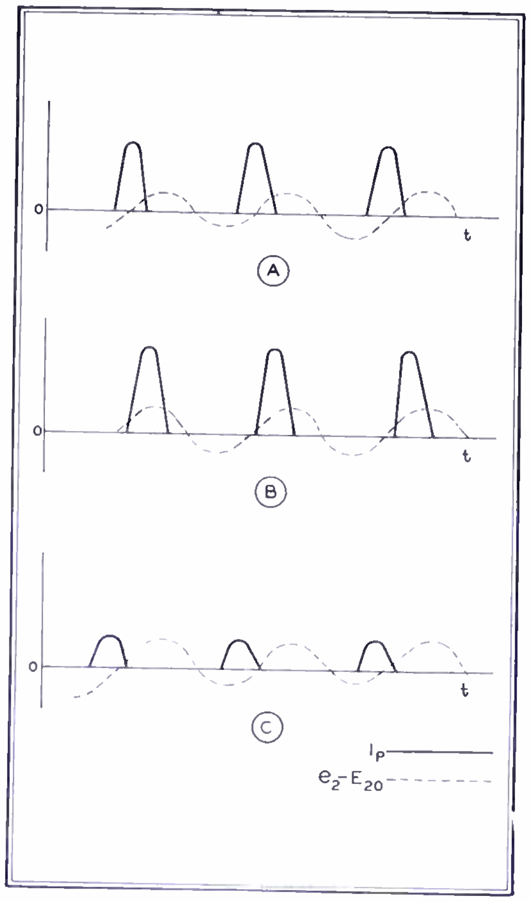


FIG. 2. FUNCTIONING OF THE SINGLE-STAGE DETECTOR CIRCUIT

the fundamental component, since this current consists of a train of short pulses. This is true regardless of their shape.

Behavior in Operation ★ Since it affects the plate current's magnitude, the phase of the incoming signal with respect to the oscillator affects the oscillator frequency. This is explained by two considerations previously described, namely that the signal; and further that the oscillator

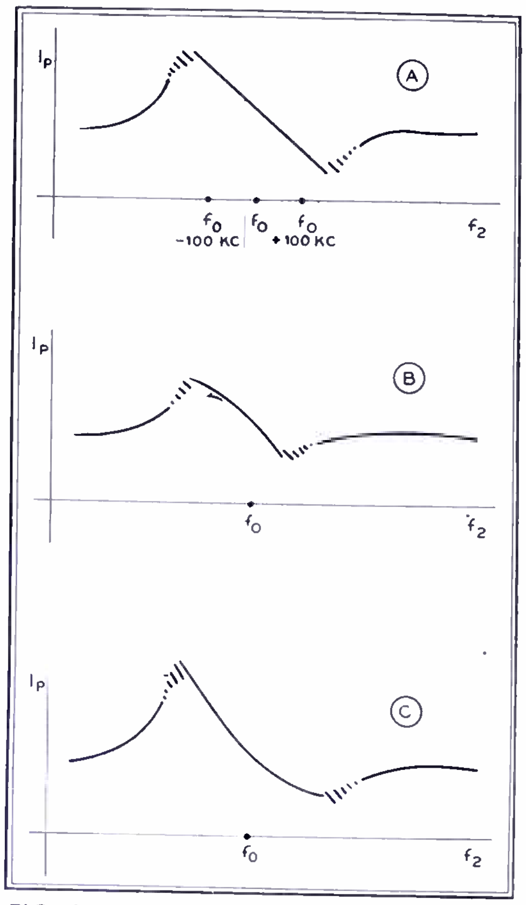


FIG. 3. PLATE CURRENT VS. FREQUENCY IN THE PHASING CIRCUIT

frequency is linearly proportional to the plate current magnitude. The net result is that the phase relationship between the incoming signal and the oscillator tends to change toward an equilibrium phase relation.

It follows that the oscillator locks into a nearly fixed phase relation with the incoming signal. Consequently, the oscillator frequency is the same as that of the signal. But we have seen how the oscillator frequency is controlled solely by the fundamental component of plate current and is linearly proportional to that component. Hence this plate current component must vary linearly with signal frequency deviation.

Also, since the mean plate current is proportional to the fundamental component, this mean current or audio output varies linearly with the signal frequency. In other words, the detector is directly and uniformly responsive to deviation in frequency of the carrier wave, fulfilling the first requirement for an ideal FM detector.

Considering the phase relationship from another aspect, if the fundamental component of plate current were *not* directly proportional to signal frequency, then the oscillator would not remain locked in phase with the signal. But actually there is a strong tendency for the oscillator to seek an equilibrium phase relation with the signal, as noted above. Thus, so long as the incoming signal is strong enough to cause the oscillator to lock in, the plate signal required for lock-in is in the order of 0.5 volt.

With the oscillation frequency of the detector, in the absence of a signal, adjusted to be at the center of the IF band, suppose that a signal is applied at this frequency. Then the oscillator must adjust itself to be in quadrature with the incoming signal. Only at the instant that the incoming sine wave passes through zero can a plate current pulse pass through the tube without being either increased or decreased in size by the effect of the signal voltage, which would change the phase back toward quadrature. Actually, of course, there are two such instants — when the sine wave passes through zero — in each complete cycle, but only one corresponds to a stable lock-in condition. The other effectually repels the pulse in phase until it moves to the stable condition. This situation is shown in Fig. 2A.

Variations in the size of plate current pulses resulting from two typical conditions of phase difference between the oscillator and incoming signal are illustrated in Figs. 2B and 2C.

If the signal frequency changes to a new value within the IF band, the phase slowly changes until a new plate current is established consistent with the new signal frequency. With a large signal, only a very small phase variation between oscillator and signal suffices to reach equilibrium; with weak signals, the variation of phase is greater. If the signal is too small and the frequency deviation too great, no phase may exist at which the instantaneous grid potential is sufficiently different from the bias potential to produce the required plate current. In such a case, the oscillator will fall out of synchronization. The signal strength required to maintain synchronization varies directly with deviation.

Suppose that, while the frequency is off center, the amplitude of the incoming signal is varied. The only effect will be that the oscillator phase readjusts itself continuously to maintain the plate current demanded by the frequency.

As may be seen from this discussion, the Advanced FM circuit functions as a detector with an extremely linear response to Frequency Modulation and with no response of the mean plate current to Amplitude Modulation, so long as the incoming signal is large enough to synchronize the oscillator.

Fig. 3 shows plate current vs. frequency characteristics for various adjustments of phasing circuit A. In Fig. 3A, this circuit is tuned for quadrature, while 3B and 3C demonstrate the effects of mistuning. Note that the correct adjustment does not give the greatest lock-in range for a given incoming signal; a slightly detuned adjustment, as in Fig. 3C, provides somewhat greater lock-in range.

ities further, the receiver designer may wish to use the neutralizing circuit shown dotted in Fig. 1, which consists of a blocking condenser in series with a nearly self-resonant choke. Actual field tests by Philco engineers indicate that this neutralizing circuit is not noticeably better, since the unneutralized circuit has practically no response to AM signals. Hence it fulfills both the second requirement for an ideal FM detector, and also the dictates of mass production manufacturing economy. Fig 4 shows the circuit diagram of the FM detector circuit of the Philco 1213 receiver.

in Fig. 5, are typical of this entire test program on FM broadcast interference.

The amount of *interfering* signal required to produce 3% distortion is shown in the test plotted in Fig. 5.

At the center frequency point on the curves, with the interfering signal on the same channel as the desired signal, the new FM detector required that the desired signal be only about twice as strong as the interfering signal, or 100 microvolts vs. 45 microvolts. By comparison, the double-limiter discriminator required that the desired signal be nearly five times as strong as the interfering signal,

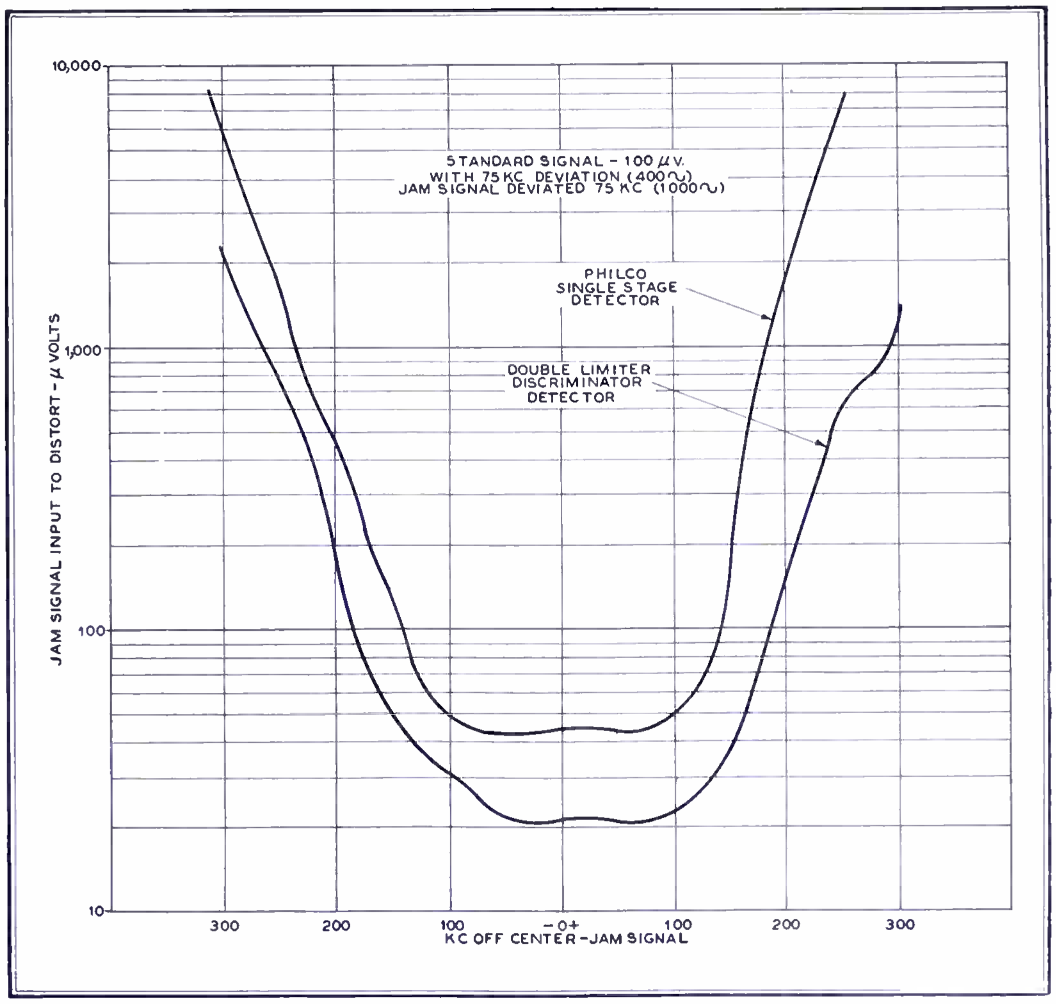


FIG. 5. COMPARISON OF SINGLE-STAGE DETECTOR & DOUBLE-LIMITER DISCRIMINATOR

Discrimination Against Interfering FM Signals ★ Still another important consideration is the ability of an FM detector to discriminate against unwanted FM signals of two principal kinds. The first, or *intra*-channel unwanted signal, is a weaker signal on the same frequency as the desired program. The second, or *inter*-channel unwanted signal, is a stronger signal one or more channels removed from the desired signal. In other words, these are co-channel and adjacent channel interference sources.

Many field and laboratory tests have been made by Philco engineers to determine the response of this single-stage FM detector to both desired and interfering signal inputs of widely varying amplitude and frequency. Also, these tests have included a careful comparison of the per-

or 100 microvolts vs. 21 microvolts. This means that the single-stage detector was twice as effective as the conventional circuit in attenuating co-channel FM interference.

Similarly, those portions of the curves on either side of the center in Fig. 5 show that the performance of the new FM detector against adjacent-channel interference is equally impressive. The ratio of interfering signal on the adjacent channel to desired signal required to cause 3% distortion was about 4.8 to 1 for the single stage detector. The ratio for the double-limiter discriminator circuit was about 1.8 to 1. These results indicated that the new FM detector gave almost three times as much attenuation of adjacent channel interference, or was *less* responsive to interfering FM stations.

MAGNETRON: GENERATOR OF CENTIMETER WAVES

The Theory of the Magnetron, and Its Development as a Practical Means for Generating Centimeter Waves—2nd Installment

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

4. Conditions Relating Measurable Parameters ★

4.1 *Necessary Conditions for Oscillation:* After having discussed the electron motions in the interaction space of the Type III magnetron oscillator, the viewpoint will now be changed to that looking from the outside in, so to speak, and it will be asked what conditions relating measurable parameters are imposed by the nature of the electronic mechanism. Beyond the geometrical parameters of cathode and anode radii, r_c and r_a, one can determine the DC voltage V applied between cathode and anode; the magnetic field B in which the magnetron is placed; the DC current I drawn by the anode; the frequency of oscillation f; and, from impedance measurements, the RF load $Y_s = G_s + jB_s$ presented to the electrons by the resonator, output, and load.

Perhaps the most fundamental condition for oscillation of the traveling wave magnetron is that imposed by the requirement of synchronism between the electron drift and the RF field. As has been indicated, the angular velocity of a rotating component of a Hartree harmonic of the interaction field, of order k, is $2\pi f/k$. An approximate expression for the mean angular velocity of the electrons may be determined by neglecting the variation of electric field with radius and calculating the angular velocity midway between cathode and anode, thus:

$$\frac{v}{(r_a + r_c)/2} = \frac{E/B}{(r_a + r_c)/2} = \frac{V/(r_a - r_c)B}{(r_a + r_c)/2} = \frac{2V}{(r^2_a - r^2_c)B}$$

Equating this to the angular velocity $2\pi f/|k|$, one obtains the relation:

$$V = \frac{\pi f}{|k|} r^2_a B \left[1 - \left(\frac{r_c}{r_a} \right)^2 \right]. \qquad (14)$$

In this derivation it should be recognized that the angular velocity $2\pi f/|k|$ may be considered either to be that of a traveling component of the RF field with which the electron interacts or the mean angular velocity which the electron must have to maintain proper phase with the total RF fields existing across the anode gaps.

Posthumus[13] derived an expression, assuming negligible cathode diameter, which is similar to equation (14). By the same method as that used above, Slater has derived an expression differing from (14) by a term which results from the use of a more accurate value for the electron's translational velocity at the midpoint between cathode and anode in cylindrical geometry. Slater's expression is:

$$V = \frac{\pi f}{|k|} r^2_a B \left[1 - \left(\frac{r_c}{r_a} \right)^2 \right] - 2 \frac{m}{e} \left(\frac{\pi f r_a}{|k|} \right)^2 \cdot \left[1 - \left(\frac{r_c}{r_a} \right)^2 \right]. \qquad (15)$$

Hartree has derived an expression from a consideration of the conditions under which electrons are just able to reach the anode with infinitesimal amplitude of RF voltage in the k^{th} harmonic. It is:

$$V = \frac{\pi f}{|k|} r^2_a B \left[1 - \left(\frac{r_c}{r_a} \right)^2 \right] - 2 \frac{m}{e} \left(\frac{\pi f r_a}{|k|} \right)^2. \qquad (16)$$

In a sense this condition represents a cut-off relation for the oscillating magnetron analogous to Hull's cut-off relation for the DC magnetron, equation (8).

Plotted on a V-B graph, the expressions (14), (15), and (16) represent parallel straight lines. The line of equation (14)

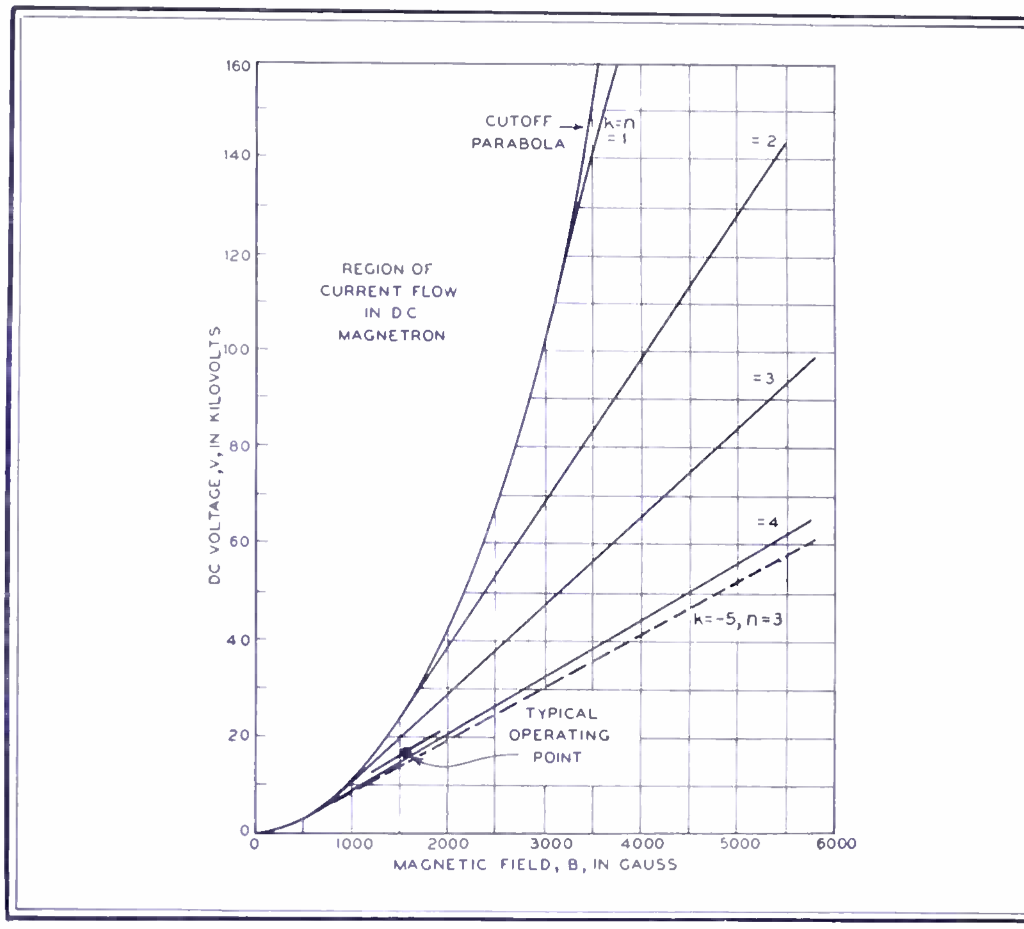


FIG. 16. A V-B plot for a magnetron having eight resonators (see footnote 16) showing the cut-off parabola and Hartree lines for several rotating field components. The ranges of DC voltage and magnetic field have been extended considerably beyond values ever applied to such a magnetron to show the lines for the fundamentals of all of the modes. The typical operating point plotted is that specified in footnote 16 and plotted in Fig. 17.

passes through the origin; the so-called Hartree line of (16) is tangent to the DC cut-off parabola; the so-called Slater line of (15) lies above the Hartree line but below the line of expression (14). Each of the above expressions indicates that the electrons will drive a given harmonic of the RF interaction field in a Type III magnetron oscillator only at values of DC voltage and magnetic field which bear a definite relation. This relation expresses the fact that V/B is very nearly constant [equation (14)].

In Fig. 16 are plotted, as an illustration, the Hartree lines for the fundamentals ($p = 0$) of the $n = 1, 2, 3,$ and 4 modes and for the $k = -5$ harmonic ($p = -1$) of the $n = 3$ mode of a 10 cm. magnetron with eight resonators.[16] Since the operating voltage is found to increase with increasing current, oscillation at a constant anode current takes place along a line, such as the Slater line for example, lying slightly above and parallel to the Hartree line (see Fig. 16). The separation of the operating line from the Hartree line increases with increasing DC current.

The necessary conditions for oscillation discussed above have been of great value in the identification of the modes of operating magnetrons and as the starting point in the design of new magnetrons for given wavelength, magnetic field, and voltage.

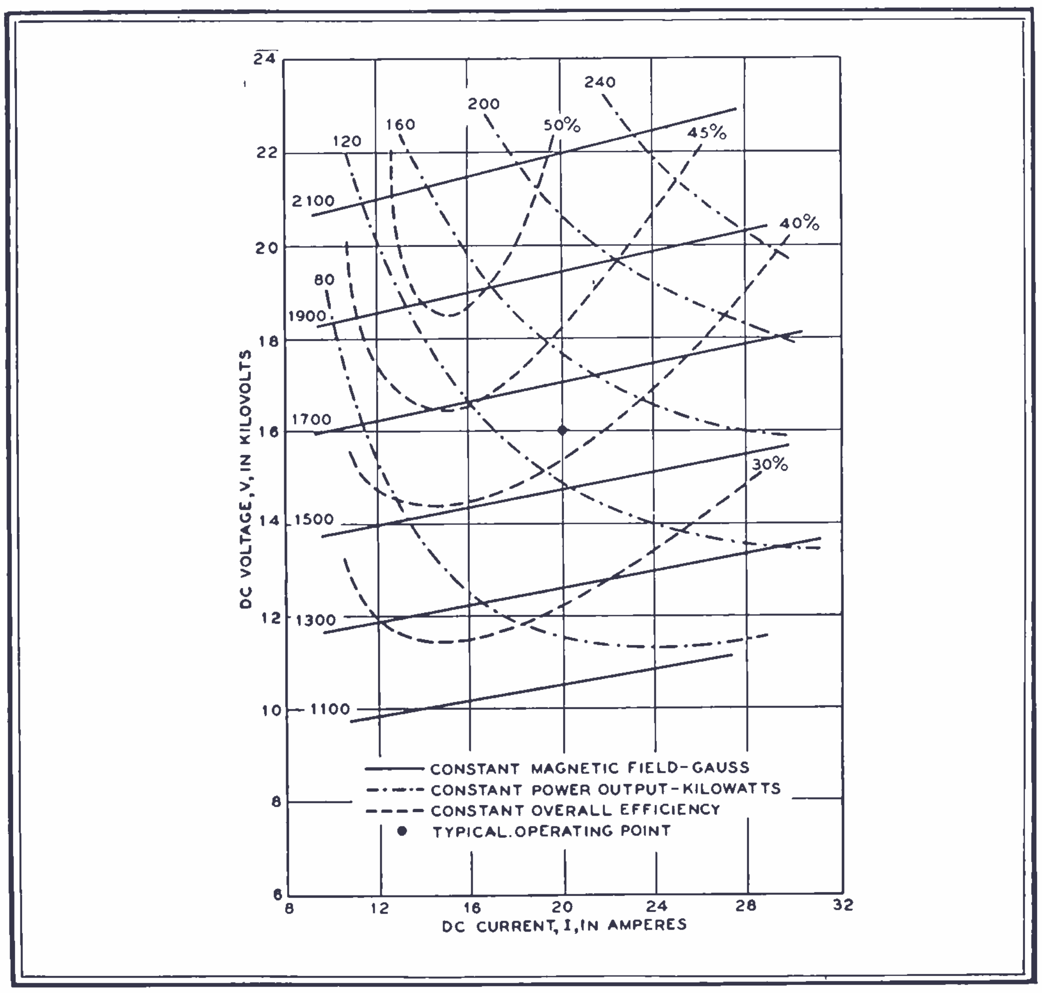


FIG. 17. A *V-I* plot or performance chart for a magnetron having eight resonators (see footnote 16). Contours of constant magnetic field, power output, and over-all efficiency are shown. The typical operating point plotted is that specified in footnote 16 and plotted in Fig. 16.

4.2 *The Performance Chart:* Another fundamental performance characteristic of the operating magnetron is the *V-I* plot or performance chart. In Fig. 17 such a chart is plotted for the same magnetron [16] used as the example for Fig. 16. In it are plotted contours of constant magnetic field, RF power output, and over-all efficiency. The fact that the constant magnetic field contours are nearly horizontal and spaced as they are is a manifestation of the oscillation conditions of equations (15) and (16). The increase of voltage with current is an effect, attributable to the space charge, quite independent of the condition of synchronism between field and electrons. For if the magnetron is to deliver more power at a given magnetic field, the induced RF current must increase. This entails increased space charge and a greater DC current flow. To maintain the increased space charge additional DC voltage is required.

4.3 *The Electronic Efficiency:* The performance chart also shows the not too surprising fact that more power may be drawn from the magnetron as the voltage and current are increased. More interesting are the increase of the over-all efficiency with voltage and the maximum through which the efficiency passes with increasing current. This variation of over-all efficiency η is to be attributed to changes in the electronic efficiency η_e since the other factor involved in the over-all efficiency, the circuit efficiency η_c is essentially constant over the diagram ($\eta = \eta_e \eta_c$).

The increase of electronic efficiency with voltage, and hence magnetic field, may be explained by the picture of electron motions in the interaction space. The highest electronic efficiency is attained when the electrons reaching the anode do so with least kinetic energy. For the approximate orbit of Fig. 12, the energy lost at the anode per electron is that gained as kinetic energy beyond the last cusp. Bringing the last cusp closer to the anode, corresponding to a reduction of the amplitude of the rotational component of the electron motion, reduces the ratio of kinetic energy lost at the anode to the potential energy possessed by the electron at the cathode. Thus, according to equation (6) for the radius of the rolling circle, this fractional energy loss should vary as V/B^2 or, since V/B is approximately constant, as $1/B$, η_e increasing with B. In terms of the approximate electron orbits for a plane magnetron, Fig. 18 shows how increase in voltage and magnetic field increases the electronic efficiency. The dependence of electronic efficiency on B predicted by this simple picture is in accord with the dependence predicted by more sophisticated theories.

In all probability the decrease of electronic efficiency toward low and high currents is, in part at least, the result of decrease in the phase focusing action. This occurs as a result, on the one hand, of low RF field strength in the proper mode when the current and RF oscillation are small and, on the other hand, as a result of space charge debunching when the current and space charge become very large. In addition, at low currents the leakage to the anode of electrons which are not effective in interaction with the RF field assumes a more dominant rôle, reducing the effective electronic efficiency. These electrons are no doubt those emitted near or at the ends of the cathode.

Of importance to the motion of electrons near the ends of the interaction space, and thus to the electron leakage, are the configurations of the DC electric and magnetic fields there. These depend upon the geometry of the cathode ends and surrounding walls and of the magnetic pole pieces. The electrons are largely confined to the interaction space by the axial force, directed toward the center of the interaction space, produced by the nonuniformities in the electric and/or the magnetic fields. For uniform magnetic field, the desired focusing action on the electrons may be achieved by disks at cathode potential which are mounted at each of the cathode and extend beyond the cathode surface over the ends of the interaction space as may be seen in Fig. 1. In other cases, distortion of the magnetic field in the end spaces of the magnetron, in addition to cathode end disks, has been used to produce the same effect.

Although the dependence of operation of a magnetron oscillator on load is primarily a circuit problem, detailed discussion of which will be delayed until the RF circuit has been discussed, there is one feature of the dependence on load and circuit characteristics which may properly be discussed now. This is the dependence

[16] This magnetron, used as an illustrative example in Part I, has the following characteristics:
- Number of resonators, N = 8.
- Cathode radius, r_o = 0.3 cm.
- Anode radius, r_a = 0.8 cm.
- Anode length, h = 2.0 cm.
- Anode to end cover distance = 0.6 cm.
- Frequency (π mode), f = 2800 mc/s.
- Wavelength (π mode), λ = 10.7 cm.
- DC operating voltage, V = 16 kv.
- Operating magnetic field, B = 1600 gauss.
- Typical operating peak current, I = 20 amps.
- Over-all efficiency, η = 42%.
- Peak power output, P_o = 135 kw.
- Pulse duration τ = 1 microsecond.
- Pulse repetition frequency = 1000 pps.

of the electronic efficiency η_e on the circuit conductance G_s, presented to the electrons. The plot in Fig. 19 is a typical example, and shows an optimum value of conductance, to each side of which η_e decreases. With decreasing G_s the RF voltage increases. Whereas initially the increase of V_{RF} with decreasing G_s increases the phase focusing properties, it results eventually in such strong RF field that electrons are drawn more or less directly to the anode where they arrive with considerable kinetic energy. On the other hand, the decrease in V_{RF} with increasing G_s eventually will result in an RF field too weak to produce the necessary amount of phase focusing. The value of G_s presented to the electrons depends not only upon the output circuit properties and load but also upon the parameters of the resonator itself. The dependence of electronic efficiency upon G_s is a good example of how intimately the electronics and circuit of the magnetron oscillator are associated.

4.4 *Scaling:* Once an efficient design has been achieved for a given wavelength, voltage, current, and magnetic field, one is interested in reproducing it at other values of these parameters. In doing this, use is made of the theory of scaling. For cases where the interaction space remains geometrically similar and the magnetron operates in the same mode, the same efficiency is presumably achieved when it is arranged that the electron orbits remain similar. Directly from dimensional arguments applied to Maxwell's equations for the electromagnetic field and to the equations of motion of the electrons, it can be shown that the orbits and operation will be equivalent for all conditions for which the loading and the quantities

$$\lambda B,\ (\lambda/r_a)^2 V,\ \text{and}\ (\lambda^3/r_a{}^2 h) I$$

remain invariant.

It would perhaps be of interest to consider, as a simple example, the case for which all the linear dimensions of a given

The new resonant wavelength λ' is equal to $\alpha\lambda$, since the new resonator is α times the size of the original, while the new frequency is $f' = f/\alpha$. The new anode radius, cathode radius, and anode length scale directly so that

$$r'_a = \alpha r_a,\ r'_c = \alpha r_c \text{ and } h' = \alpha h$$

Since λB, $(\lambda/r_a)^2 V$, and $(\lambda^3/r_a{}^2 h) I$ must remain invariant,

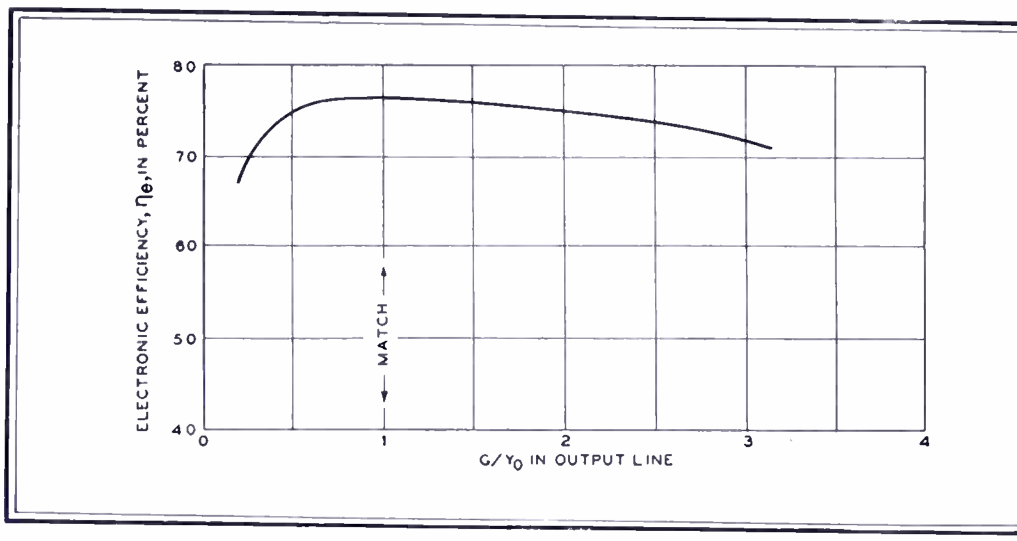


FIG. 19. A plot of electronic efficiency as a function of load conductance. The conductance G/Y_0 in the output line is related to that presented by the circuit to the electrons, G_s, directly through the magnetron resonator and output circuits. The magnetron with which these data were obtained is a 3.2 cm. magnetron having sixteen resonators.

$$\lambda' B' = \lambda B \text{ or } B' = B/\alpha,$$

$$(\lambda'/r'_a)^2\, V' = (\lambda/r_a)^2\, V \text{ or } V' = V,$$

$$\text{and } (\lambda'^3/r'_a{}^2 h')\, I' = (\lambda^3/r_a{}^2 h)\, I \text{ or } I' = I.$$

Thus the magnetic field changes by $1/\alpha$ and the operating voltage and current remain unchanged.

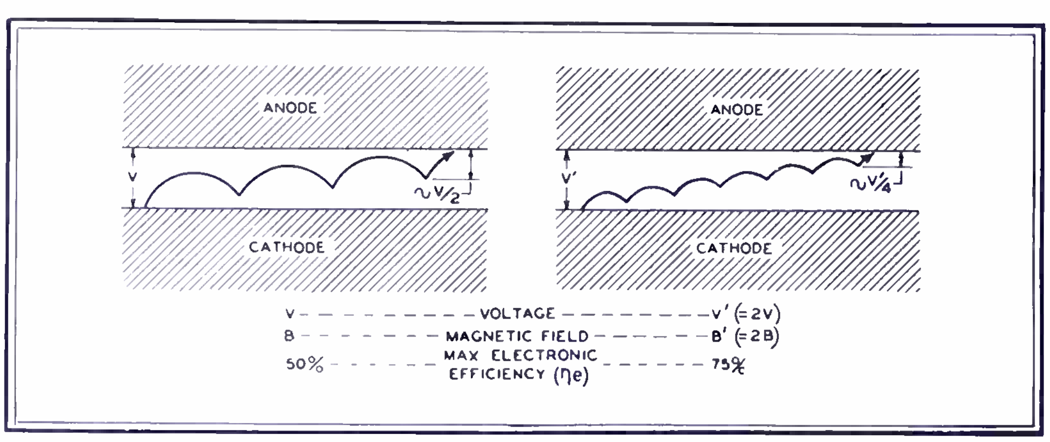


FIG. 18. Approximate orbits of electrons which transfer energy to the RF field, plotted for operation of a plane magnetron at two different magnetic fields. It is shown how the relative kinetic energy gained beyond the last cusp and dissipated at the anode decreases as the magnetic field and voltage of operation are increased, resulting in increased efficiency of electronic conversion of energy from the DC field to the RF field. The two illustrative cases differ by a factor two in DC voltage and hence by the same factor in magnetic field and diameter of the rolling circle.

The idea of scaling has been extended to magnetrons of varying r_c/r_a and N by the introduction of sets of reduced variables for V, B and I involving r_c/r_a and N, in terms of which the performance may be expressed independently of the exact nature of the magnetron.

4.5 *Effect of Other Components in the Interaction Field:* In the discussion of the has been considered that the electrons interact with a single traveling RF field component, generally a component of the fundamental of the π mode. The justification for this, as has been stated, is that from the point of view of the electron the fields of all other Hartree harmonics of the π mode vary so rapidly that their effects average out over an appreciable number of RF cycles. This is generally true, as well, for the harmonics of other modes which may be excited. The fact has been mentioned that it is possible for the values of V and B for oscillation in the π mode very nearly to satisfy equation (16) for oscillations in a harmonic of another mode. Then the angular velocity, $2\pi f'/|k'|$, of the harmonic very nearly equals that of the π mode $2\pi f/N/2$, and the Hartree line of the harmonic lies very close to that of the π mode (see Fig. 16). The effect of this situation on magnetron operation will be discussed in connection with the problem of *moding* in Section 10.6 *Oscillation Buildup—Starting.*

Of particular interest is the presence in the interaction space, in addition to the π mode field, of an RF field component which is independent of angle. Such a component appears, for example, as an inherent contamination in the interaction field of the so-called *rising sun* type resonator system to be described later. Generally, this component is of no concern because the electrons interact with the π mode component throughout a time interval covering several cycles, during which the effect of the contamination averages out. The exception to this occurs when the frequency of the rotational component of the electron motion, approximately the cyclotron frequency, resonates with the RF frequency as in a Type II magnetron. From equation (2) this occurs for the plane case when $f = c/\lambda = eB/2\pi m$, from which $\lambda B = 2\pi cm/e = 10{,}700$ gauss-cm. For a typical cylindrical case the constant is somewhat greater, being this value, perturbation of the electron motion occurs, decreasing the efficiency of interaction with the traveling wave and manifesting itself on the performance chart as a *valley* in operating efficiency appearing along the constant B line for which λB = 12,500 gauss cm. In Fig. 20 is plotted the performance chart of a magnetron, having a rising sun type anode structure which exhibits this kind of behavior. In general, it would be preferable to operate this magnetron at magnetic fields above the valley, but considerations having to do with available magnetic fields, in some cases may make it necessary to operate near the efficiency maximum at lower magnetic fields.

5. The RF Circuit of the Magnetron Oscillator ★

5. *General Considerations:* The discussion to this point has presented a picture of how the multicavity magnetron oscillator works from the point of view of its electronics; how in this respect it is related to other types of magnetron oscillators; and how, on the basis of the picture of the electronic mechanism, some of its fundamental operating characteristics are to be accounted for. In the same manner the RF circuit of the magnetron oscillator, comprising the resonator system, the output circuit, and the load, will be discussed. The importance of this part of the magnetron is apparent. It provides the RF fields with which the electrons interact. To do this, electromagnetic energy must be stored in the cavities of the resonator, which reservoir in turn is tapped to deliver energy through the output circuit to the useful load. The detailed manner in which these functions are performed has a bearing not only on such circuit characteristics as circuit efficiency or on the effect of load on frequency but, as has been seen, on the electronic efficiency as well. Furthermore, the circuit analysis of the magnetron oscillator enables one to explain the remaining important operating characteristic, the so-called Rieke diagram, which describes the operational dependence on load.

The type of resonator system used in the magnetron oscillator of concern here has already been indicated in Fig. 1. It is a resonator system comprising a number of cavities spaced equally about the cylindrical anode. This general shape is dictated by the slotted anode cylinder upon which the RF interaction field is set up. To be sure, other types of resonators have been devised which contrive to place π mode potentials on the anode segments of a cylindrical magnetron. Here, however, except for brief references, the discussion will concern itself with the multicavity resonator system of the general type shown in Fig. 1. Although the individual cavities have not been limited to hole-and-slot geometry like those shown in Fig. 1, and other features have been added, a resonator system consisting the anode in the manner of Fig. 1, has been used in the majority of magnetron oscillators developed for centimeter wave generation since 1940.

5.2 *Simple Single Frequency Resonator:* The fact that the magnetron resonator system has a number of cavities electromagnetically coupled together makes it multiresonant. What has been learned about the various modes and their electromagnetic field configurations, and how they may in a sense be controlled to improve magnetron operation must be discussed in some detail. Before this is done, however, it would be well to refresh one's memory as to the fundamental ideas concerned with a single electromagnetic resonator like one of the magnetron cavities.[17] This is important not only because the magnetron resonator system comprises a number of such cavities but also because the resonator system as a whole may under certain circumstances be considered to resonate at but one frequency, in which case it behaves like a simple single frequency resonator.

Concerned with the simple electromagnetic resonator are the fundamental ideas of a natural frequency of resonance, of the resonance, and of the characteristic admittance or the energy storage capacity. The electromagnetic resonator, whether it has lumped or distributed constants. consists of a device in which energy is transferred between electric and magnetic fields cyclically in a manner entirely analogous to the transfer of energy between potential and kinetic in the simple swinging pendulum. Each of these oscillations, electromagnetic or mechanical, is described by a second order differential equation in terms of a parameter such as voltage or current on the one hand, and

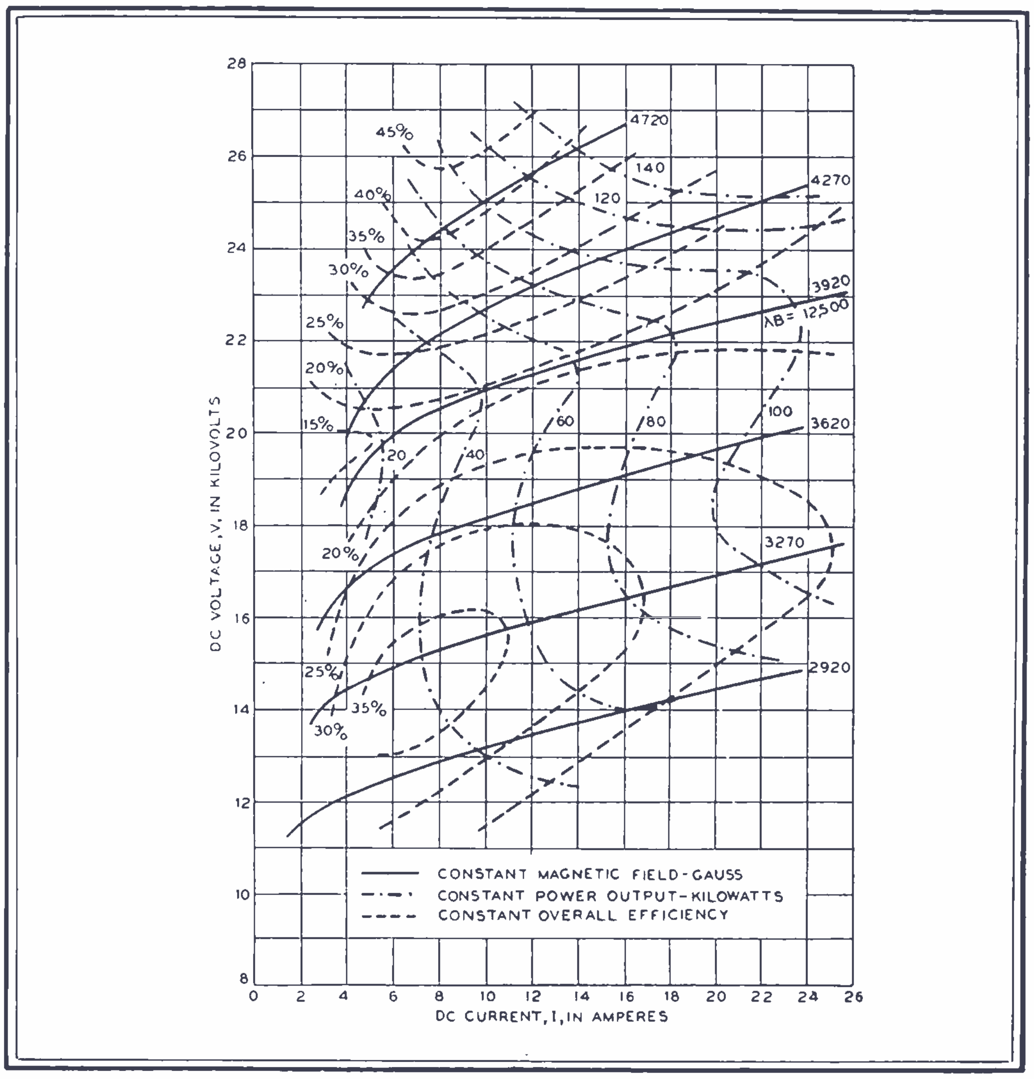


FIG. 20. A performance chart for a magnetron which has present in its interaction field a contaminating component independent of azimuth. Note the efficiency valley appearing along the line B = 3920 gauss (compare with Fig. 17). The wavelength of the magnetron being 3.18 cm., λB along the efficiency valley is 12,500 gauss-cm. The data were obtained on a magnetron having a rising sun type resonator system and are reproduced here through the courtesy of the Columbia Radiation Laboratory.

[17] In the next sections of this paper, material has been drawn from the theory of a single resonant circuit having either lumped or distributed constants, the theory of coupled circuits, and the theory of centimeter wave transmission in coaxial lines and wave guides, treatments of which are to be found in the following representative texts:

L. Page and N. I. Adams, "Principles of Electricity," D. Van Nostrand Co., New York (1931).

E. A. Guilleman, "Communication Networks," Vols. I and II, John Wiley and Sons, New York (1931).

J. G. Brainerd, G. Koehler, H. J. Reich, and L. F. Woodruff, "Ultra-High Frequency Techniques," D. Van Nostrand Co., New York (1942).

J. C. Slater, "Microwave Transmission," McGraw-Hill Book Co., New York (1942).

R. I. Sarbacher and W. A. Edson, "Hyper and Ultrahigh Frequency Engineering," John Wiley and Sons, New York (1943).

angular displacement of the pendulum bob on the other. The solutions represent simple harmonic oscillations, the one for the simple electrical circuit having the frequency,

$$f_0 = \frac{\omega_0}{2\pi} = \frac{1}{2\pi\sqrt{LC}}. \tag{17}$$

This occurs when the susceptances of the two components of the circuit, L and C, are equal, or when

$$\frac{1}{\omega_0 L} = \omega_0 C. \tag{18}$$

The fact that a finite time is required to transfer the energy between the electric and magnetic fields in a lumped constant circuit is not surprising since a finite time is required for a condenser to charge or discharge, and for a current to build up or decay in an inductance.

5.3 *The Q Parameters:* The type of oscillation of the simple L-C circuit discussed above is its natural or free oscillation, not constrained by the application of any external driving force. It is the sort of oscillation the circuit would undergo were it left to itself after being excited or started initially. Such an oscillation, once started, does not continue indefinitely because the energy put into the circuit initially dissipates itself in resistive losses in the circuit components and in a load which may be coupled electromagnetically to the circuit. The exponential rate at which the orginal energy is dissipated is a very important characteristic of the circuit. It is usually specified by a parameter Q, defined as 2π times the ratio of the energy stored in the circuit to the energy dissipated per cycle of the oscillation.[18] Thus a circuit always loses a certain fraction of its energy per cycle independent of how great this energy may be. In the exponential decay of oscillations in a resonator from which the drive has been removed, $Q/2\pi$ is the number of cycles of oscillation required for the stored energy to decay to $1/e$ of its initial value. Similarly, in the buildup of oscillations in a resonator to which is fed a constant amount of energy per cycle, $Q/2\pi$ is the number of cycles required for the stored energy to build up to $(1 - 1/e)$ of its final equilibrium value.

It is possible to define several types of Q's for a circuit, depending upon the nature of the energy dissipation being considered. If one considers only the energy lost in the resistance of the circuit components themselves, one defines the so-called unloaded Q, Q_0. If the circuit is coupled electromagnetically to a resistive load, the Q defined in terms of the energy dissipated in the load and internal resistance is called the loaded Q, Q_L. Finally, for some purposes it is convenient to consider the ratio of energy stored to that dissipated in the external load only. This defines the external Q, Q_{ext}. It is clear that both Q_L and Q_{ext} are functions of the degree of coupling between the oscillating circuit and the resistive load.

The Q parameters, however, tell one more than the rate at which energy is dissipated in a circuit oscillating at its natural frequency. The admittance of the circuit, measured as a function of the frequency of an external driving source, passes through a minimum at the natural frequency of oscillation of the circuit. The sharpness of the dip in the admittance curve is determined by the Q_L of the circuit in such a manner that the sharper the dip, the higher the Q_L. In passing through resonance, the susceptance of the circuit changes sign from inductive, for frequencies below the frequency of resonance, to capacitive, for frequencies above the frequency of resonance. The rate at which the susceptance varies with frequency is another measure of the sharpness of resonance and of the Q_L of the circuit.

5.4 *Energy Storage and Loss:* The remaining ideas concerned with a simple L-C circuit of lumped constants which should be mentioned here are the characteristic admittance of the circuit, the energy storage capacity, and how these are related to each other and to the concepts already mentioned. For this purpose it is convenient to consider the circuit shown in Fig. 31 (c). Across the terminals AB is connected the L-C circuit in which the resistive losses are represented by the circuit conductance G_c. The circuit is loaded by the admittance $Y''_L = G''_L + jB''_L$.

Looking into the circuit at the terminals AB one sees the admittance:

$$Y_s = G_c + jB_c + Y''_L = G_c + \frac{1}{j\omega L} + j\omega C + Y''_L$$

which may be rewritten:

$$Y_s = G_c + j\sqrt{\frac{C}{L}}\left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}\right) + Y''_L$$

$$\cong G_c + 2j\left(\frac{\omega - \omega_0}{\omega_0}\right) Y_{0c} + Y''_L, \tag{19}$$

where $\omega_0 = \dfrac{1}{\sqrt{LC}}$ and $Y_{0c} = \sqrt{\dfrac{C}{L}}$.

The expression $\sqrt{\dfrac{C}{L}}$, having the dimensions of an admittance, is by definition the characteristic admittance of the circuit, Y_{0c}. Its relation to the energy stored in the circuit, and through this to the various Qs defined above, can be seen from the following: Using the root mean square value of voltage, the energy stored in the circuit is CV^2_{RF}. This can be reduced by the use of the definition of the resonant frequency and by differentiation of the expression (19) for the admittance, thus:

$$CV_{RF} = \frac{Y_{0c}}{\omega_0} V^2_{RF} = \frac{1}{2}\left|\frac{dB_c}{d\omega}\right|_{\omega=\omega_0} \cdot V^2_{RF}. \tag{20}$$

Thus, at a given frequency ω_0, the energy stored in the circuit for unit voltage applied to it may be specified either by the characteristic admittance of the circuit Y_{0c}, or by the rate of change of susceptance with frequency at the resonant frequency, $\left|\dfrac{dB_c}{d\omega}\right|_{\omega=\omega_0}$.

The loss of energy per cycle in the circuit itself, that is, in the shunt conductance G_c, is the power loss in the circuit divided by the frequency, $\dfrac{V^2_{RF} G_c}{\omega_0/2\pi}$. From this and equation (20) the unloaded Q is seen to be:

$$Q_0 = 2\pi \frac{\dfrac{Y_{0c}}{\omega_0} V^2_{RF}}{\dfrac{V^2_{RF} G_c}{\omega_0/2\pi}} = \frac{Y_{0c}}{G_c}. \tag{21}$$

Similarly, for the loaded and external Qs:

$$Q_L = \frac{Y_{0c}}{(G_c + G''_L)}. \tag{22}$$

$$Q_{ext} = \frac{Y_{0c}}{G''_L}. \tag{23}$$

It follows that the Qs are related thus:

$$\frac{1}{Q_L} = \frac{1}{Q_0} + \frac{1}{Q_{ext}} \tag{24}$$

The efficiency of the circuit, defined as the fraction of the energy which reaches the useful load is then:

$$\eta_c = \frac{G''_L V^2_{RF}}{G''_L V^2_{RF} + G_c V^2_{RF}} = \frac{G''_L}{G''_L + G_c}$$

$$= \frac{\dfrac{Y_0}{Q_{ext}}}{\dfrac{Y_0}{Q_{ext}} + \dfrac{Y_0}{Q_0}} = \frac{1}{1 + \dfrac{Q_{ext}}{Q_0}} = \frac{Q_L}{Q_{ext}}. \tag{25}$$

5.5 *Resonators with Distributed Constants.* The individual cavities of the magnetron oscillator, however, are circuits in which the parameters are distributed and not lumped. They may be considered to be "strip-type" resonators, three forms of which generally used in magnetrons are shown in Fig. 21 (a), (b), and (c). Type (a) has been called the slot type resonator; (b), the vane type, deriving its name from a common method of fabrication in which rectangular plates are disposed around and brazed to the inside of a cylindrical cavity; and (c), the hole-and-slot type resonator. The forms of these resonators, especially the parallel strip form of Fig. 21 (a), suggest that the resonators may be considered as sections of terminated transmission lines.

Voltage and current waves traveling down a section of uniform transmission line, terminated at one end by a short circuit and driven by a sinusoidal voltage at the other end, are reflected at the shorted end. The interference of the incident and reflected waves results in stand-

[18] As will be seen in the subsequent discussion the factor 2π is included here so as to simplify the definition in terms of admittance.

ing waves of voltage and current along the line. Since the voltage and current waves suffer phase changes on reflection differing by π radians, the corresponding standing waves are shifted by $\pi/2$ radians relative to one another. Thus the input admittance of the section of line is a periodic function of the distance ℓ to

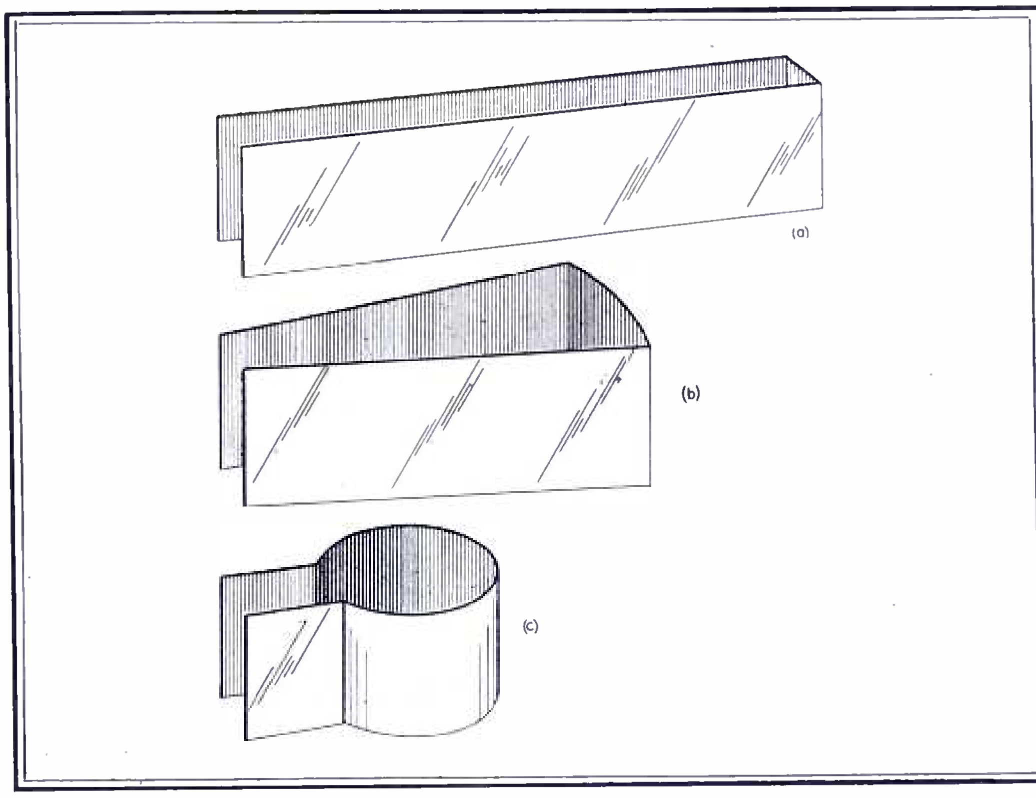


FIG 21. Three strip type cavities commonly used in magnetron resonator systems, each resonant at the frequency c/λ. Type (*a*) is essentially a quarter wavelength ($\lambda/4$) section of uniform transmission line. It should be noted how types (*b*) and (*c*) are physically shorter than type (*a*) by virtue of the greater relative capacitive loading near the open ends.

the shorted end. For a lossless line, this admittance is given by the expression:

$$Y = -jY_0 \cot\frac{2\pi\ell}{\lambda} = -jY_0 \cot\frac{2\pi f\ell}{c} \cdot \quad (26)$$

In (26), Y_0 is the characteristic admittance of the line. For a line of given length, this expression gives the input admittance as a function of frequency. When the frequency is $c/4\ell$, the line is a quarter wavelength long, and the input admittance, if the line is lossless, is zero. In other words, the section of line resonates at this frequency.[19] In a quarter-wavelength resonator of uniform geometry, the voltage is maximum at the input end and the current is maximum at the shorted end, each varying sinusoidally to a node at the other end of the line.

The frequency of resonance of a section of terminated uniform line is thus determined by its length. If the geometry of the line is nonuniform, the frequency of resonance may be determined by the solution of Maxwell's equations with the appropriate boundary conditions. In general, this procedure is involved and tedious, however. One can get a reasonable idea of the values of ω_0 and Y_0 by assuming the half of the resonator near the open end to be capacitive only, the half near the closed end inductive only, and calculating C and L by application of elementary formulas to an equivalent parallel plate capacitance and a single turn sheet inductance of height h and proper cross sectional area. In the case of geometry like that of Fig. 21 (c), the division of the resonator on this basis is obvious.

A line of physical length ℓ', less than $\lambda/4$, may be made to resonate at the frequency c/λ by connecting across its input end a lumped capacitive susceptance, of magnitude ωC, equal to that of the inductive susceptance of the line, $Y_0 \cot 2\pi\ell'/\lambda$ [see equations (18) and (26)]. In like manner, resonators like those of Fig. 21 (b) and (c), whose physical length is less than $\lambda/4$, can be considered to be made up of an inductive section of uniform line across which additional capacitance has been inserted near the open end, bringing the frequency of resonance to c/λ. In Fig. 21, the three resonators of different physical lengths all resonate at the same frequency.

In addition to the resonant frequency of a resonator of distributed constants, one can define its Q's and characteristic admittance and link these to the rate of change of susceptance and energy storage capacity at resonance, as was done for the circuit of lumped constants. Resonators of different geometry but of the same resonant frequency differ in characteristic admittance and loss conductance and hence in the Q's and the amount of energy which can be stored with unit voltage impressed across the input end. Of the resonator types shown in Fig. 21, the slot tope has the largest admittance, the vane type, the smallest admittance, with the hole and slot type intermediate.

[19] The frequency of resonance, $f = c/4\ell$, is the fundamental or lowest frequency of an infinite series of resonant frequencies for which the line length is $[2q-1)\lambda/4$;

$$f_q = (2q-1)c/4\ell,\ g = 1, 2, 3, \cdots.$$

These frequencies may be specified by considerations of the phase relationships which must exist between oppositely traveling waves on a lossless line for constructive interference. These considerations are similar to those employed later in the discussion of the modes of oscillation of the magnetron resonator system as a whole.

FM, FACSIMILE, TELEVISION

(CONTINUED FROM PAGE 21)

only to discourage new applications on 30 to 40 mc.

Fastest growing section of the communications field is taxi service. The success of the first installations has far exceeded all expectations as to increased revenue and reduced cruising mileage. This has proved to be the case with small concerns operating 6 or 8 cabs, as well as with the large fleets.

TELEVISION

Three important events have taken place in the television field. In chronological order, they were the TBA Conference in New York City; the filing by CBS of a petition asking the FCC to adopt standards for color television and to authorize commercial operation; and RCA's surprise demonstration of electronic color television.

TBA Conference ★ Exhibits of television receivers and the excellent quality of black-and-white demonstration programs at the Television Broadcasters Association Conference in New York indicated enormous technical progress during the past year. Among the notable items were the handsome Dumont receivers with big, direct-viewing tubes, RCA's table-model receiver, and G.E.'s pulsed light which eliminates the shutter mechanism from the motion picture projector.

While receiver prices are high and deliveries slow, production seems to be moving along at about the same rate that merchandising, installation, and service problems are being met.

CBS Petition ★ Although it seems unlikely that the FCC will take any immediate action on the CBS petition to establish standards for color television, it is none too early to explore this subject. To that extent, the CBS move may have a salutary effe

However, the text of the letter from president Frank Stauton, which accompanied the petition, raises some doubt as to whether CBS is altogether sincere in asking for color television standards at this time, or if there may be an intent to

(CONTINUED ON PAGE 50)

WHAT'S NEW THIS MONTH

(CONTINUED FROM PAGE 4)

want to continue in this direction. That is why a quorum of the Commission and its principal staff officers have moved here to Chicago for your Convention. We are here to consult with you, to learn your problems, to advise you in any way and in every way that we can.

It is our objective that the FCC shall not in your mind be a house of mystery, a dark chamber where schemes are hatched to plague you. And in this connection I want to say that, if I were a broadcaster, and if I believed some of the things that have been said and some of the things that have been written, I would spend many a sleepless night. I am sure that while trying to count sheep I would, instead, find myself counting six FCC Commissioners jumping over the fence.

It is my purpose here today to tell you where the Commission stands on the problems of current importance to broadcasters. So far as is humanly possible, we are now operating and we will continue to operate in a goldfish bowl. The production lines, and the statements which we have issued from time to time, are tangible evidence of this desire. We want you to know exactly where we stand. If the only thing that has been keeping you awake at night is worrying what the FCC is planning to do next — I am assuming there is nothing else on your conscience — then tonight you shall enjoy a good night's sleep.

Blue Book ★ It is in this spirit of letting you know exactly what we are thinking and precisely what we are doing that I want to approach my discussion of the Blue Book.

First, I wish that you would put aside some of the things that you have heard and read that purport to sum up what the Blue Book says. Then, I wish you would sit down and actually re-read the Blue Book. If you did, this is what you would find. It makes these points:

1. The Blue Book says that when an applicant represents that he is going to do certain things, he should in fact do something reasonably close to that which he said he would do.

2. The Blue Book says that a reasonable amount of time, including some time in the desirable parts of the broadcast day, should be devoted to sustaining programs. This is to keep the broadcaster's hands free to offer the balanced program that every real broadcaster has always been eager to offer. Don't let anyone tell you that the Commission has said that a commercial program cannot be a public service program. The Book says no such thing and the Commission intends no such thing.

3. The Blue Book says that a broadcaster should devote a reasonable amount of time to local, live programs. I shouldn't think that there could be any dispute about this. If a man is truly entitled to call himself a "broadcaster" he would, I should think, want to originate some programs of his own so that the community which he is licensed to serve will have an outlet for the discussion of its local problems, and for the development of its local talent and resources. A true broadcaster will not content himself simply with plugging his transmitter into a network or a turntable and going off to Florida for the winter. Unless there is to be local origination of programs, we don't need radio stations in the various communities; all we require are unattended boosters.

4. The Blue Book says that radio should not content itself with being simply an entertainment medium, leaving it to the press and the movies to keep the American people informed on the important issues of the day. Radio, it says, should make an adequate amount of time available for the discussion of public issues.

5. The Blue Book says that advertising plays an indispensable part in our system of broadcasting. But that should not mean that broadcasting should be run solely in the interest of the advertisers, rather than that of the listeners. Specific advertising excesses are described. Financial statistics are cited to show it is not necessary for the industry to indulge in these advertising excesses to enjoy a decent profit.

In appraising the standards of service from broadcast stations, we must take into account that we are not dealing with an out-at-the-elbows industry that must scrimp to make both ends meet. By 1939, the annual return on the depreciated cost of tangible property, before Federal income tax, for all networks and stations had already reached 67%. But that was just a beginning. In the following years, it reached 83%, 99%, and 96% in 1942. But even greater prosperity was just around the corner, for in 1943 the return went up to 158%. The next year the return was 222%. For 1945, the figure was 201%.

6. The Blue Book then comes to the question of what can be done. First, it says that the primary responsibility for corrective steps "rests with the licensees of broadcast stations, including the network organizations" and the industry trade associations. Finally, it points out that the Commission has a statutory responsibility for the public interest. The Commission says that in discharging this responsibility it will, in examining license renewal applications, take into account the principles I have just summarized.

That is the Blue Book. We do not intend to bleach it. We, at the Commission, sincerely believe that every principle enunciated in it is calculated to increase the stature of the individual broadcaster, to encourage him to exercise greater control over his own business, and to assist him to escape dictation of the advertiser.

However, my host in various public statements over the nation since the publication of the Blue Book has been teasing the Commission, saying we are stooges for the Communists. He has said that we have violated the First Amendment which guarantees freedom of speech. He has called us "obfuscators," "intellectual smart-alecks," "professional appeasers," "guileful men," "astigmatic perverters of society."

Now, those comments haven't cooled our friendship because, you see, we believe in free speech.

Meanwhile, many of America's leading newspapers have also been looking into this problem. In view of the fact that they might be counted upon to be alert to any threat to free speech in this Country, I think you will find some of their comments interesting. You may have missed these because your usual sources of information have not been over-zealous in bringing them to your attention.

The Milwaukee Journal: "Some (station operators) seem to have lost sight of the fact that they operate by grace of the public, and have a public responsibility."

The Washington Post: "The recent report of the Federal Communications Commission . . . sets forth a doctrine which seems to us incontestable. . . ."

Life Magazine: "The American radio currently presents one of history's most amusing, yet disturbing, instances of mankind's technology getting ahead of its culture."

The Christian Science Monitor: "The blatant and insistent commercials to which the FCC called attention have in many cases become offensive."

The Miami Daily News: "Some stations are too commercially minded to fulfill their obligations to the public welfare."

The New York Herald Tribune: "If certain practices are losing listeners, radio should reform itself. And it is about time to get on with the job."

The St. Louis Post-Dispatch: "The FCC cannot permit such betrayal of the public trust by those licensed to uphold it."

St. Louis Globe-Democrat: "Until radio learns the same self-control (as newspapers) over its more noxious commercials, it merits censure."

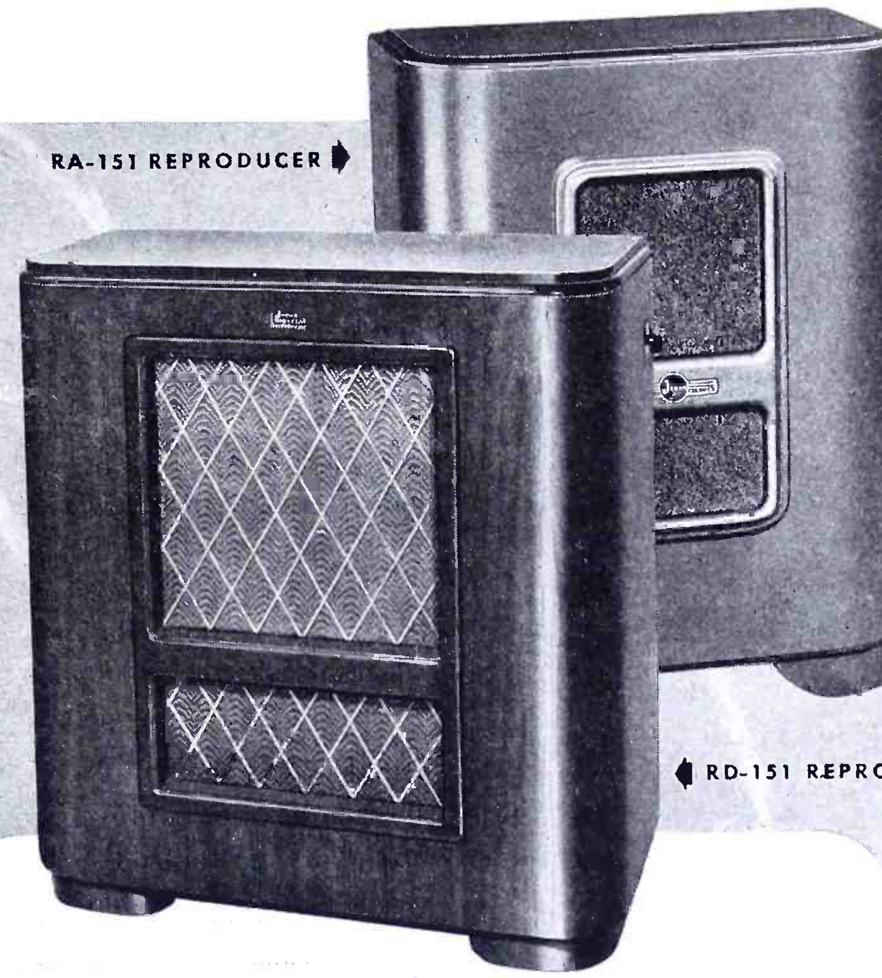
Variety Magazine: "Slowly but surely, over the past few years, over-commercialization has won out. Good taste, development of original radio technique, and cognizance of public service programming have gone by the boards."

The Cleveland Plain Dealer: "Radio can aid by carrying more of the good chain cultural and public service shows which now go by the boards."

The New York Times: "Surely, it cannot be construed as a challenge to freedom of speech to insist that a person using a

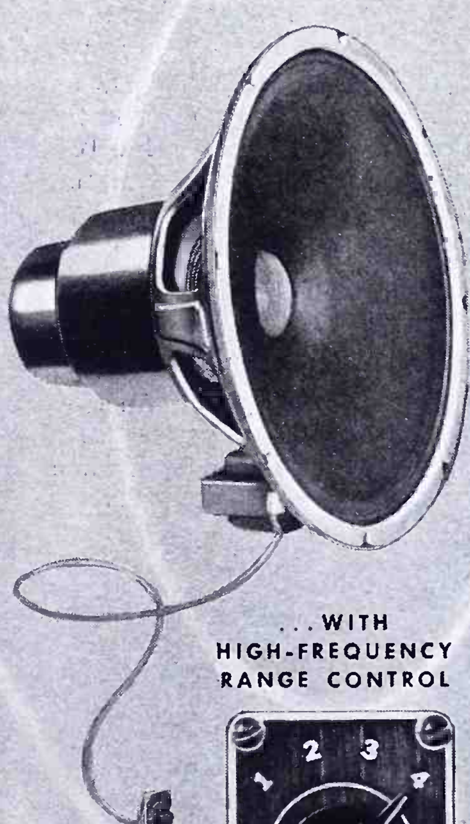
(CONTINUED ON PAGE 57)

RA-151 REPRODUCER

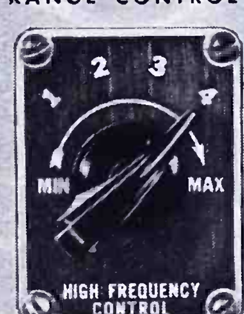


Listen ...it's a Jensen SPEAKER!

RD-151 REPRODUCER



...WITH HIGH-FREQUENCY RANGE CONTROL



Jensen High Frequency Control gives you the kind of reproduction you want when you want it . . . all the way from two-way system high fidelity to conventional single speaker performance. Now you can adjust for best results on every program, every record, every type of service.

Now you can hear ALL program material at its best with the new JENSEN Coaxial Reproducers

- ★ Two articulated, coaxially mounted speakers
- ★ JENSEN *Bass Reflex** Cabinets for full low register
- ★ High-Frequency Range Control for all-purpose flexibility
- ★ Beautifully styled walnut and utility cabinets
- ★ Built-in Frequency-dividing Network

*Trade Mark Registered

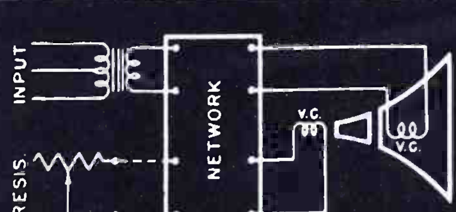
Never before have you been able to buy such performance . . . such versatility . . . at so low a cost. JENSEN now brings you the ultimate in reproducers with top performance so fine, so nearly ideal acoustically that obsolescence is eliminated for years to come. Yet you can instantly adjust response for most pleasing results with every type of program material in use today. Ideal for professional and home use for FM-AM reception and monitoring, transcriptions, commercial phono records . . . for practically every moderate-level high-quality application.

JENSEN MANUFACTURING CO., 6609 S. Laramie Ave., Chicago, U.S.A.

In Canada: J. R. Longstaffe, Ltd., 11 King St., Toronto

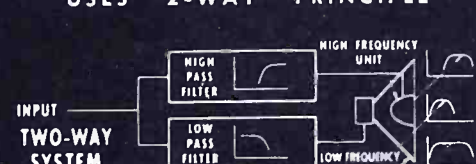
Jensen SPEAKERS WITH ALNICO 5

Designers and Manufacturers of Fine Acoustic Equipment



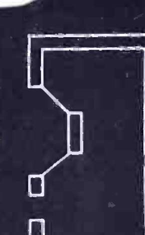
Separate coaxially-mounted speakers for low and high frequencies, with integral two-channel network. (Range control not shown.)

USES "2-WAY" PRINCIPLE

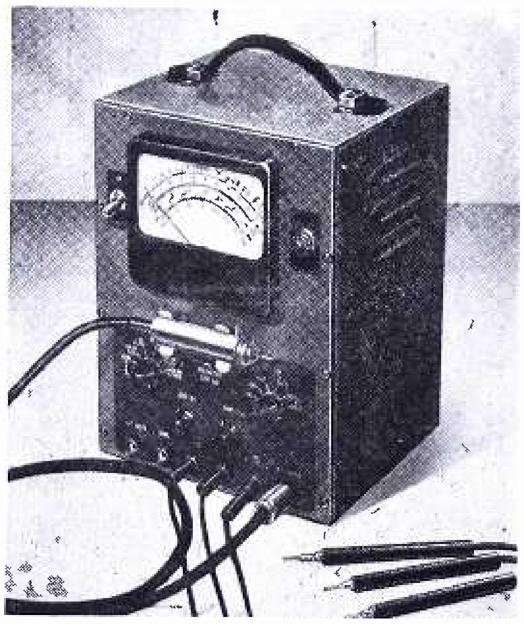


JENSEN BASS REFLEX

Acoustically-correct Bass Reflex Cabinet gives smoothly extended low register. Better than an "infinite" baffle . . . efficiently uses back radiation too.



RADIO EQUIPMENT AND INSTRUMENTATION



SYLVANIA METER FOR WIDE RANGES OF VOLTAGE, CURRENT, RESISTANCE

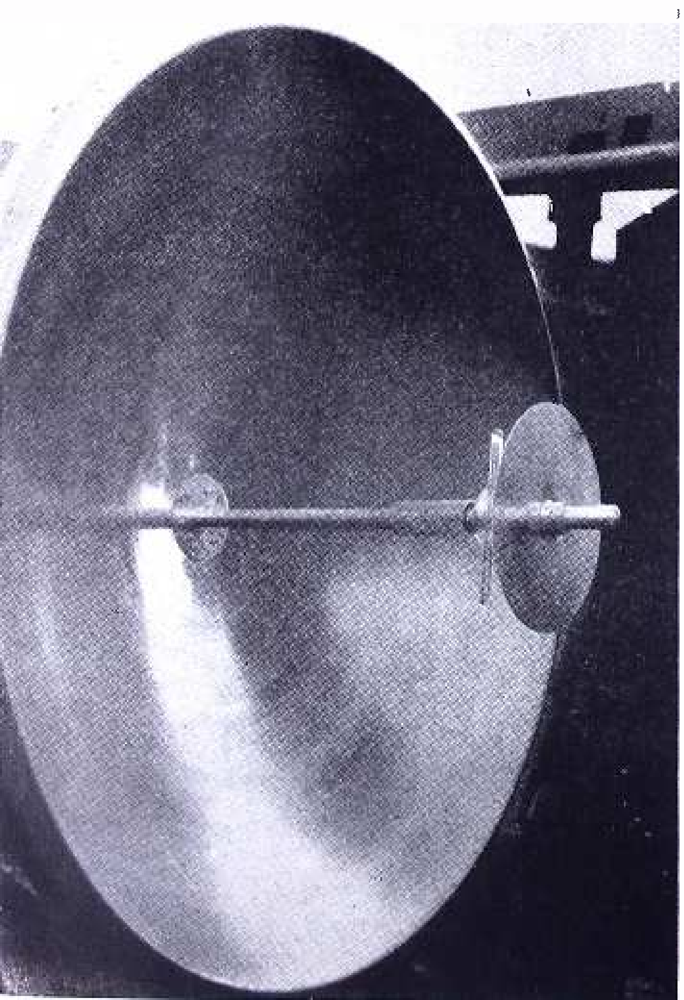
Test Meter: A test meter providing a convenient means of measuring a wide range of voltage, current, and resistance values has been announced by Sylvania Electric Products, Inc., 500 Fifth Avenue, New York 18. Measurements can be made on DC, and AC up to 300 mc. There are 6 DC voltage and 7 DC current ranges, 5 AF and 5 RF voltage ranges, and 6 resistance ranges. Special feature is a vacuum-tube probe using a proximity fuse type of tube. The instrument draws 30 watts at 105 to 125 volts, 50 to 60 cycles.

Parabolic Antenna: One of the latest antennas engineered and manufactured by Workshop Associates, Newton Highlands, Mass., is the 890-mc. parabola illustrated here. Two of these have been delivered to CBS for their television installation on the Chrysler Building, New York. Although simple in appearance, the design of such antennas involves many engineering problems.

For example, to keep the standing waves at a minimum, impedance measurements were made by building a slotted line into the rear of the first model, so as to measure the standing wave ratio directly. Careful adjustments were then made so that the antenna presented an impedance of 52 ohms to the line. Finally, accurate pattern measurements were made over and over again to find the optimum adjustment for the reflector and choke. The resultant antenna has a very narrow beam, which accounts for its high gain. Half-power angle in the vertical plane is 21.5°, and in the horizontal plane it is 18.5°.

Connections are provided by a type N connector to RG-8/U coaxial cable. Outside diameter of the reflector is 40 ins. Antennas of this type are suitable for studio-to-transmitter links, remote television pickup, and multi-channel point-to-point and relay systems.

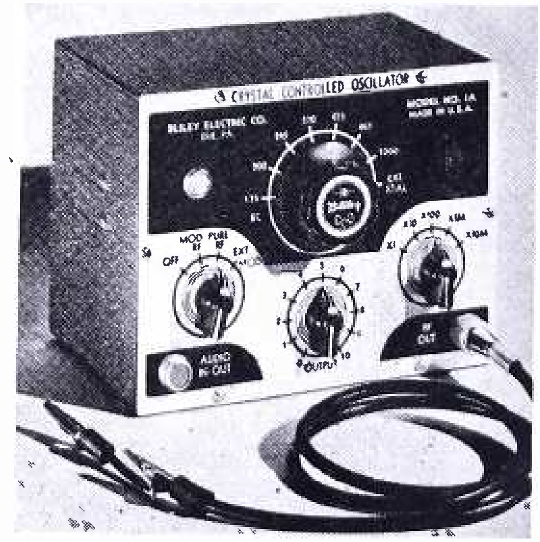
PARABOLIC ANTENNA FOR 890 MC., PRODUCED BY WORK SHOP ASSOCIATES



MALLORY VIDEOCOUPLER SIMPLIFIES THE COIL DESIGN OF TELEVISION SETS

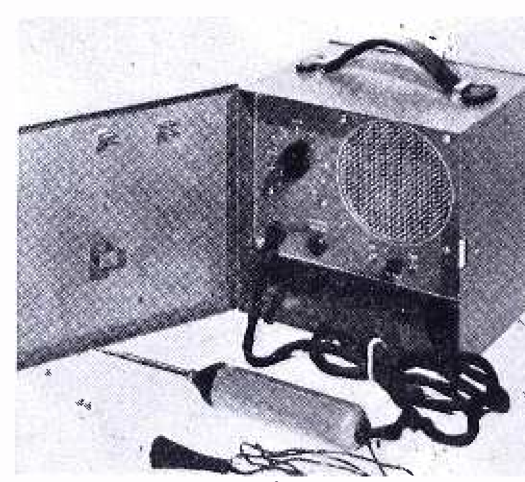
Videocoupler: P. R. Mallory & Company, Inc., Indianapolis, Ind. have added another item to their line of television components. The latest is a 3-terminal network designed to couple the video amplifier to the picture tube. The unit, illustrated here, combines in one assembly two peaking inductances and the load resistor, thus simplifying the design of wide-band amplifier circuits.

Calculator: A very cleverly designed circular slide rule, called the "Calculade," is offered by American Hydromath Company, 145 W. 57th Street, New York 19. It shows at one setting the physical dimensions of a coil and the capacity of a condenser required for any given wavelength and frequency. Frequency range is from 400 kc. to 150 mc. Coil data ranges from lengths of ¼ to 10 ins., diameters from ¼ to 5½ ins., and wire sizes from No. 10 to 35, with silk, cotton, or enamel insulation.



BLILEY USES HIGH-STABILITY CRYSTALS FOR THIS TEST OSCILLATOR

Crystal-Controlled Oscillator: A new test oscillator has been brought out by Bliley Electric Company, Erie, Pa. It employs quartz crystals of low temperature coefficient to furnish instant selection of the five most commonly used intermediate frequencies, with a stability of ±.1%. These are 175, 262, 370, 455, and 465 kc. Direct crystal control is also provided at 200 kc. for RF alignment and at 1,000 kc. for short-wave alignment. An extra socket is provided to plug in crystals of other frequencies. There is a 3-position modulator selector and a 5-step attenuator.



SPECO'S BATTERY-OPERATED SIGNAL TRACER FOR CIRCUIT CHECKING

Signal Tracer: Special Products Company, Silver Springs, Md. has announced a portable battery-operated signal tracer. Mounted in a gray-finished steel case 5¼ by 6¼ by 6 ins., it weighs only 4½ lbs. A circuit is employed to give high sensitivity and hum-free operation, with low-drain tubes for maximum battery life.

In order to protect the batteries, a safety switch is actuated by the cover. Thus the tubes cannot be left on after the case is closed. An extra-long probe and leads are furnished so that the instrument can be set up at a convenient distance from the work.

ZENITH

Is Building An FM Audience For You With Both Large and Small Sets

• *Zenith Builds a Class Audience . . .*

As of Sept. 13—62.2% of all the FM-equipped radio-phonograph consoles produced postwar were ZENITHS

• *Zenith Builds a Mass Audience . . .*

As of Sept. 13—70.7% of all the FM-equipped table model sets produced postwar were ZENITHS

These latest available figures (October 15, 1946), from Haskins & Sells, the official reporting agency of the Radio Manufacturers Association, are proof of Zenith's confidence in FM. And remember, every Zenith FM receiver uses genuine Armstrong Wideband FM with both the 45 megacycle and the 100 megacycle tuning bands. Zenith owners enjoy FM at its best . . . they are FM's biggest boosters.

Zenith . . . First in FM

ZENITH RADIO CORPORATION • *Chicago 39, Illinois*

FM, FACSIMILE, TELEVISION

(CONTINUED FROM PAGE 45)

confuse the present black-and-white situation.

This is indicated by Mr. Stanton's statement to the Commission that: "So long as color television continues in an experimental status, the entire industry will be subject to uncertainty, and the investment of the public and broadcaster in low-frequency, black-and-white television may be in jeopardy."

In the opinion of many who have seen CBS color television, any method which employs a whirling disc to provide the color must be considered as not having advanced beyond the technical and commercial uncertainties of experimental status.

RCA Electronic Color Television ★ Until October 30th, the impression prevailed throughout the industry that electronic color television was something of the indefinitely distant future. On that date, however, RCA invited representatives of the press to witness the first demonstration, at the Princeton Laboratories, of television in which color was provided without the use of mechanical motion, and projected on a 21-in. screen. The equipment is shown in the accompanying illustrations.

At the transmitting end of this system, slides or motion picture film are scanned by the light spot of a cathode-ray tube. Light, passing through the film, is broken up so that the red, green, and blue are directed to separate photo-electric cells which control transmission on three separate but adjacent frequency channels.

The receiver has separate cathode-ray tubes to supply the three colors for projection, through separate lenses, onto the television viewing screen.

During the demonstration, witnessed by 50 or 60 men and women, two color receivers were used, and another, operating only from the green transmitter channel, produced the same images in black and white. Both methods of reception gave excellent results on slides, free from flicker and other optical defects, and adequately bright when the room was lighted enough for newspaper reporters to write on-the-spot dispatches.

To show that motion pictures could be transmitted by the same method, several colored shorts were run off. RCA officials explained that further work was necessary before they would be fully prepared to demonstrate colored motion pictures. However, reproduction on this occasion was surprisingly good, the only criticism being that, at times, the red was disproportionately strong.

RCA president Sarnoff summed up the advance represented by this demonstration in this way:

First, replacement of the motor-driven color wheel by the electronic system rep-

(CONCLUDED ON PAGE 60)

BROWNING UNIVERSAL TUNER

DESIGNED TO MEET THE NEEDS OF ALL TYPES OF INSTALLATIONS AT THE LEAST COST FOR FINEST FM-AM PERFORMANCE

THE BROWNING Universal Tuner, as the name implies, is designed to suit each individual installation for use in the home, the broadcast studio, the laboratory, or the advertising agency audition room.

Therefore, it is furnished without power supply, audio amplifier, or loudspeaker. This enables the individual purchaser to work out his own ideas as to the audio system and method of installation, depending upon whether the installation is for a small room, a public auditorium, a skating rink or a dance hall, or some other special purpose. The BROWNING Universal Tuner will deliver undistorted, static-free FM signals, plus AM and record-playing, to whatever audio system you select. The use of the Universal Tuner provides high-quality performance at the lowest cost, since it is necessary to add only the accessories needed at a given installation. Employs Armstrong circuit.

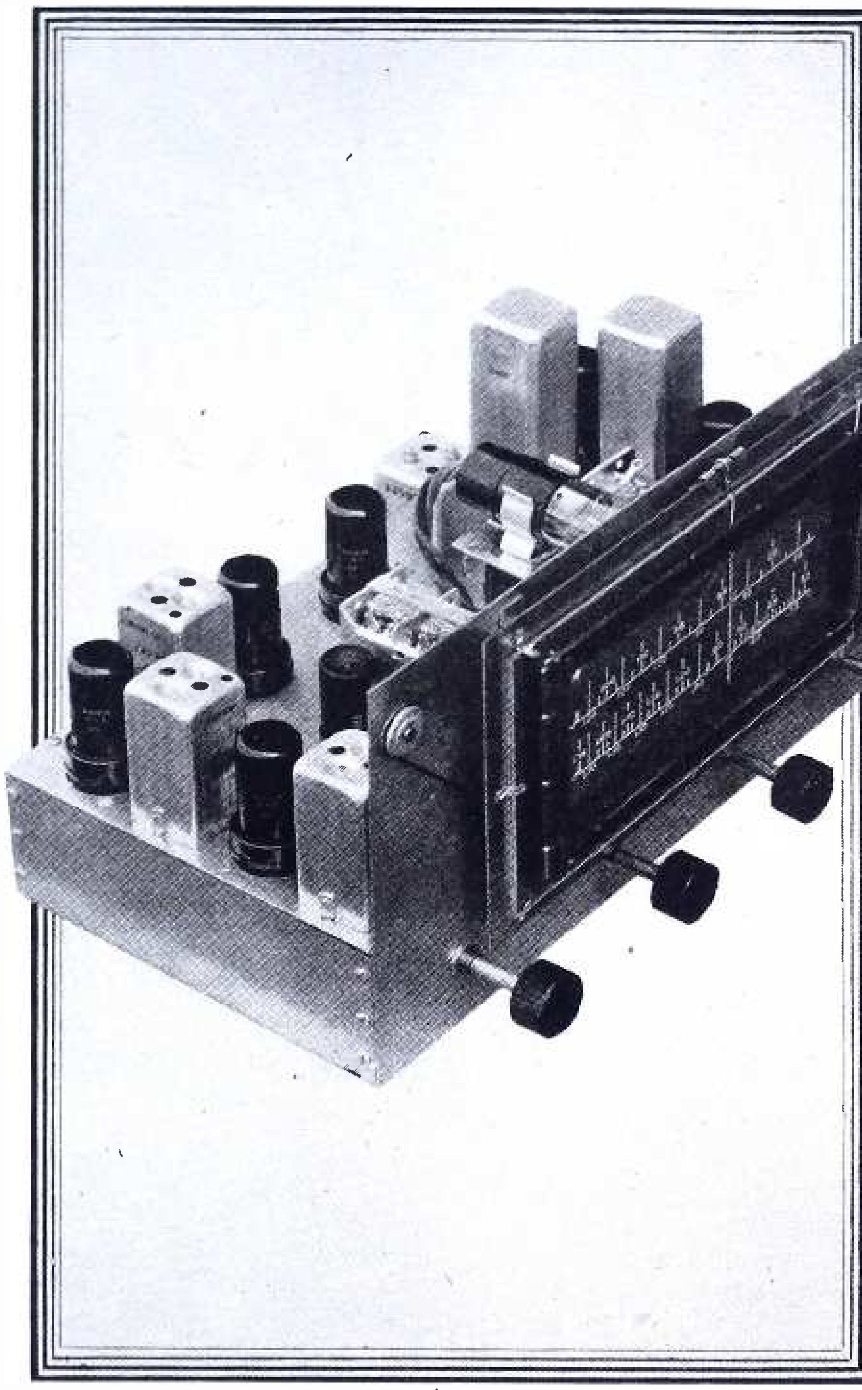
BROWNING LABORATORIES, INC.

Engineers and Manufacturers

WINCHESTER • MASSACHUSETTS

Canadian Representatives

Measurements Engineering, 61 Duke Street, Toronto



UNIVERSAL TUNER, MODEL RJ-12.......$114.50

RACK PANEL TUNER, MODEL RJ-14.....$134.80

POWER SUPPLY UNIT, MODEL PF–12.....$ 14.75

SPECIFICATIONS ON THE RJ-12 TUNER

1. TUNING RANGE: 88 to 108 mc. on FM, and 535 to 1650 kc. on AM. These are the tuning ranges for FM and AM established by the FCC.

2. SENSITIVITY: On FM, complete noise-limiting action is obtained with signals of 15 microvolts. AM circuits respond to signals of 1 microvolt.

3. FM CIRCUITS: A separate high-frequency FM section employs tuned antenna and RF stages feeding a mixer, and using a separate oscillator tube. Image interference is minimized by operating the local oscillator at a frequency higher than that of the incoming signals.

The output of the mixer is fed through two IF stages to a dual limiter, where static and other amplitude disturbances are removed. The output of the limiter is applied to the discriminator which produces a demodulated audio signal for feeding into a separate power amplifier.

4. AM CIRCUITS: An independent AM section provides a tuned antenna and RF stage to eliminate image response. This is followed by a converter stage, a high-gain IF stage, and a diode detector which furnishes AVC voltage and AF output to the amplifier. FM and AM output levels are approximately the same.

5. PHONOGRAPH: Terminals for connections from a phonograph pickup are at the rear of the chassis. A third position on the band switch cuts in the phonograph, and its volume is regulated by the FM-AM volume control.

6. NEW TUBES: Miniature tubes are used in the FM section to obtain maximum efficiency.

CONTROLS: Single-knob FM and AM tuning, on-off switch, volume control, and FM-AM phonograph band switch.

TUBE COMPLEMENT: The following tubes are furnished in the Universal Tuner: one 6BE6, one 6C4, one 6BA6, three 6SG7, two 6SJ7, one 6H6, one 6SA7, one 6SF7, and one 6E5.

DIMENSIONS: Height 7⅜ ins., width 13½ ins., depth 9 ins.

HOME FACSIMILE STANDARDS

(CONTINUED FROM PAGE 22)

preferences, that 4- or 5-in. paper and a speed of 3 ins. per minute involve the least risk in program problems and cost for purposes of building mass market coverage.

At this rate, the copy comes out as fast as it can be read, the recorder mechanism takes up little space, the amplifier is of lower rating, and the motor is not only less expensive but requires less of a motor amplifier — if the system used requires one — than will be the case if $8\frac{1}{2}$-in. paper is employed.

Editor's Note: *Mr. Alden will discuss other facsimile problems affecting standards in a forthcoming issue.*

FM RAILROAD RADIO

(CONTINUED FROM PAGE 29)

could improve its service in connection with freight movement, increase the efficiency of the yard organization, and raise the factor of safety for the personnel.

The advantages of the radio communications system in handling unscheduled or emergency situations were well illustrated during a portion of the formal demonstration period when the special train carrying the guest observers came to a stop near the north end of the yard area. In front of the special train, and on the same track, an electric engine had stalled through failure of its motor. Seeing what had taken place, a yard official on the special train contacted a control point operator along the line by means of the radio system, and a Diesel yard engine was immediately dispatched to the scene. The Diesel coupled onto the stalled freight locomotive, moved it to a siding, and the special then continued on its way down the cleared track.

2. The radio circuit provided means by which the yardmaster could immediately deliver instructions to or obtain information from a locomotive engineer or conductor. Conversely, either the locomotive engineman or conductor could request instructions from or deliver information to personnel at any of the fixed-station remote control points.

3. The remote control units in the cab and on the forward platform provided trainmen with a communications link unaffected by adverse weather conditions such as rain, snow or fog, visual obstructions, or darkness, thus providing greater and more certain coördination of train crew activities.

In this connection, yardmaster Kemp Rush made some interesting comments during the NBC broadcast transcription interview. He stated that, during the period of the radio tests, efficiency of communication had been excellent, and that in foggy weather he could get in touch with engineers and train crews to expedite classification operations when visual signals could not be seen due to the fog.

4. The intercommunication circuit established over telephone lines between remote control points permitted the yard manager, yardmasters, and other personnel to talk to each other without going on the air. Moreover, they could monitor any conversation between the control units, or between any control unit and a locomotive, and also monitor any incoming signals transmitted from the locomotives.

5. As personnel at the different fixed-station control points could talk together, operations throughout the yard area could be checked and supervised at all times.

6. The installation of remote control units on the forward platforms of locomotives, as well as in locomotive cabs, enabled the conductor and other crew members to be in direct voice communication with each other. Thus, whether crew members were in the cab, riding the forward platform, or working on the ground in the vicinity of the front of the engine, they could hear incoming radio calls via the loudspeakers on the locomotive, and could quickly acknowledge the calls by use of the control unit at the front of the engine or in the cab.

In permanent installations, remote control units may be placed on both the front and rear of locomotives, in order to comply more fully with the high standards

(CONTINUED ON PAGE 57)

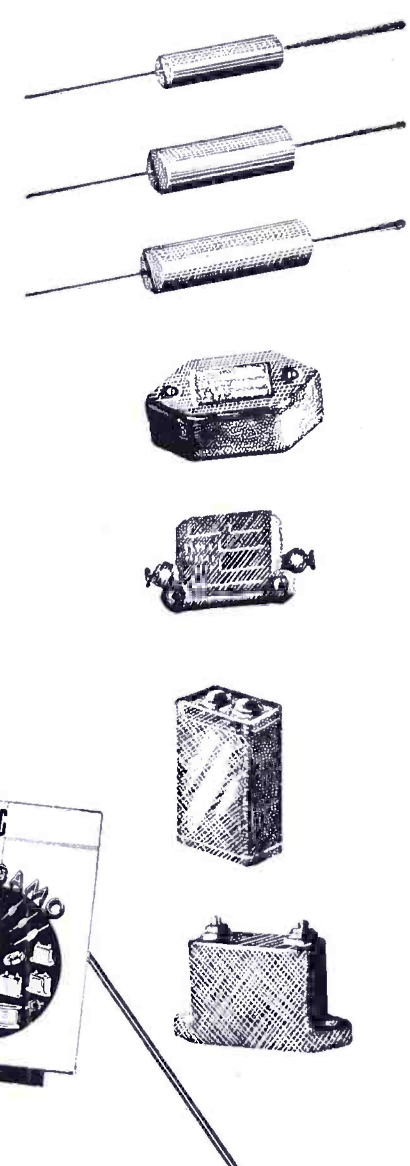

For Efficient Radio Electronic Arteries...
Choose Amphenol Components!
Amphenol is known, and relied upon, by amateurs and professionals in every branch of radio and electronics. The encyclopedic array of more than 8,000 *different* Amphenol components completely serves the entire range of frequencies in use today.
Amphenol engineers steadily are helping to pierce the veil of the unknown in the higher television and FM frequencies. They have been among the pace-setters in achieving the higher standards of mechanical efficiency and electrical correctness upon which progress in these fields depends.
Teamed with top-flight production facilities, Amphenol research has continuously developed new products to keep the Amphenol line of cables, plugs, connectors, fittings sockets, antennas and plastic components the most complete available from any one source in the world today.
Wherever you find electrons at work, you'll find Amphenol components recognized as the standard of performance.
AMERICAN PHENOLIC CORPORATION, CHICAGO 50, ILLINOIS
In Canada • Amphenol Limited • Toronto
AMPHENOL
COAXIAL CABLES AND CONNECTORS • INDUSTRIAL CONNECTORS, FITTINGS AND CONDUIT • ANTENNAS • RF COMPONENTS • PLASTICS FOR ELECTRONICS

JACK OF ALL TRADES*

SANGAMO METAL-CASED MINERAL OIL PAPER CAPACITORS

Mineral oil filled to assure longer life and more stable performance over a wider range of operating temperatures.

*A Sangamo Capacitor that will fill your needs



Sangamo Types 20 and 21 Capacitors have attained extreme popularity with their users because of their excellent by-pass and coupling qualities. Vacuum impregnated and filled with the highest grade of mineral oil, their capacity is stable from 55°C below to 85°C above zero. Capacitors are available within the range of 200 to 2000 volts working.

Write for the new Sangamo Capacitor Catalog which contains complete information for your use

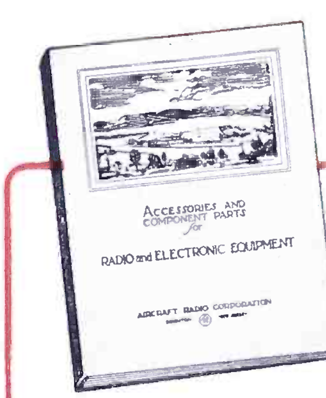
SANGAMO ELECTRIC COMPANY
SPRINGFIELD • ILLINOIS

Recently released from Army-Navy classification, this equipment, formerly known as the TS-223/AP, is now being produced by Aircraft Radio Corporation as the A.R.C. Test Set, Type H-10.

This highly specialized test equipment is used primarily for the measurement of radar receiver sensitivity, frequency and band width; and transmitter power and frequency, in the 24,000 Mc. band. Other field or laboratory measurements possible with this equipment include testing of type 2K50 r-f oscillator tubes and measurement of radar receiver recovery time.

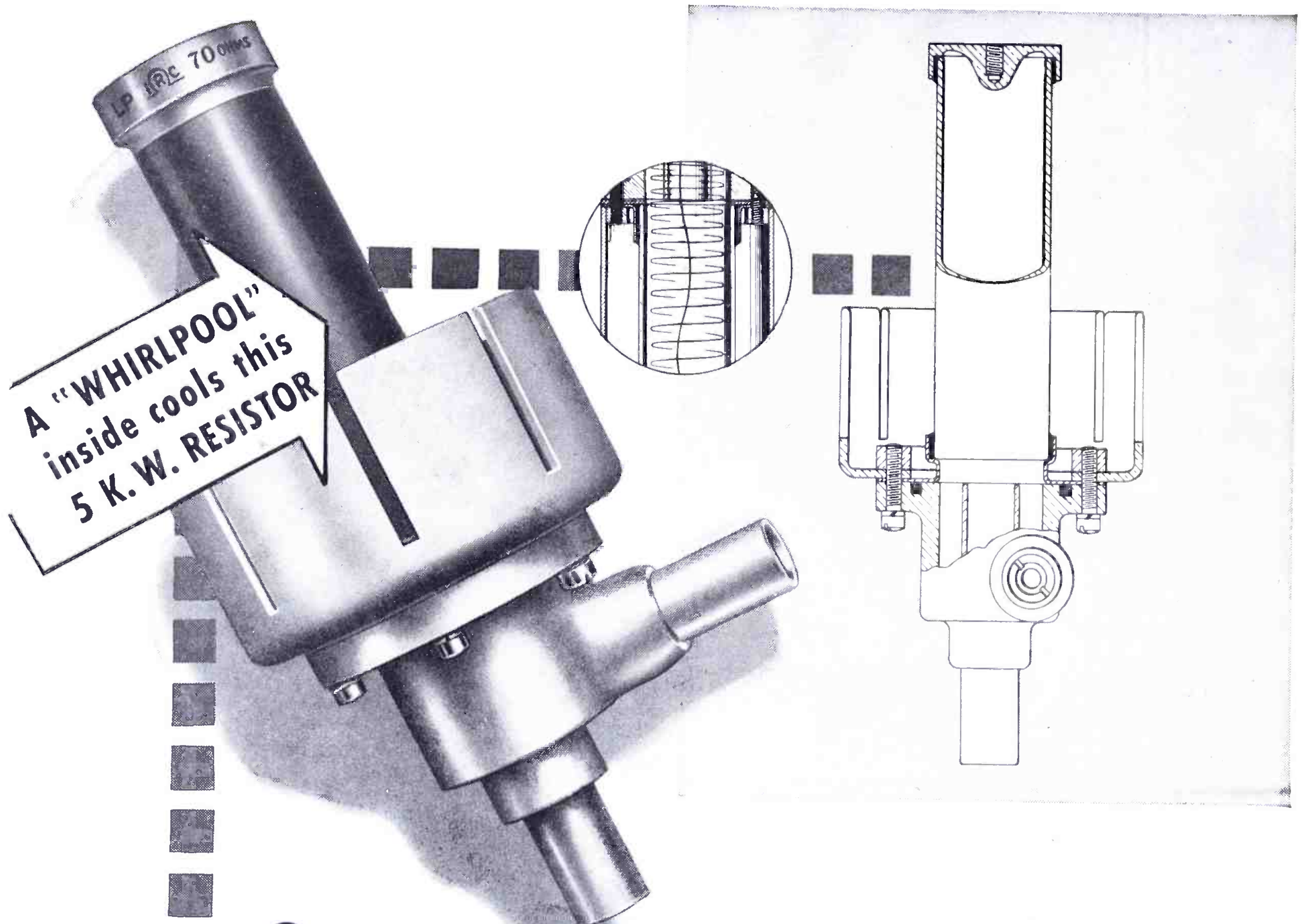
The heart of the A.R.C. Test Set, the 24,000 Mc. wavemeter and attenuator, is available separately, if desired.

For full information on A.R.C. microwave accessories and component parts, write



NOW AVAILABLE: free, illustrated catalog of A.R.C. Radio and Electronic Component Parts and Accessories

AIRCRAFT RADIO CORPORATION



Unique IRC High Frequency-High Power Resistor for Television, FM, and Dielectric Heating Applications

PREFERRED FOR PERFORMANCE · IRC · FIXED & VARIABLE RESISTORS

Inside IRC's new Type LP resistor a high velocity stream of water flows in a spiral path against the *metallized* resistance film and, through centrifugal force, maintains intimate thermal contact with the entire surface. Interchangeable intake nozzles permit adjusting the rate of water flow and therefore the cooling action to suit local water pressure and power dissipation up to 5 K.W.

A resistance film less than 0.001" thick, with an active length considerably less than ¼ wave length at FM and television frequencies, gives good inherent frequency characteristics.

The mechanical design permits direct mounting on the end of a coaxial line with both water intake and outlet connections at R.F. ground potential. Resistor elements are interchangeable. Different values or service replacements can be readily installed in the field.

The IRC Type LP Liquid Cooled High Frequency High Power Unit is the latest in IRC's continuing development of resistors. It is available in resistance values of 35 ohms to 1500 ohms. Resistance tolerance: ±15% standard. Tolerances of ±10% and ±5% can be supplied at increased cost.

SHORT DELIVERY CYCLE

Fittings are now carried in stock. Resistance elements are made to order for range and tolerance.

For specific engineering information contact your IRC Sales Engineer or write Dept. 9-K

INTERNATIONAL RESISTANCE CO.

401 N. BROAD ST., PHILADELPHIA 8, PA.

In Canada: International Resistance Co., Ltd., Toronto, Licensee

FM RAILROAD RADIO

(CONTINUED FROM PAGE 52)

of safety sponsored by the Interstate Commerce Commission. This dual installation precludes any necessity for trainmen to stand between a locomotive and a car to use the radio.

7. The 11,000-volt electrified catenary did not interfere with radio transmission and reception. Moreover, since the stubby firecracker antenna projected less than 1 ft. above the roof of the cab, there was ample clearance with the wires. Accumulation of an electrical charge on the mobile antenna was precluded by reason of the fact that all sections of the antenna were at common DC ground potential, draining off any electro-static charge.

8. In general, the consensus of opinion among railroad and government officials at the tests appeared to be that the radiotelephone system had proved its value as an operational and safety aid in railroad service. Mr. Clark Hungerford, Vice President of the Association of American Railroads, said: "I think it is a well known fact that communications are most essential in railroad operation, and the better the communication the better the operation. . . . I am sure that radio, as it is developed, will play an important part in the future improvement of operations in yards such as this."

WHAT'S NEW THIS MONTH

(CONTINUED FROM PAGE 46)

public property treat that property as he himself said he would."

The Hartford Courant: "Hats off to the FCC."

The Blue Book is not a lone voice crying in the night.

The Blue Book says that American radio is over-commercial. If it is not over-commercial, let's have the facts which prove it. If it is, then take steps to eliminate the excesses. Don't use a sacred constitutional freedom as a shield to ward off charges that your industry is too commercial.

I say that, as applied to the Blue Book, the cry "free speech" is a red herring.

What is the Commission's next move? I take this occasion to deny that the Commission is planning to punish large numbers of wayward broadcasters by forcing them to listen to their own stations two hours every day. This would be clearly unconstitutional, as cruel and unusual punishment. (VIII Amendment)

Of the 322 applications pending for renewal at the time the Blue Book was issued, seven have now been set down for hearing.

These are not the only stations which present problems, but the Commission felt that no useful purpose would be served by wholesale license renewal proceedings. We

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WHAT'S NEW THIS MONTH

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are proceeding slowly and judiciously. We will gather information on this problem as we go along. As announced in the report, we hope that the public and the industry will do their part. We are waiting for you to act. We hope that this Convention will produce constructive measures for the solution of this problem, so that broadcasting will raise its sights and go on to still greater achievements.

AM Licensing Policy ★ My next subject is one which finds my host and me in complete agreement. It is the Commission's AM licensing policy.

When the war ended, there were 936 AM stations. We announced that the wartime freeze on broadcast construction was being lifted, and that we would be back in business at the same old stand beginning October 8, 1945.

A year has passed. Let's see what has happened. We have granted 448 permits for the construction of new AM stations, and we still have 659 more AM applications pending.

The applicants who are waiting for their file numbers to be reached in our application processing lines (and incidentally no one has succeeded in inventing a way for getting his case considered ahead of his turn), and the applicants who are in hearing say that we are moving at a snail's pace.

On the other hand, there are a few broadcasters who joined the lodge prior to October, 1945 who fear that the Commission is introducing competition to their communities with "irrational haste."

To the applicants who say we move too slowly, I answer that in the last 12 months we have done almost 11 years work. In the 11 years between 1924 and October 1945, the Commission licensed 451 new AM stations. And, as I have said, in the 12 months between October 1945 and October 1946, we authorized 448 new stations, only 3 short of equalling the total actions of the preceding 11 years.

Now, my next remarks are addressed to the handful of broadcasters who regard this new competition as unwelcome. They cry for the Commission to preserve the position they have enjoyed as a result of the wartime freeze on the construction of new stations. They ask the Commission to make an economic determination as to the number of stations their communities will support. I don't believe they realize the degree of Federal regulation which they invite. This is what would be involved:

First, the FCC would have to make an estimate of the potential radio advertising revenue in the market. This would, of course, vary depending upon the efficiency of the operators to tap that potential.

So, the second step would be to make an appraisal of the efficiency of the present broadcaster and the new applicant.

Third, the Commission would have to determine what a fair revenue for the existing broadcaster would be. This would be necessary in order to ascertain whether there would be enough left over for a new station.

Fourth, to be certain that all similarly-situated, existing broadcasters are treated alike, we would have to prescribe a uniform system of accounting.

Fifth, this would involve a review of your capital investment, your income account, and your operating expenses, including the salary you pay yourself and your office boy.

In other words, the suggestion is that the Commission concern itself with the details of your business activities even to the point of saying what your income shall be. In fact, like the Indians, you would become wards of the Government.

I don't think the industry wants this. Fortunately, the Communications Act would not permit such regulation. The Act provides for free competition and the wisdom of this system has been demonstrated by 20 years of experience.

I recognize that new competition will bring with it some change. It will bring men with new ideas, new ways of doing business, new ways of programming. To meet this, you will find new and better ways of serving the public. By this process you yourselves advanced American radio when you entered the field. And by this process we shall advance still further.

As new faces appear around these tables, don't assume that they will have to be served from the same pie, and that your slice will be that much smaller. There are vast opportunities for this business which are as yet untapped. Today's pie will not have to feed us tomorrow. As the newcomers take their places beside us, the pie will grow larger.

In this connection, I should like to point out that 52% of the stations granted in the last year have gone to communities which heretofore have had no station. Certainly these will not take the bread out of anyone's mouth. Twenty-two percent went to towns where heretofore there was only one station.

Frequency Modulation ★ My next subject is FM. The Commission has expressly authorized me to say to you again that it is our opinion that FM is the finest aural broadcast system attainable in the present state of the radio art. FM is not coming; it's here! And it is growing fast. Already there are 66 stations in operation and 564 more authorized, counting both construction permits and conditional grants. In addition, there are 307 applications pending. Our long-range plans for FM look forward to the day when every square inch of every state from the Atlantic Ocean west to the middle of the Dakotas, Nebraska, Kansas, Oklahoma and Texas will be covered, night and day, with satisfactory FM signals. Similarly, FM signals will blanket the Pacific Coast states solidly. The area in between these two sections is what is now the poorest-served portion of our Country. FM will serve large parts of it, but cannot reasonably be expected to serve it all. Here our long-range plans look for a revamped AM service to fill in the gaps.

Most AM broadcasters are pulling for FM. And well they should! Many local channel operators will, when they get FM, be able for the first time to sit in their homes in the evening and hear their own stations. Thus, it is not hard to understand why 579 (65%) of the established AM stations licensed prior to Oc-

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tober, 1945, have applied for FM. There are 315 (35%) who have not applied. Of these, 215 are locals, and I urge them to get their applications in just as fast as they can. Of the 100 remaining holdouts, 83 are regionals and 17 are 1A and 1B clear channels, who may be relying on their higher power to shelter them from FM. They may find it won't work that way. I believe they should review their positions.

I have heard it said that some broadcasters are afraid that FM is a booby trap. They say they have been told that if they get an FM station, then the duopoly rule will spring into play and they will be forced to sell their AM. As we see it today, the AM broadcaster who goes into FM will continue to operate his AM station until FM replaces AM in that area.

Today, there is one loud, discordant note in FM: receivers. While the manufacturers have turned out an unprecedented quantity of low-priced AM sets, the FM sets have been coming very slowly except from the production lines of several manufacturers who are solidly behind FM. Some say that the other manufacturers are sabotaging FM. I do not go this far. I am convinced that some manufacturers who believe in FM have been handicapped by production difficulties and inability to get materials. Others have been lethargic and said: "FM can wait. Right now there is a lush market for cheap AM receivers and I'm going to get my share."

I am convinced, however, that the majority of the manufacturers recognize the rôle that FM is destined to play in our broadcast structure, and will do their part. After all, 12 months from now, when we have hundreds of FM stations on the air, there is going to be a tremendous demand for FM receivers. In fact, if a man lives in a town with 3 AM stations and 3 FM stations, do you think he will buy a receiver which can only get half of the stations in town?

In a sentence, the way to get FM moving still faster is for you to get stations on the air, and the public will demand receivers. I know it's hard to convince yourself that you should spend money to put on a program that nobody can hear. But it's even harder to convince the public that it should buy sets when there is nothing to listen to. It's your next move. Give this new superior broadcast service to the people as soon as possible.

Television ★ The Commission also sees a bright and important future for television. We are convinced that the American people want television and that they need television. Television will not be simply a luxury entertainment service. Its educational potential is unlimited. It will be the most powerful communication tool of

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FM, FACSIMILE, TELEVISION

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resents as great an advance in color television as the progress from mechanical to electronic scanning for black-and-white television.

Second, the problem of obsolescence has been answered, since the present low-band, black-and-white receivers, using an upper-band adapter, can be operated by tuning to green-channel color television.

Third, the RCA system can be used for upper-band transmission of both color and black-and-white television. This is not practical with the whirling disc method.

Altogether, the RCA demonstration was very promising and encouraging. However, E. W. Engstrom, in charge of research at the Princeton Laboratories, repeated the RCA prediction made last December that five years will be required to set up a complete color television broadcast system for home reception.

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

Of *FM* and Television, published monthly at Great Barrington, Massachusetts, for October 1, 1946

State of Massachusetts } ss.
County of Berkshire }

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

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

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

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

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

(*Signed*) Milton B. Sleeper, *Owner.*

Sworn to and subscribed before me this Sixteenth day of October, 1946.

[Seal] J. H. Lansing, *Notary Public*
Commission expires January 23, 1953.

TELEVISION HANDBOOK

— *By* —

MADISON CAWEIN

An Announcement of Great Importance

ANYONE who has seen the degree of detail and sharpness now available in television receivers, and who is familiar with the latest developments in cameras, studio equipment, and broadcast transmitters must recognize that television has reached a point from which it will progress steadily as a public service.

From now on, this progress will be determined to a large degree by the rate at which the basic details of television circuits and their functions become common knowledge throughout the radio industry.

This calls for a handbook of basic information, presented without recourse to involved mathematics, and so written and illustrated that it can be understood by anyone in the industry who has a knowledge of elementary electricity and radio circuits.

As far as I know, there is just one man in this Country who has both the understanding of television and the ability to present such a complex subject simply, clearly, and in words of not more than three syllables!

He is Madison Cawein, Director of Research for Farnsworth Television and Radio Corporation. Since early in 1946, we have had under discussion the plans for a series of articles entitled "Television Handbook", to be published in *FM* AND TELEVISION Magazine and, later, in book form.

The complete outline was worked out last summer, and now, with the text and illustrations for the first chapters finished, we can start Madison Cawein's "Television Handbook" in our December issue.

In order to lay the groundwork of the succeeding chapters, the first will be devoted to definitions. Accordingly, if you are not a subscriber already, I urge you to enter your subscription to start with the December issue, since this will be necessary to an understanding of the subsequent installments. We have increased our print order to 10,000 copies, but don't delay. They will go quickly. Be sure you get your copy. — *Milton B. Sleeper*

Starting in the December Issue of

FM AND TELEVISION MAGAZINE

WHAT'S NEW THIS MONTH

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them all. Already 41 television stations have been authorized, and receiver production lines are in motion.

I am not going into detail on television this afternoon because the Commission, on December 9th, will hold a hearing where we hope to obtain a great deal of information. After the hearing, we shall inform the industry and the public of everything we have learned.

Clear Channels ★ The clear channel proceeding, contrary to some reports, is not a dead duck. There will be no further sessions in 1946. The reason is that the Commission and industry engineers are busy making studies looking toward concrete proposals for revamping clear channels so as to get service to the white, unserved areas on the coverage map. I don't know what the engineers will come up with, but I believe that it should be possible to make some changes so as to bring a measure of relief to people without service. I don't know whether the answer will be breakdown of clear channels, reallocation of clear channels, or higher power, but certainly by one means or another, or by a combination of all three, we look forward to substantial improvements.

Don't look for a breakdown of clear channels so as to provide further service to urban areas that are already saturated. The purpose of the proceeding is to get service to people who don't have it.

Also, be assured that if new assignments become available, everyone who is interested in applying will be given an equal chance. The fellow who is sitting on the frequency daytime only, or on an adjacent channel will not have a head start.

And now for some spot announcements on other topics:

540 Kilocycles ★ Many government services will have to be shuffled around and NARBA must be revised before 540 kc. can be added to the broadcast band. Don't expect the final answer for at least another year.

Money Give-Away Programs ★ We are trying to frame rules and regulations which will guide you in determining whether any particular program does or does not violate the lottery prohibition of the Communications Act. If we succeed in getting something on paper that looks pretty good to us, we will issue it as a proposal and hold oral argument.

Transcription Rule ★ Oral argument on a proposed new rule is scheduled November 25. Don't assume that the Commission has made up its mind to adopt the proposed rule. We have advanced it simply so that there will be a concrete proposal

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for discussion at the hearing. The date of the argument has been purposely postponed until after this Convention so that you will have an opportunity to consider the question at this meeting.

Political Broadcasts ★ Thus far in this election year, radio has an excellent record. There have been few complaints of discrimination in the handling of political talks. I urge you to keep it that way. You play a vital rôle in our democratic processes, and it is imperative that you earn and keep the reputation of being scrupulously fair to all sides.

Your responsibility, as we see it, does not stop, however, with treating candidates of all parties on exactly the same basis. You have, in addition, the affirmative responsibility to make your facilties fully available so that the electorate may be thoroughly informed.

I respectfully suggest that, at this Convention, you review the practice which is still prevalent in some quarters of the industry of charging twice as much for a political broadcast as you do for a commercial program. Why should a candidate pay twice as much for his time as Evan Lewellyn Evans does for the Beautee Soap program?

Conclusion ★ That, I believe, brings you pretty well up to date. I have told you all our secrets. I hope you sleep well tonight.

It is not enough, however, for me to tell you all of our problems; we must know your problems. To help make this possible, Judge Miller has suggested that I should have luncheon at your expense, not just once each year at an NAB convention, but once a month. I have accepted, and I am looking forward to these regular luncheons with him where we will discuss each other's problems.

At the time of your last convention, in 1944, the world was in the flames of war. American radio certainly did its part to speed the day of victory.

Now, at the time of this Convention, we are at one of the most critical turning points in human history. Problems of baffling complexity beset the road to permanent peace, recovery, and progress. To fail in conquering these problems means chaos. No force in our society has a greater opportunity or a greater responsibility in this struggle than you broadcasters. No one else can arm the people with facts so fully or so quickly on all phases of these issues. No one else can inspire the people so effectively to exert their highest intelligence and their noblest impulses as responsible citizens in a free democracy.

The Commission pledges you every cooperation in enabling American radio to meet the challenge.

30 ~~60~~ DAY DELIVERY

Unit 524 Transcription Turntable

Fairchild is now in a position to accept additional orders for the NEW Unit 524 Transcription Turntable on a 30-day delivery basis.

Here again, Fairchild has anticipated the needs of FM with the Unit 524 Transcription Turntable. It's completely new. It offers 'WOW'-free performance without turntable noise, rumble or vibration for either FM or AM recorded broadcasts; for dubbing from disc to disc, or to film; and for laboratory uses where extraneous noise and distortion cannot be tolerated. It has been engineered for wide dynamic range, minimum distortion content and wide frequency range—*to keep the record alive!*

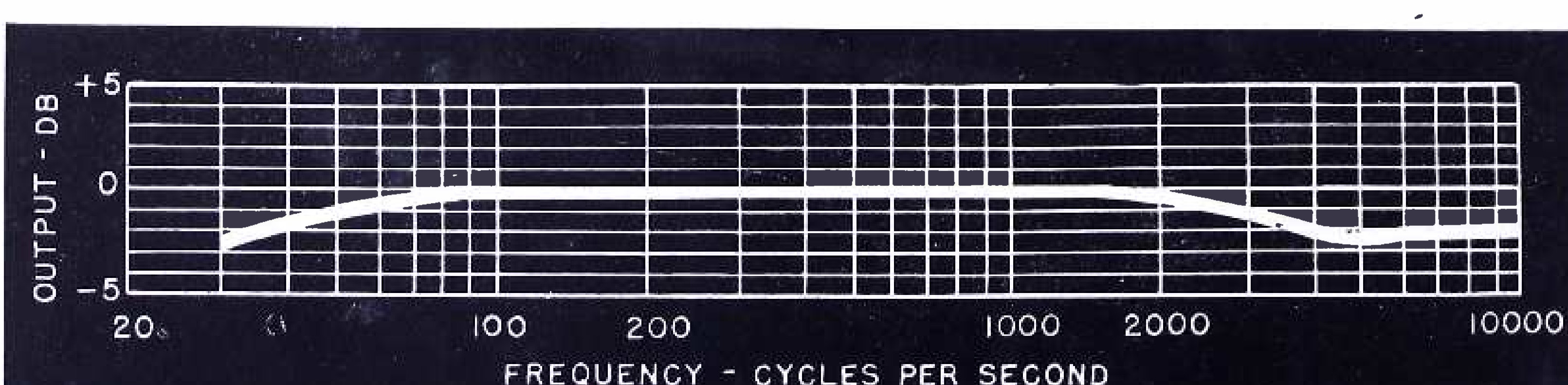
The drive and turntable have been newly designed for cabinet installation. They are *not* portable units set in a console. A vibration-proof rubber coupling connects the synchronous motor and drive which are spring mounted and precision aligned in a single heavy casting — *at the bottom of the cabinet* — as shown in the illustration above.

'WOW'-free operation is assured at either 33.3 or 78 rpm by a carefully maintained evenness of speed. Split-second timing is guaranteed by the positive Fairchild direct-from-the-center turntable drive. 30 to 10,000 cycle frequency response is provided by Fairchild's patented 25 gram 'floating' pressure Lateral Dynamic Pickup—*as shown below in the typical production line frequency-response curve!*

For complete information address: 88-06 Van Wyck Blvd., Jamaica 1, N. Y.

SOUND EQUIPMENT

Fairchild CAMERA AND INSTRUMENT CORPORATION



HIGHBALLING THRU with Radio Teamwork

UP Adopts Motorola 2-Way Radiotelephone

Pioneering a movement expected to contribute greatly to the efficiency of railway operation procedure, Union Pacific Railroad has recently equipped many of its engines, cabooses, and yardmaster stations with Motorola 152-162 mc. 2-way F-M radiotelephones. Usage of the 2-way interference-free radiotelephone system is proving a decided boon to UP, enabling yardmaster, conductor, and engineer to function as a coordinated team. Communications from yardmaster to engineer, engineer to caboose, or between trains is possible with virtually no delay and noticeably devoid of weather- or terrain-induced static.

Welcome to

Motorola EXHIBIT

Communications Section
Association of American Railroads
HOTEL STATLER • DETROIT
NOVEMBER 19 to 21

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with **Motorola**
152-162 MC. 2-WAY F-M RADIOTELEPHONE

Instant contact among yardmaster, conductor, and engineer means less running time, far greater safety, more efficient traffic control. Only MOTOROLA 152-162 mc. 2-way F-M radiotelephone communication offers:

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2. FAMOUS RESERVE GAIN FEATURE
3. RADAR TYPE CIRCUITS

MOTOROLA radios already in use on railroads have proved their efficiency. Police of 34 states and over 2500 communities depend on MOTOROLA for unfailing service. The battle-tough MOTOROLA "Handie Talkie" and "Walkie Talkie" demonstrate the ruggedness and dependability of MOTOROLA products. MOTOROLA engineers *know* mobile communications, and their vast experience in the field will enable them to make specific recommendations concerning your communications problem. Write today, without obligation of course.

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