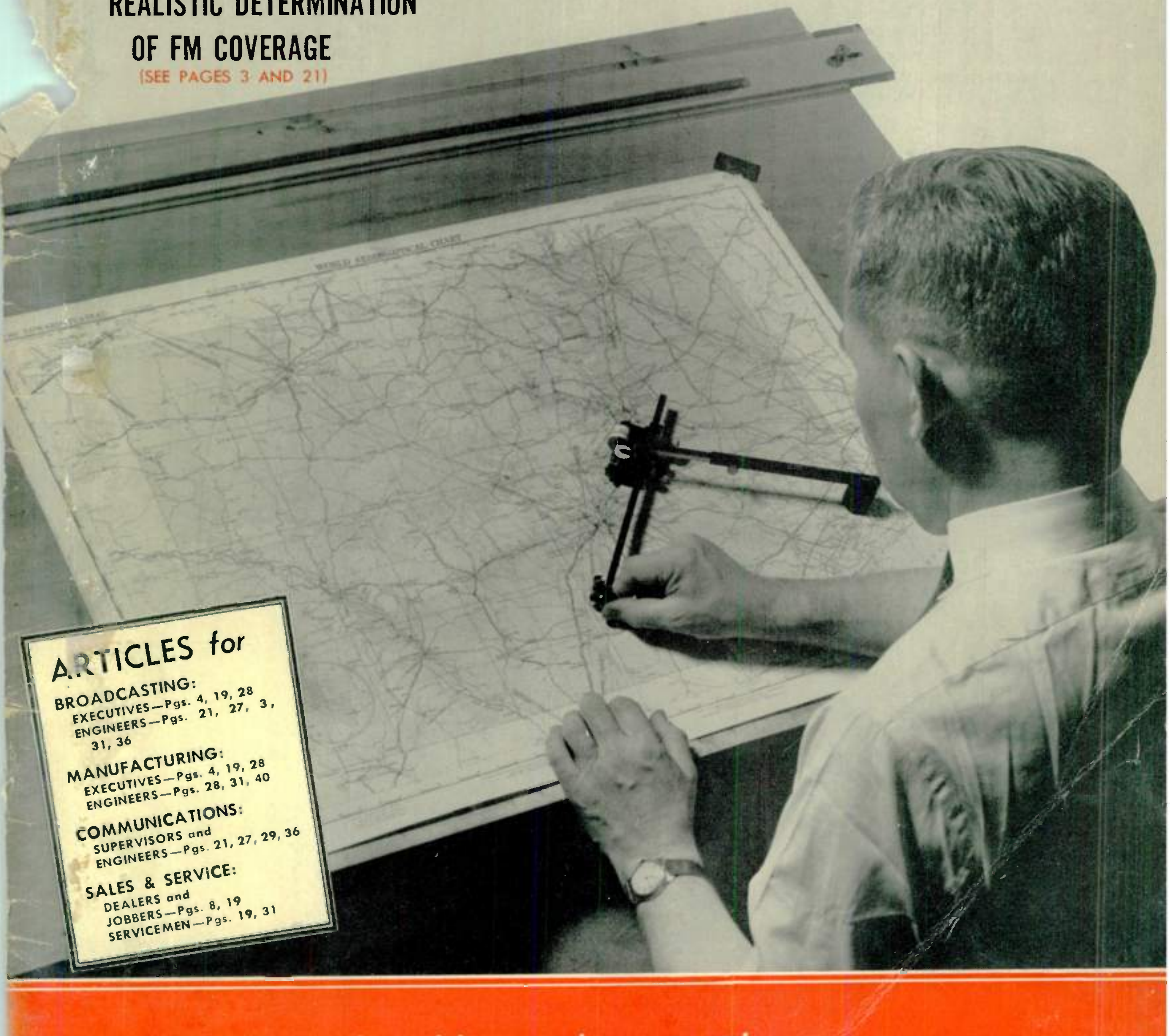
PRICE FIFTY CENTS

FM AND TELEVISION

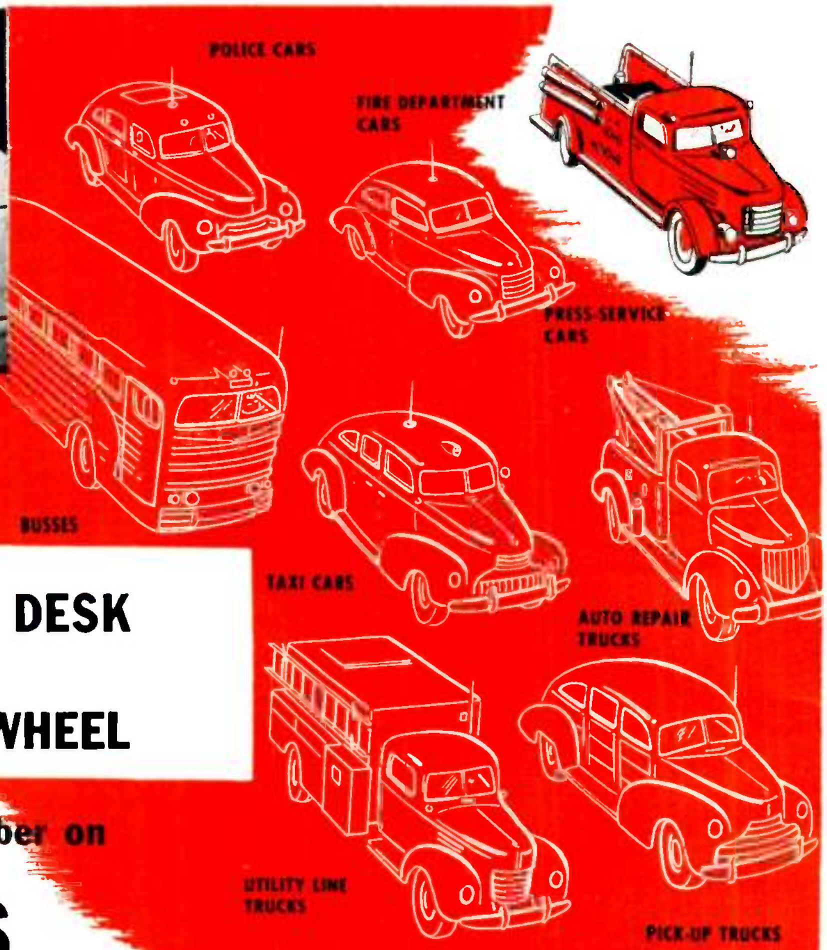
APRIL 1947

REALISTIC DETERMINATION OF FM COVERAGE

(SEE PAGES 3 AND 21)



★ ★ Edited by Milton B. Sleeper ★ ★



NOW

THE MAN BEHIND THE DESK
can keep in touch with
THE MAN BEHIND THE WHEEL

simply by calling his number on

FEDERAL's

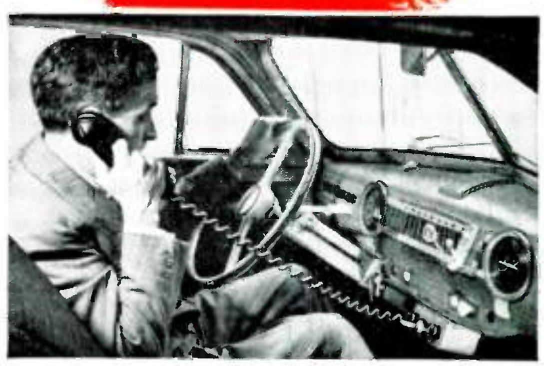
MOBILE 2-WAY FM RADIO TELEPHONE

YES — it's as easy as that! The car you want to contact may be miles away — buried in a maze of traffic. Yet the driver of that car is no further than your radiotelephone transmitter. It gives you instantaneous contact with *any* or *all* cars in the fleet.

You'll find that radiotelephone contact with your cars while they're on the job will get faster action — cut down unnecessary mileage — increase your operating efficiency. A mobile radiotelephone is an *investment* in your business. And to get the greatest return, you want the finest equipment available — with minimum operating expense and maintenance. Check these outstanding Federal features, and you'll see why —

FEDERAL IS YOUR BEST BUY IN MOBILE RADIO!

- **Effective Squelch Action** — receiver muted until called
- **Two-way Operation** — with one antenna
- **Low Current Drain** — receiver standby, 6.0 amp.
  transmitter standby, 30 to 44 Mc 2.1 amps
  152 to 162 Mc 0.415 amps
- **Small Size** — approx. 9⅝ x 12 x 13½ in.
- **Interchangeable Units** — for fast servicing
- **Low Maintenance Expense** — high quality components throughout
- **Single Cable** from dash-board control to transmitter-receiver unit
- **Selective Calling** available in all models



Federal Telephone and Radio Corporation

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

AN IT&T ASSOCIATE — FEDERAL TELEPHONE & RADIO FTR

100 Kingsland Road,
Clifton, New Jersey

READY NOW

IN ANSWER TO HAMS' DEMANDS

EST. 1914

Hams around the world have been National's collaborators in creating the NC-173—ready now after five years of intensive research. Here are some of the advantages this 13-tube superheterodyne receiver offers:

- The NC-173's newly designed adjustable threshold double diode noise limiter—working on *both phone and* CW—has an extremely high limiting efficiency because of the short recovery time.

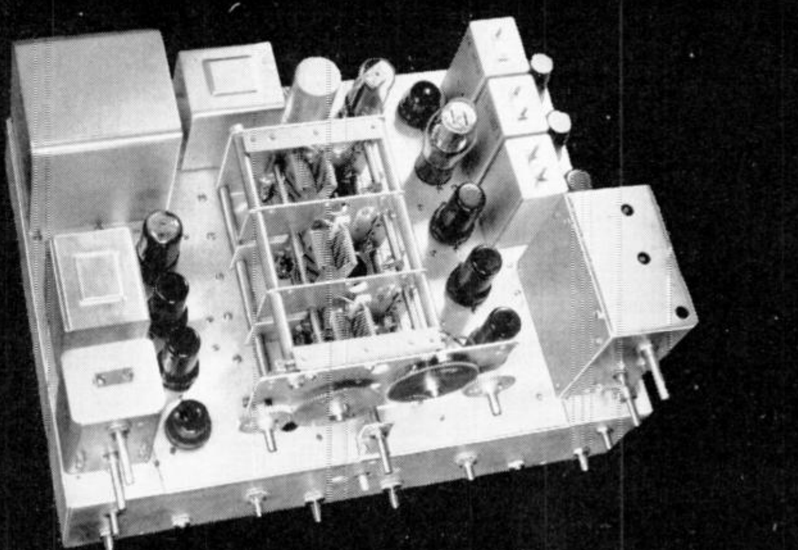
- Voltage regulated circuits give the NC-173 high stability and less drift for changes in powerline voltage. The pitch of code characters barely changes — even over extended listening periods.

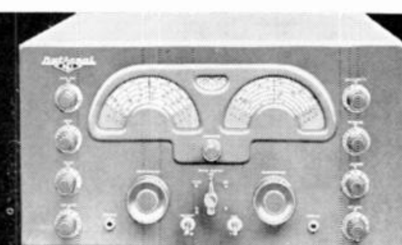
- The S-meter circuit allows signal strength recordings to be taken on either *phone or code*.

- Works equally well on coaxial feed-line, single-wire, directional or balanced antenna.

- AC powered. Will also operate on battery for portable or emergency use —110/120 or 220/240 volts, 50/60 cycle. Frequency range .54 to 31 and 48 to 56 MC. (Includes calibrated band spread on 5, 10, 11, 20, 40 and 80 meters).

- Ask your dealer to let you see and hear the new moderate-priced NC-173.





THE NATIONAL NC-173

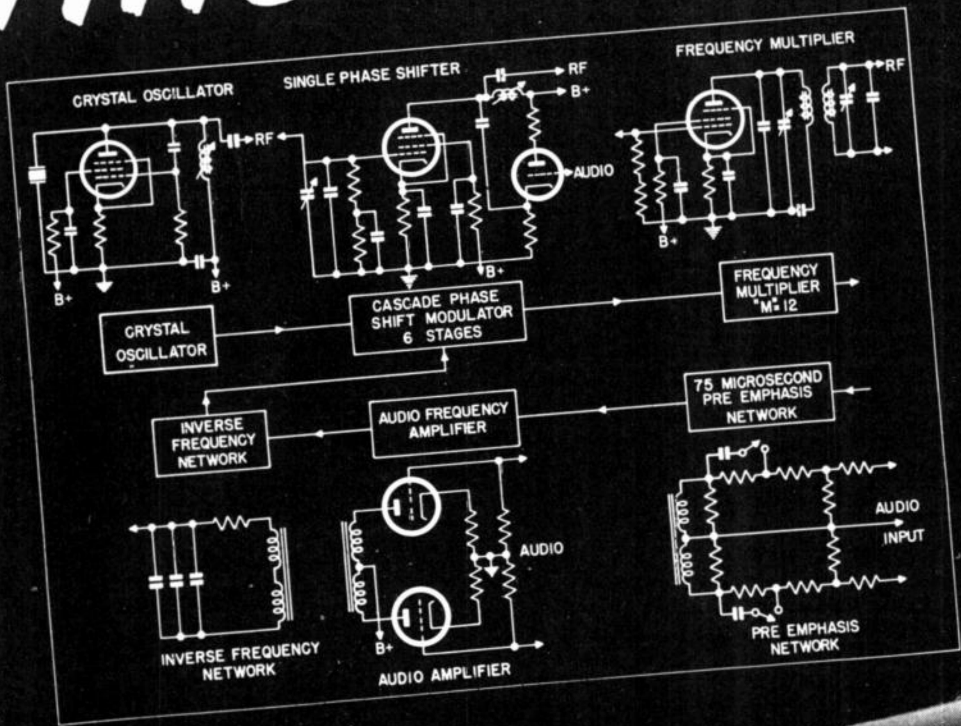
NATIONAL

COMPANY, INCORPORATED

MALDEN, MASS.

THE MOST DISTINCTIVE NAME IN RADIO COMMUNICATIONS

THIS PROVES IT!



Cascade
PHASE SHIFT MODULATION

RAYTHEON FM

IS BETTER...

12 Ways

BECAUSE IT:

1. Features direct crystal control
2. Gives the most desirable electrical characteristics
3. Contains fewest circuits, fewest tubes
4. Has the simplest circuits
5. Is easiest to tune and maintain
6. Has *inherently* the lowest distortion level

AND ELIMINATES ALL:

7. High orders of multiplication
8. Complex circuits
9. Expensive special purpose tubes
10. Discriminator frequency control circuits
11. Pulse counting circuits for frequency control
12. Motor frequency stabilizing devices

See your consulting engineer and write for fully illustrated booklet giving complete technical data and information. Write today to:

RAYTHEON

Excellence in Electronics

RAYTHEON MANUFACTURING COMPANY

Broadcast Equipment Division, 7545 North Rogers Avenue, Chicago 26, Illinois

FM AND TELEVISION

FORMERLY, FM MAGAZINE and FM RADIO-ELECTRONICS

VOL. 7 | APRIL, 1947 | NO. 4

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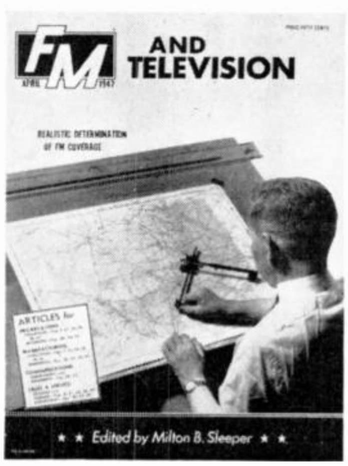

Experience has already demonstrated that mathematical theory alone is inadequate as a means of predicting FM broadcast station coverage. Therein lies the unrealistic element of the method now employed by the FCC. The basic errors are introduced as a result of assuming standard conditions of terrain and atmosphere which are as rarely encountered in nature as straight lines and unchanging skies.

It is easy to determine coverage area from a contour drawn on a map, as this month's cover shows. This involves only the use of a Dietzgen planimeter. The problem has been to find a realistic method of estimating the contour. In this issue is the first part of a paper by Paul de Mars, one of the leading authorities on wave propagation, and Thomas Wright, in which they approach this problem on the basis of practical, physical concepts.

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MEMBER, AUDIT BUREAU OF CIRCULATIONS
ABC

WHAT'S NEW THIS MONTH

Tele-Color Decision

The following paragraphs, taken from the FCC report denying the CBS petition to adopt the simultaneous television color system as standard, summarize the unanimous views of the Commission:

"No transmitter has yet been built which will operate in the upper part of the 480 to 920 mc. band. Receiving antennas of fairly complex design have been built and tried out to some degree; apparently, the standard form of antenna will not be adequate for good reception in this band. Additional tests of the antennas should therefore be made.

"So far as studio and pickup equipment is concerned, Columbia stated that it has built an image orthicon camera and has pointed it out the window for outdoor pickups. It should be noted that no attempt was made to demonstrate this equipment at the hearing. Moreover, Columbia admitted that it has not used this equipment to televise sporting events or any outdoor special events.

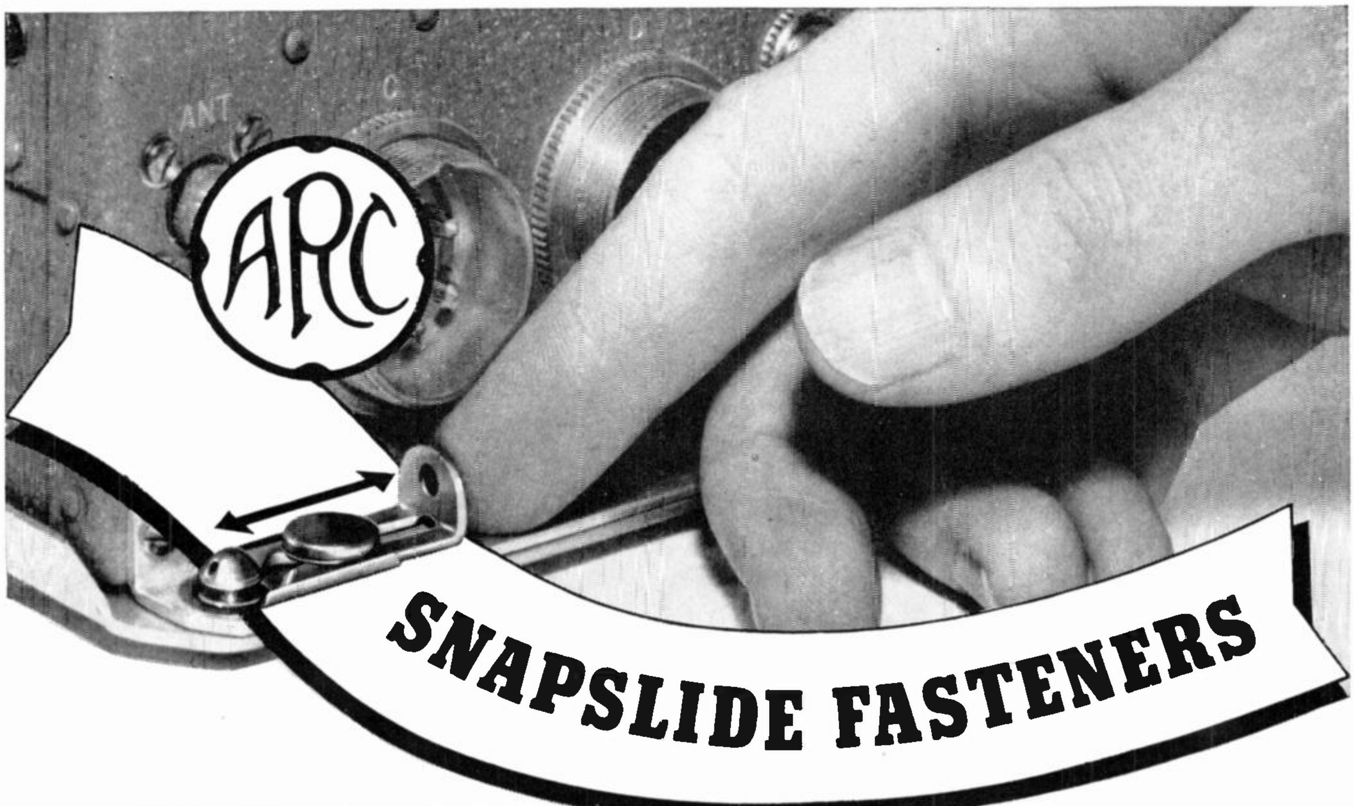
"In addition to the question of field testing, the Commission is of the view that further experimentation is necessary in the color television field. From a consideration of the Columbia petition and the evidence adduced at the hearing it is evident that the Columbia system is in effect the present monochrome television system with color added. While the present system affords an adequate black-and-white service to the public, the fact remains that it was developed and standardized before the extensive developments in electronics which took place during the war.

"It is quite possible that as a result of wartime discoveries, improvements can be made, for example, in picture detail, picture sharpness, a simpler and more-effective synchronization system, a better sound system, etc. Furthermore, wartime developments may show that there is an entirely different method from either the sequential or simultaneous system which is superior to both. Before standardizing television in the upper band, we should be sure that all of the wartime developments have been explored to determine whether they can be applied to the advantage of television.

"Two specific problems, in the Commission's opinion, should be carefully examined. In the first place, there should be further experimentation looking to-

(CONCLUDED ON PAGE 50)

ADVERTISERS INDEX



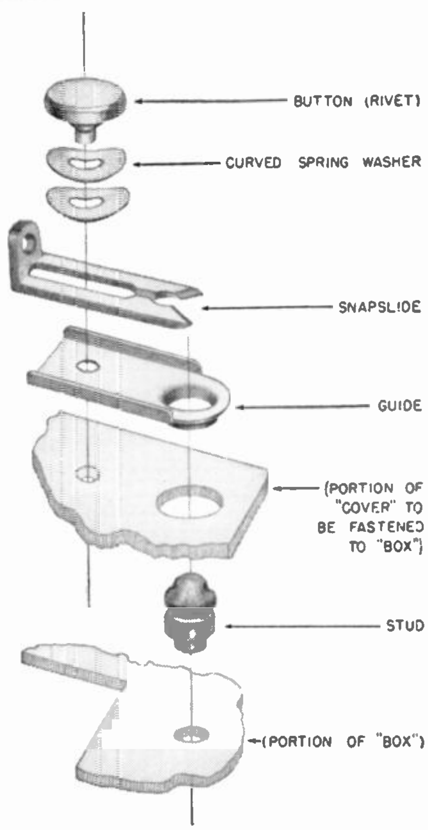
QUICK, EASY, ENTIRELY VISIBLE, NO TOOLS NEEDED

These Snapslide Fasteners were originated by A. R. C. to provide positive means of attachment and yet to allow instant disengagement. Note how the two spring jaws of the Snapslide lock around the Stud and insure complete security. Both large and small Snapslide Fasteners are available, with Buttons and Studs for various applications and different thicknesses of material.

VARIETY OF USES

Large Snapslides, approximately $\frac{7}{16}$" wide by 1" long, are suitable for attaching radio sets or such units as dynamotors, converters, etc. to shock absorbers or directly to mounting plates.

Small Snapslides, approximately $\frac{1}{4}$" wide by $\frac{19}{32}$" long, are used to hold down tube covers, fuse covers, and similar light-weight parts.



Aircraft Radio Corporation

Boonton, N. J.

Designers and Manufacturers of Radio and Electronic Equipment Since 1928

ENGINEERING SALES

Bendix: New England district manager Horace H. Silliman has been appointed manager of distribution for Bendix radio and television.

Stromberg-Carlson: Is starting a series of radio service clinics to be held in Boston, Philadelphia, Atlanta, Dallas, Los Angeles, San Francisco, Seattle, Chicago, Detroit, and Columbus. Leo Granger, service department manager, is in charge.

RCA: Will handle the export sales of Boonton Radio instruments. Arrangement with RCA International Division covers all territory outside the U.S.A.

New York City: Terminal Radio Corporation, 85 Cortlandt Street, has been appointed distributor for Pickering pickups and Brook amplifiers.

Cornish: W. F. Jessup has joined Cornish Wire Company as sales manager of the cord division.

Centralab: New representative for the 6 New England states is Stanley A. Harris Company, 126 State Street, Boston. Associated with Stanley Harris are Robert S. MacArthur and Richard I. Allen.

Sola: A New York sales office has been opened by Sola Electric Company, manufacturers of constant-voltage transformers, at 50 Church Street.

U.S.T.: Lance C. Ballou, Jr., has been appointed promotion manager for United States Television.

Merit: Newly-appointed representatives of Merit Coil & Transformer Corporation are C. E. Anderson, Rockefeller Bldg., Cleveland 13; Marty Camber, 30 Dongan Place, New York City; R. W. Farris Company, 406 W. 34 Street, Kansas City 2, Mo.; Nickerson & Rudat, 383 Brannan Street, San Francisco; and Dale G. Weber, 7026 S. W. Capitol Highway, Portland 1, Ore. Export division has been set up at 1607 Howard Street, Chicago 26, with Dan M. Ortiz in charge.

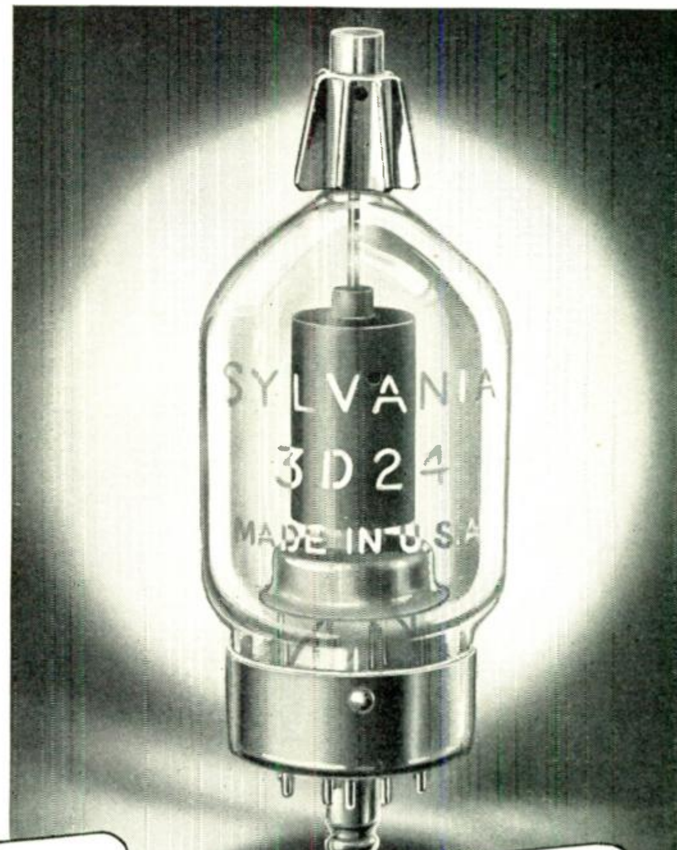
Manila: Bolinas Electronics Corporation of Manila, handling radio sales, service, and engineering in the Philippines, has opened a New York City office at 50 Broadway.

General Electronics: Has appointed Willgold Electronic Sales Corporation as representative in the New York area.

NOW you can get Sylvania quality in transmitting tubes too!

SYLVANIA INTRODUCES THE TYPE 3D24

BEAM POWER TETRODE WITH ELECTRONIC GRAPHITE ANODE



First of Sylvania's new line of transmitting tubes, the 3D24 is a four-electrode amplifier and oscillator with 45 watt anode dissipation. An outstanding development is the electronic graphite anode, which allows high plate dissipation for small area and maintains constant inter-element relationship and uniform anode characteristics.

The 3D24 may be used at full input up to 125 Mc — maximum permissible frequency will be announced later upon completion of tests.

OTHER FEATURES INCLUDE:

1. **Lock-In base.** Short leads, no soldered joints.
2. **Top cap** providing for short path, greater cooling by radiation and convection, resulting in a cooler seal.
3. **Thoriated tungsten filament,** giving high power output per watt of filament power.
4. **Vertical bar grids.** #1 grid supplied with two leads for better high frequency performance. #2 grid provided with heat-reflecting shield for greater dissipation, low grid-plate capacity.
5. **Low interelectrode capacity.** No neutralizing needed with proper circuit arrangement.
6. **Hard glass envelope.** Permits high power for small size.

The 3D24, a product of the Electronics Division of Sylvania, has interesting potentialities in amateur, police, mobile and marine radio.

MECHANICAL SPECIFICATIONS

Type of cooling ....Air—radiation and convection
Mounting position ....Vertical, base down or up
Length overall ....4.3 inches max.
Seated height ....3.769 inches
Diameter ....1½ inches
Net weight ....1.3 ounces

ELECTRICAL CHARACTERISTICS

Filament Voltage ....6.3 volts
Filament Current ....3.0 amperes
Amplification Factor 50
Direct Interelectrode Capacitances
Grid-Plate ....0.2 $\mu\mu f$ max.
Input ....6.5 $\mu\mu f$
Output ....2.4 $\mu\mu f$

3D24 TYPICAL OPERATING CONDITIONS

R. F. Power Amplifier and Oscillator—Class C Telegraphy

Characteristic	C.C.S.	C.C.S.
D. C. Plate Voltage	1500 volts	2000 volts
D. C. Control Grid Voltage	–300 volts	–300 volts
D. C. Screen Grid Voltage	375 volts	375 volts
D. C. Plate Current	90 ma	90 ma
D. C. Control Grid Current	10 ma	10 ma
D. C. Screen Grid Current	22 ma	20 ma
Peak R. F. Grid Input Voltage	400 volts approx.	400 volts approx.
Full Driving Power	4.0 watts approx.	4.0 watts approx.
Plate Power Output	105 watts	140 watts

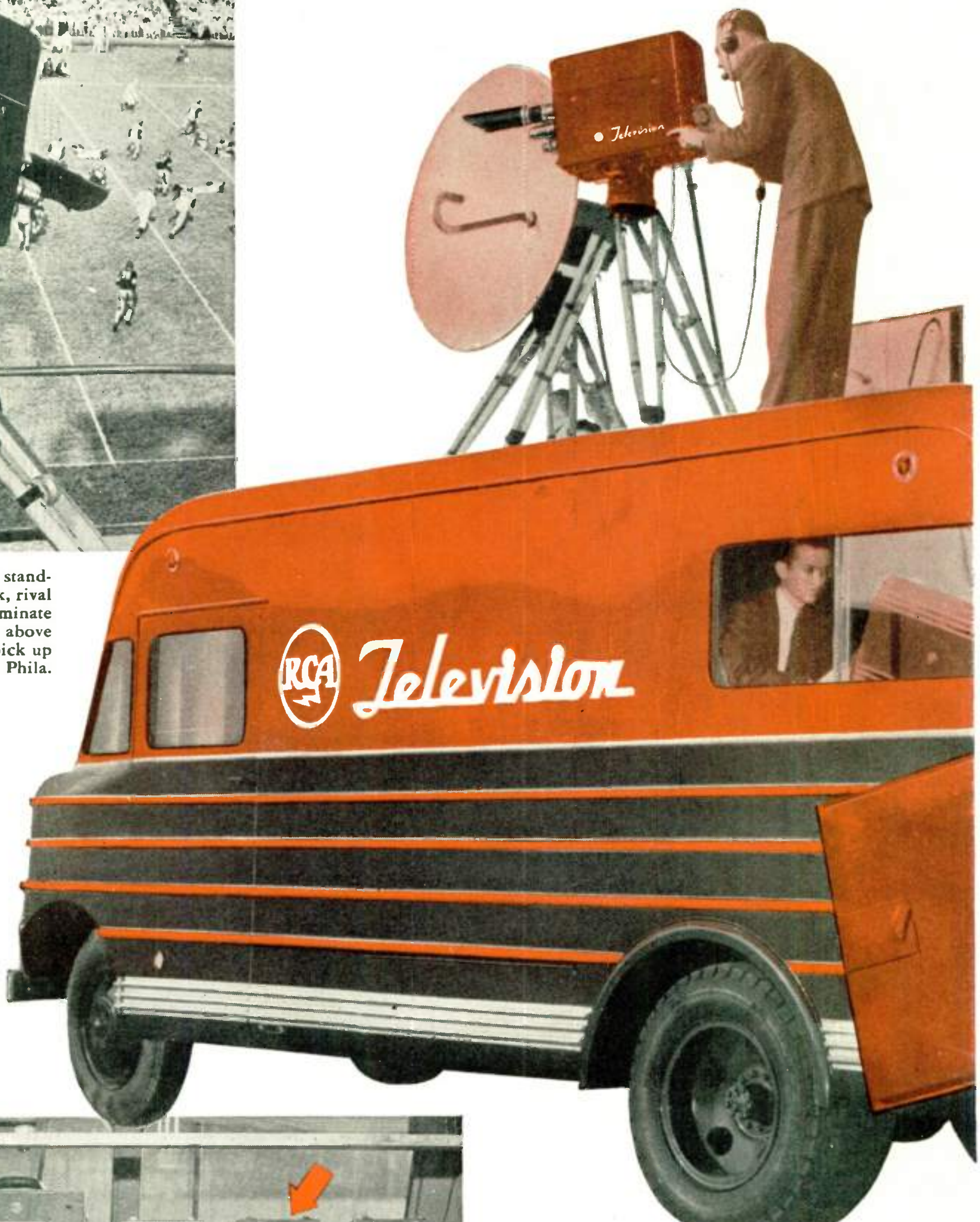
Direct inquiries to Radio Tube Division, Emporium, Pa.

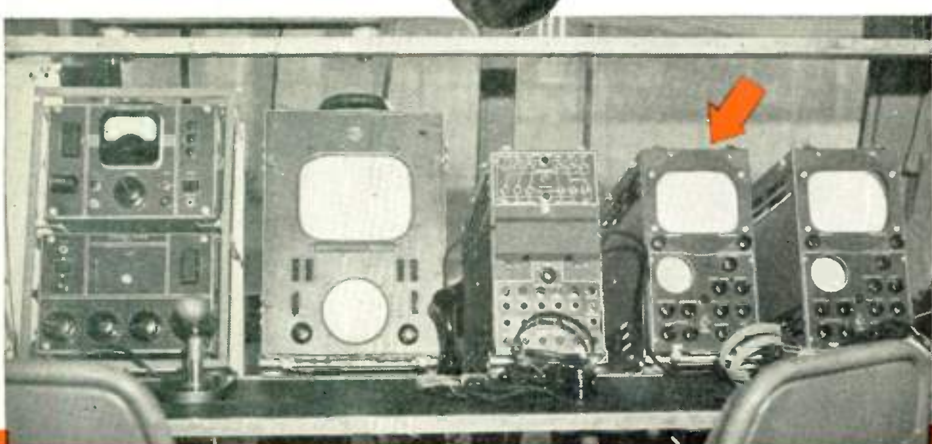
SYLVANIA ELECTRIC

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

New mobile studio

RCA image-orthicon cameras, standard equipment for the new truck, rival the human eye in sensitivity—eliminate fading of sports events. Shown above as used by Philco's WPTZ to pick up a Penn game at Franklin Field, Phila.





REMOVABLE, SUITCASE-TYPE CONTROLS SPEED SPECIAL SETUPS

Where advantageous, all necessary equipment can be easily removed from the truck, carried to program areas, and quickly set up by means of plug-in type connectors.

simplifies *at-the-scene* telecasting

Opens up a wealth of diversified, low-cost program material

Here, in one compact unit, is a complete television "studio on wheels." With it you can move rapidly to the places where local events are taking place and, with minimum effort, pick up and relay the action to your station. Picture quality is comparable to that obtained with studio equipment.

The truck body, designed by RCA engineers to provide maximum convenience and space to operators, is mounted on a standard 1½-ton Chevrolet chassis. It carries everything you need to operate a three-camera chain.

The control desk is at the back of the truck, flanked on three sides with large full-vision windows. These can be darkened by means of draw curtains when desirable.

Monitors, camera controls, a switching unit, and an audio amplifier and mixer are conveniently mounted on an inclined support at the back of the desk; pulse formers, shapers, and power supplies are installed underneath. All units are of the removable, suitcase type.

Shock-mounted lockers provide ample storage space for cameras, tripods, microwave relay, and other gear.

The roof of the truck has been strongly reinforced for use as an operating platform, when needed. Access is via a removable ladder inside the truck and a roof hatch. However, for remote pick-ups the cameras can be operated as far as 500 feet from the vehicle, if desired. Four cable reels, mounted on swinging arms in the rear truck compartment, permit easy unwinding and storage of camera cable. Each has a 200-foot capacity.

Here, we believe, is a real opportunity for diversified programming—a quick, convenient method of making remote pick-ups. It will pay you to include such a unit in your television plans. Write Dept. 35-D.

TELEVISION BROADCAST EQUIPMENT

RADIO CORPORATION of AMERICA

ENGINEERING PRODUCTS DEPARTMENT, CAMDEN, N.J.

In Canada: RCA VICTOR Company Limited, Montreal

View at left shows suitcase-type units as installed at rear of truck. View at right shows how equipment is set up by WMAL, Washington, D. C., for an indoor pick-up.

is FM a FRAUD?

People are talking about FM.

They are speaking in words that are new to their vocabularies and concepts that are beyond their past experiences: staticless reception, wide range reproduction, living tone and true high fidelity.

What's more, they have bent their ears to advertisements of broadcasters and set manufacturers.

When they open their pocketbooks for FM receivers in expectation of new wonders...what will they get?

That is a question for you to answer if FM is your future. Are you selling these people a handful of stars — or can you say, in sincerity, that they will enjoy all the benefits of FM?

For that to be true, the speaker system in an FM set must be capable of reproducing the full FM range — 50 to 15,000 c.p.s. without distortion. <u>And for such reproduction, you'll need a speaker of Duplex caliber. There is only one: The Altec Lansing.</u>

MODEL 604 DUPLEX
THE TRUE FM SPEAKER
REPRODUCES 50 TO 15,000 C. P. S.
SEND FOR TECHNICAL DATA

ALTEC
LANSING CORPORATION
1161 N. VINE ST., HOLLYWOOD 38, CAL.
250 W. 57th ST., NEW YORK 19, N. Y.

ALTEC LANSING MAKES
THE VOICE OF THE THEATRE
LOUDSPEAKER SYSTEMS USED
IN LEADING THEATRES

"KEEP ADVANCING WITH ALTEC LANSING"

FAC'S about FACSIMILE

..ALDEN FACSIMILE

The OUTSTANDING FACT about ALDEN FACSIMILE Equipment is its basic simplicity — no multiplicity of intricate gadgets or "involved" designing. It is simple to the "n-th" degree, for anything so technical . . . strong . . . serviceable . . . wear-resisting.

★

EASE OF OPERATION is another feature kept always in mind. For instance, in the CHAIRSIDE RECORDER (shown below) . . . the recorder is concealed in an attractive side-table or cabinet, when not in use. To operate you have only to press a button . . . the recorder jumps into position automatically, with only the top showing above the level of the table . . . and, it is ready to use! It's as easy as that!

★

TO LOAD WITH NEW PAPER, you have only to press a button on the recorder . . . the top springs open . . . a spindle protrudes, upon which you may slip the new paper cone without further adjustment.

★

What we have said above referred specifically to the 4" recorder, but, this same basic EASE OF OPERATION is true of ALL MODELS.

★

The only part of the recorder which wears perceptibly is the recorder plate. Whenever this plate becomes worn it can be removed and a new one *inserted so readily* that it could be done by the sense of feel alone, if necessary.

★

EVERY ELEMENT IN THE RECORDER IS MADE AS A UNIT . . . helix . . . gear mechanism . . . paper feed . . . motor . . . etc. . . . and each is so elementary and understandable as to not require the services of a trained mechanic to make replacements.

★

Present Alden models are all PROTOTYPE EQUIPMENT . . . i.e., intended primarily for test and experimental use. But, so carefully had it been thought through and planned — as to design and useability — that VOLUME PRODUCTION CAN START WITH A MINIMUM OF ADAPTATION.

★

THE GENERAL UTILITY RECORDER

1001 Practical Uses for The Alden Facsimile Recorder

HOME
AIRPLANE CONTROL
FREIGHT DESPATCH
POLICE DEPT.
FIRE DEPARTMENT
UTILITY REPAIR CREWS
INTER-OFFICE COMMUNICATION
NEWSPAPER BULLETINS
EMERGENCY NEWSPAPER
R. R. TICKET RESERVATIONS
TAXI SERVICE STATIONS
HOTEL ROOM BULLETINS

★

INDIVIDUAL ADAPTATION TO FILL NEEDS TOO NUMEROUS TO MENTION

★ ★

IF YOU ARE NOT ALREADY ON OUR MAILING LIST, SEND *Your Name and Address* TO RECEIVE OUR COMPLETE "Facsimile File", about to be issued.

NOTE THE CONVENIENCE AND DOWNRIGHT COMFORT OF THE ALDEN CHAIRSIDE RECORDER

ALDEN Products Company

117 North Main Street

BROCKTON 64FM, MASSACHUSETTS

A PLEDGE TO FM STATIONS

BROWNING UNIVERSAL TUNERS ARE DESIGNED TO GIVE YOUR LISTENERS THE FULLEST ENJOYMENT OF YOUR FM PROGRAMS, AND THE MAXIMUM BENEFITS AFFORDED BY FM BROADCASTING

DISTRIBUTION of BROWNING FM-AM Tuners is being concentrated in areas where there is active promotion of FM broadcasting. If dealers capable of handling high-fidelity FM receivers in your area are not being supplied with adequate allotments of BROWNING Tuners, please advise us, giving their names and addresses.

Even though our increased production has not reduced our backlog of orders, our distribution is expanding steadily, and we shall be glad to cooperate with you in your efforts to build your FM audience.

We suggest that you follow the practice of recommending BROWNING FM-AM Tuner installations with high-fidelity amplifiers and speakers wherever you are particularly anxious to have your station heard to best advantage, or where conditions call for extreme sensitivity and noise-limiting action.

For details on the BROWNING Tuner, or special engineering information, address:

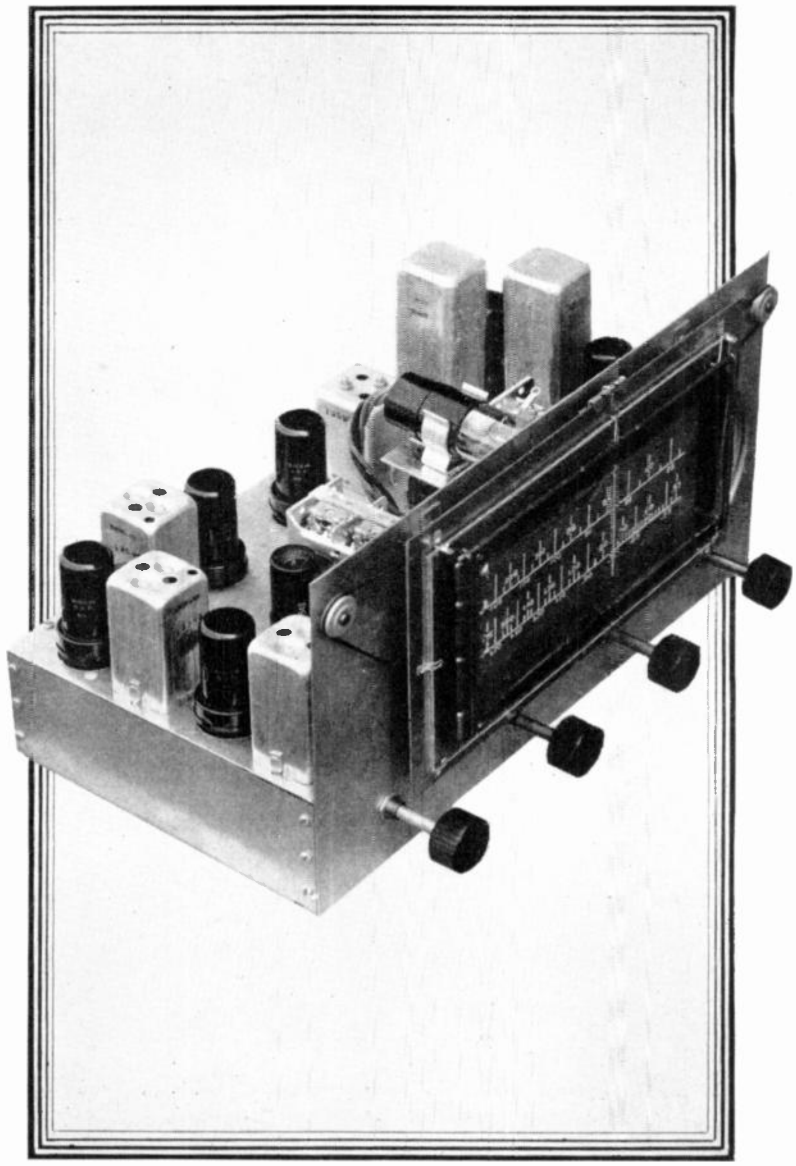
BROWNING LABORATORIES, INC.

Engineers and Manufacturers

WINCHESTER • MASSACHUSETTS

Canadian Representatives

Measurements Engineering • 61 Duke Street, Toronto



UNIVERSAL TUNER, MODEL RJ-12 .... $143.90
RACK PANEL TUNER, MODEL RJ-14 .... $165.60
POWER SUPPLY UNIT, MODEL PF-12 .... $ 15.78

(Prices include Federal tax)

INFORMATION ON THE RJ-12 TUNER

The BROWNING Tuner covers 88 to 108 mc. on FM, and 535 to 1650 kc. on AM. It is intended to feed any type of high-fidelity amplifier and loudspeaker, according to the user's requirements.

Thus, the BROWNING Tuner provides sufficient flexibility to meet the needs of every type of installation, and at less than half the cost of a cabinet model of equivalent performance, but of less adaptable design.

This is as true for simple home installations as for schools and public buildings where phonograph turntables and sound equipment are required in conjunction with FM and AM radio reception.

Remember: When you use a BROWNING Tuner, you can give free rein to your ingenuity in planning an installation as simple and inexpensive or as elaborate as you choose. In either case, you are assured of the fine radio performance represented by the BROWNING name for nearly a quarter of a century.

Complete data on the BROWNING FM-AM Tuner and Power Supply will be sent upon request.

Professional Service Directory

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AN ORGANIZATION OF
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DEDICATED TO THE
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Decatur 1234

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Consultation and planning service based on practical experience with AM, FM, Facsimile and Television.
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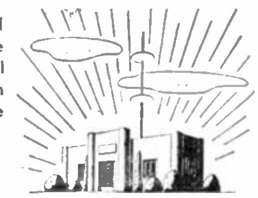

RADIO CONSULTANTS, Inc.
LEONARD ASCH, Director
1010 VERMONT AVE., WASHINGTON, D. C.

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Stratford, Conn. — Phone 7-2465
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• Construction Supervision (FM AM), Technical Maintenance, and Business Services for Radio Broadcast Stations.
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FM WINS LISTENERS AND WORRIES AM'ERS

Latest Crop of Rumors about FM Indicate the Alarm with Which AM'ers View Public Acceptance of FM

BY MILTON B. SLEEPER

ONE of the remarkable things about the science and the business of radio is that, although nearly every contribution to progress has been staunchly opposed by one group or other, the record of the industry shows continuous advancement, nevertheless! In fact, it is probably accurate to say that the violence of opposition to any new technique or method has been an approximate measure of its eventual value as a public service.

For the most part, the public and the industry have benefited by this trial by fire. Initially, every invention has its points of strength and weakness. Discussion, however prolonged and bitter, finally emphasizes the advantages and challenges the inventor to perfect or modify or justify the features against which legitimate objections are directed.

This has been the history of Frequency Modulation. Today, its established position in both communications and broadcasting has been made secure by a series of victories, first against indifference and then by well-organized opposition on the part of many manufacturers, broadcasters, and a segment of engineers in Government service and in private practice.

It was a long fight, and fairly waged in so far as the participants were identified and their business connections were a matter of common knowledge in the press, and in the records of the RTPB and the FCC.

Recently, however, there has appeared a rash of rumors in newspapers and trade publications which imply that experience is uncovering conditions which threaten FM broadcasting with what is described as "a life or death crisis."

Since publicity is being given to these rumors without disclosing any authority behind them, it will serve a useful purpose to bring them out into the open, and to present related facts, documented with their sources:

RUMOR An anonymous manufacturer is quoted as declaring that "There has not been an FM receiver yet that worked perfectly." The implication is that it is unwise to buy an FM set now, and that such a purchase should be postponed until sometime in the future.

FACT It is true that relatively few set manufacturers have engineering departments with personnel and facilities for doing any original development and design work. Even for their AM sets, the smaller concerns draw largely on such organizations as Hazeltine and the RCA License Laboratory for their design information. As for FM circuits, they cannot cope with the new problems involved unless or until they obtain outside engineering assistance. If they do undertake the design of FM sets on their own, the performance is very liable to be unsatisfactory. However, most of the larger companies are already producing excellent FM-AM sets.

The personal experience of this observer has been limited to Freed, Zenith, Browning and REL [1] receivers. All but the last were observed at Great Barrington, Mass., farther from the nearest FM transmitter than is considered normal operating range. Thus, lack of sensitivity or tendency to drift would have showed up immediately. However, these sets have proved completely satisfactory in day-to-day use over a period of months.

In several cases, sets of various makes have failed to give satisfactory FM reception, but only because of indifference or lack of knowledge on the part of dealers who installed them. While this condition might properly be blamed on the manufacturers because they released sets to dealers without first instructing them in the special problems of FM circuits and installations, this was no fault of the sets themselves.[2]

RUMOR FM stations and receivers tend to drift in frequency, and cause cross-talk in areas of primary coverage. This has emerged as a basic problem which affects the FM system.

FACT It is the FCC's responsibility to check the frequency of all broadcast stations, and a considerable part of the FCC's field engineering staff is assigned to this work. We have not been able to find that a single complaint has been filed against any FM station because of failure to maintain its frequency within the required limits.

As for drift in FM receivers, it has been this observer's experience that some models show no drift whatever, while others drift slightly during the first 5 or 6 minutes of operation, but are entirely stable after that initial period of warming up.

Any set that continues to drift after the first few minutes it has been switched on should be returned as defective to the dealer from whom it was purchased.

RUMOR Although it has hardly been discussed publicly, tests in Syracuse, N. Y. have crystallized the view that the plan of alternate FM channel allocations will not work. This indicates, according to one (unidentified) top radio executive that FM may be "a flash in the pan, certain of early demise," while another (also unidentified) stated that this condition means that AM will remain "forever."

FACT In the first place, it seems very doubtful that any man in the position of responsibility that would qualify him as a "top radio executive" would jump to such a conclusion.

But let's examine the situation in Syracuse. With one FM station there, reception was altogether satisfactory. Major Armstrong has urged, from years back, that FM transmitters in one service area should be grouped together closely, as a measure of protection against interference. In Syracuse, however, the second FM transmitter was erected several miles from the first one.

Consequently, a receiver located near station No. 1, using an antenna capable of picking up an adequate signal from the more distant station No. 2, picks up an overpowering signal from No. 1.

This observer, anticipating that such conditions might be encountered in some areas, discussed the matter of FM allocations with respect to receiver performance with C. M. Braum, Chief of the FCC's division, and with George Adair, while he was still Chief Engineer of the FCC. We wanted to know what operating characteristics of FM receivers were assumed when the alternate-channel allocations plan was adopted by the FCC. We urged that this information should be published because, if FM sets are produced in quantities that do not meet the specifications assumed by FCC engineers in setting up the allocations, the result would be to break down the allocations plan.

However, we were unable to get any information at all on this point, and Messrs. Adair and Braum left us with the impression that the alternate-channel system was largely guesswork on the part of the FCC, unsupported by any thorough, prior engineering determination.

[1] For a report on the performance of the REL receiver, see "FM Clinic for Broadcast Engineers" by Milton B. Sleeper, *FM and Television*, March, 1947.

[2] For more detailed discussion of these conditions, see "Facts of Life about FM" by Milton B. Sleeper, *FM and Television*, January 1947

Since General Electric's electronics department is located in Syracuse, G. E. engineers were in a position to make a careful study of the interference conditions there. In a letter from W. R. David, G. E. broadcast equipment sales manager, he reported: "It can now be shown that it would be extremely difficult and economically unsound to produce FM receivers which would successfully separate FM stations in a given city with the present channel spacing of 400 kc. The FCC engineers are attacking this problem with dispatch, and we all expect the announcement of a more workable plan in the very near future.

"In conclusion, I can say that the problem is one which can be readily corrected by reallocating the FM stations three or four channels apart; also, that this can be done most conveniently at this time when many of the FM stations are operating on an interim basis. Under such a change, the same ultimate number of FM stations could be accommodated except in the major centers of population where more channels may be required. Even in these major centers, proper physical location of the FM stations would go a long way toward solving the problem."

This recalls the occasion of the FM hearing at the FCC when various manufacturers warned Paul Porter, then Chairman, that if the FM band was changed, considerable time would be required to field-test new receiver designs, and that such tests could not be made until a substantial number of upper-band transmitters were on the air. So we find that while Mr. Porter could and did reject the testimony of experienced engineers, his pronouncements could not and did not alter the fundamentals of sound engineering practice. As for receivers that will provide interference-free reception under the alternate-channel allocations plan, we have W. R. David's word that the FCC and the manufacturers have discussed this question, and that they agree that it is possible but not practical from the point of view of cost.

RUMOR The Radio Technical Planning Board recommended the alternate-channel allocations plan. Now it appears that the RTPB didn't know enough about FM propagation, and that the promotion behind FM stampeded all those concerned, both within and without the industry, into premature action.

FACT A careful review of the testimony at the RTPB FM Panel meetings does not disclose any recommendation of an allocations plan. Those records are available to anyone who wants to study them. Specific information can be obtained from C. M. Jansky, Jr., who was chairman of the FM Panel.

The records also show that all the recommendations made by Major Armstrong, Paul de Mars, Dr. Pickard, Dr. Beverage, Dr. Stetson, Stuart Bailey, and Dr. Burrows, by the RTPB FM Panel, the pioneer FM manufacturers, and TBA were completely rejected by the FCC. Whatever stampeding took place was done by Paul Porter, who rode rough-shod over the opinions of those who were experienced in FM, and chose for his guidance the theories advanced by Kenneth Norton, whose name had not been previously associated with FM.

RUMOR Another fault in the FM broadcast system is disclosed by the determination that three stations in New York are interfering with the airport radio system, and three stations will have to close down or be shifted to other channels.

FACT It is true that, surplus Army equipment, not intended for civilian use, is being employed on some planes landing at New York, and that it is subject to interference from WBAM, WNYC-FM, and WGYN. Since it will take several months to replace the obsolete equipment by modern instruments, the frequencies of these stations must be shifted. That, according to the FCC, is FM's misfortune, but not its fault. It is not a serious misfortune. We remember that, a few years ago, AM stations survived a wholesale shift of frequencies throughout the Nation, and no harm resulted. As far as listeners are concerned, the shift in New York involves only two stations, since WBAM, WOR's FM affiliate, has not started scheduled broadcasting on the upper band.

RUMOR The drift problem is proving to be a basic fault in Frequency Modulation, and if a reallocation of channels and a redefinition of channel standards are not accomplished at once, FM will be dealt a mortal blow.

FACT Anyone who presents the drift problem as a basic fault of Frequency Modulation is either guilty of deliberate misstatement or of failing to ascertain the truth. If drift were a basic fault at 88 to 108 mc., it would be even more serious on 152 to 162 mc., where hundreds of mobile FM installations are in use for police and other communications services.

The only difference between the broadcast and communications equipment is that the former employs crystal frequency control at the transmitter only, because broadcast receivers must cover a range of frequencies, while communications receivers are designed for fixed-frequency operation.

However, we have long advocated the use of plug-in crystals for broadcast receivers as the best method of obtaining push-button tuning.

CONCLUSION As Fred Lack of Western Electric remarked at the recent I.R.E. Conference: "The radio industry deals with facts. The arguments come from the interpretation of these facts."

The full import of that remark is made clear by a paragraph in the report of the Commission on Freedom of the Press: "— What a mind does with a fact or an opinion is widely different when it is serene and when it is anxious; when it has confidence in its environment and when it is infected with suspicion or resentment; when it is gullible and when it is well furnished with the means of criticism; when it has hope and when it is in despair."[4]

Considered in the light of facts which are available to all who want to know them, it seems as if the rumors[3] the FM faces a "life or death crisis" must issue from minds beclouded by the acid mists of anxiety, suspicion, resentment, and despair.

As a restatement of our editorial policy, we offer the following from the report entitled "A Free and Responsible Press," by the Commission on Freedom of the Press.[3]

"The right of free public expression does include the right to be in error. Liberty is experimental. Debate itself could not exist unless wrong opinions could be rightfully offered by those who suppose them to be right. But the assumption that the man in error is actually trying for truth is of the essence in his claim for freedom. What the moral right does not cover is the right to be deliberately or irresponsibly in error.

"Whether a unit of the press is an advocate or a common carrier, it ought to identify the sources of its facts, opinions, and arguments so that the reader or listener can judge them. Persons who are presented with facts, opinions, and arguments are properly influenced by the general reliability of those who offer them. If the veracity of statements is to be appraised, those who offer them must be known.

"Identification of source is necessary to a free society. Democracy, in time of peace, at least, has a justifiable confidence that full and free discussion will strengthen rather than weaken it. But if discussion is to have the effect for which democracy hopes, if it is to be really full and free, the names and characters of the participants must not be hidden from view."

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[3] This report on mass communication, covering newspapers, radio, motion pictures, magazines, and books, was prepared by the Commission on the Freedom of the Press, under the chairmanship of Robert M. Hutchins, chancellor of The University of Chicago. The report was furnished as a supplement to *Fortune*, April, 1947. Additional copies can be obtained from the University of Chicago Press, at $2 each.

[4] *Editor's Note:* The sources of these rumors are not identified here for obvious reasons, but we'll be glad to furnish them on request.

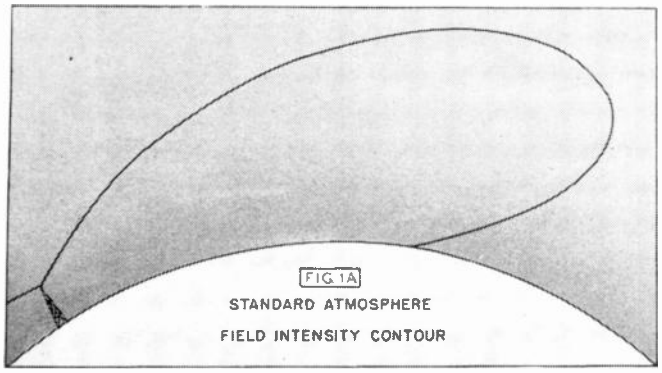


FIG. 1A. BOUNDARY OF FIELD INTENSITY CONTOUR OVER SMOOTH EARTH UNDER THE CONDITION OF STANDARD ATMOSPHERE

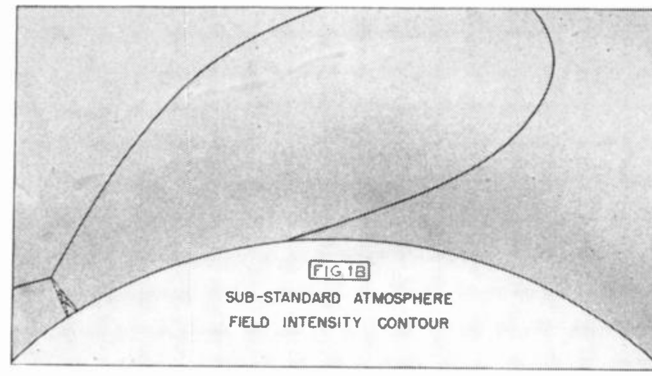


FIG. 1B. MODIFICATION OF THE SAME FIELD INTENSITY CONTOUR BY SUB-STANDARD ATMOSPHERIC REFRACTION

PRACTICAL CONSIDERATIONS OF FM COVERAGE

Part 1—General Considerations of Propagation—Effect of Troposphere on Signal Intensities vs. Distance for Varying Antenna Heights

BY PAUL de MARS AND THOMAS A. WRIGHT*

FM BROADCAST service coverage is generally estimated today by the procedure outlined in the Federal Communications Commission's Standards of Good Engineering Practice concerning FM broadcast stations. The distances to the signal intensities recommended for urban and rural coverage are derived from the chart (Fig. 1 of the "Standards") published by the FCC entitled "Ground Wave Signal Range for FM Broadcasting."

FCC Procedure ★ There is a twofold reason for this. First, the Rules and Regulations of the FCC require that estimates of FM station coverage be calculated in accordance with the above-mentioned procedure in order to obtain consideration by that body. Second, there has never been published hitherto by informed and reliable sources any substantially different propagation data or methods of estimating FM coverage, although some treatments of this matter have appeared from time to time dealing with some phases of the problem.

While the factors affecting propagation in the FM band are quite well understood, and have been determined quantitatively to a fair degree of accuracy, they are not all contained in the FCC charts of so-called ground wave signal ranges. Neither do the procedures for determining service ranges provide for taking them into consideration.

The authors believe, therefore, that it is timely to treat this subject at some length and present herein, and in the two parts to follow, the presently known facts.

Actual vs. Assumed Conditions ★ The FCC charts of ground wave signal range for FM broadcasting are derived from theoretical calculations based upon certain assumptions. Although the conditions underlying the calculations are not clearly set forth on these charts, they are based upon a smooth spherical earth with uniform ground constants and a *standard atmosphere* in which the dielectric constant of the air varies uniformly as the height above the earth increases. The standard atmosphere has been chosen to represent a meteorological mean. The average bending of the radio waves due to refraction in the standard atmosphere is included by assuming that the effective radius of the earth is increased to four-thirds of its actual value.

It has long been known that atmospheric refraction can and does cause very large and persistent fluctuations in signal strengths and operating range in the FM frequency band. The meteorological origins of these effects are complex and varied, and occur in some form over all of the earth's surface. The concept of an equivalent earth's radius to account for refraction is totally inadequate to explain or deal with tropospheric variations in signal intensities. Furthermore, it is now recognized that reflection and refraction occur at air mass boundaries and other meteorological irregularities. The dependence of radio propagation on the weather increases as the frequency increases, and the variation in signal

* Respectively, Associate and Engineer, Raymond M. Wilmotte, Inc., 1469 Church Street NW, Washington 5, D. C.

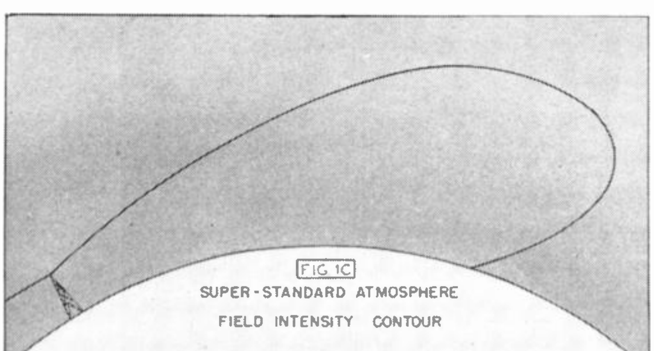


FIG. 1C. EXTENDED COVERAGE DUE TO SUPER-STANDARD ATMOSPHERE WITH ABOVE-AVERAGE REFRACTIVE INDEX

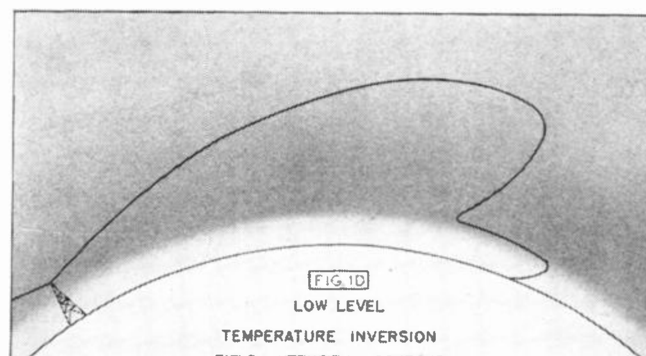


FIG. 1D. EFFECT UPON THE FIELD INTENSITY CAUSED BY CONDITIONS OF LOW-LEVEL TEMPERATURE INVERSION

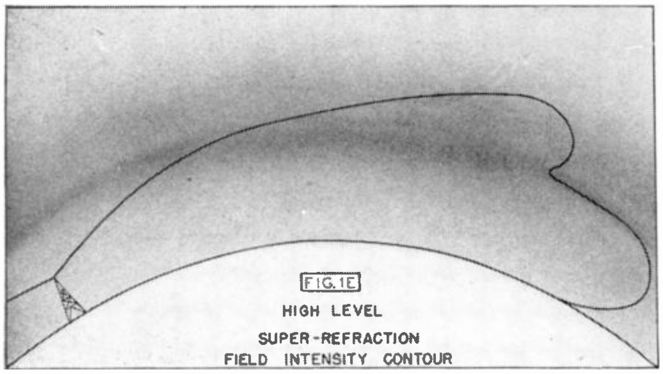


FIG. 1E. EFFECT UPON THE FIELD INTENSITY CAUSED BY CONDITIONS OF HIGH-LEVEL TEMPERATURE INVERSION

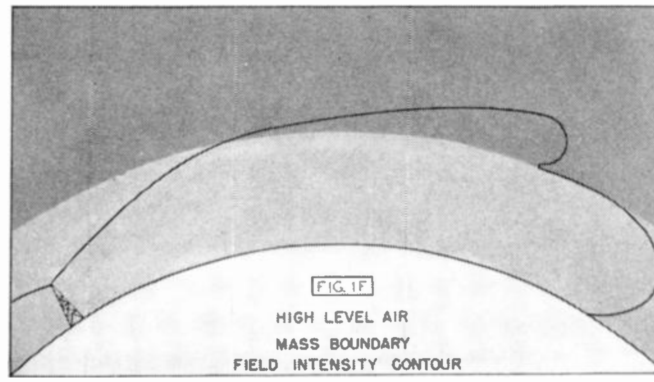


FIG. 1F. FIELD INTENSITY RESULTING FROM A MARKED AIR MASS DISCONTINUITY OCCURRING AT A HIGH LEVEL

intensity increases as the distance from the transmitter increases. Beyond the horizon the major factor affecting signal intensity is the effect of the troposphere.

The quasi-optical characteristics of the frequencies above 30 mc. were recognized by the early experimenters in the VHF band and have been well known for the last fifteen years. The shadow loss behind hills is considerable at the low frequencies, and this loss increases with frequency. In practice, the shadow effect of irregularities in terrain, of hills and mountains results in signal intensities being less, by varying amounts, depending upon the degree of irregularity of the terrain, than those predicted by theoretical calculations which assume a smooth earth.

Because the FCC's FM signal range charts are calculated upon average and constant meteorological conditions and a smooth earth, their use can, at best, yield only a sort of statistical mean of signal intensity, the accuracy of which decreases with distance and the irregularity of the terrain.

Ground Wave & Primary Coverage ★ From custom and usage the term *ground wave* has acquired a specific meaning. In broadcasting and communications, it is used to define the radiated energy that propagates over the surface of the earth and produces field intensities at any distance which, while determined by the conductivity, dielectric constant, and curvature of the earth, do not fluctuate.

Just as the term ground wave has been shown to have a specific meaning by custom and usage, so has the concept of *primary coverage* acquired a definite meaning in broadcasting. It is used to define the service area of a station free of interference, covered by the ground wave. Service that may result from fluctuating signals, such as nighttime skywave propagation via the ionosphere in the 550-to 1600-kilocycle band or service that may be intermittent due to sporadic interference, is defined as secondary or intermittent.

In dealing with FM coverage the FCC recognizes primary service only, since the standards state as follows: "Although some service is provided by tropospheric waves, the service area is considered to be only that served by the ground wave. The extent of the service is determined by the point at which the ground wave is no longer of sufficient intensity to provide satisfactory broadcast service."

The concept of the validity of applying average or median values of fluctuating signals for determining primary broadcast service may appeal to the physicist concerned with statistical analysis of the general characteristics of the radio spectrum. It does not suffice, however, for the engineer who undertakes the planning and building of the new FM broadcast service. He requires full information of all facts. The absurdity of expecting that

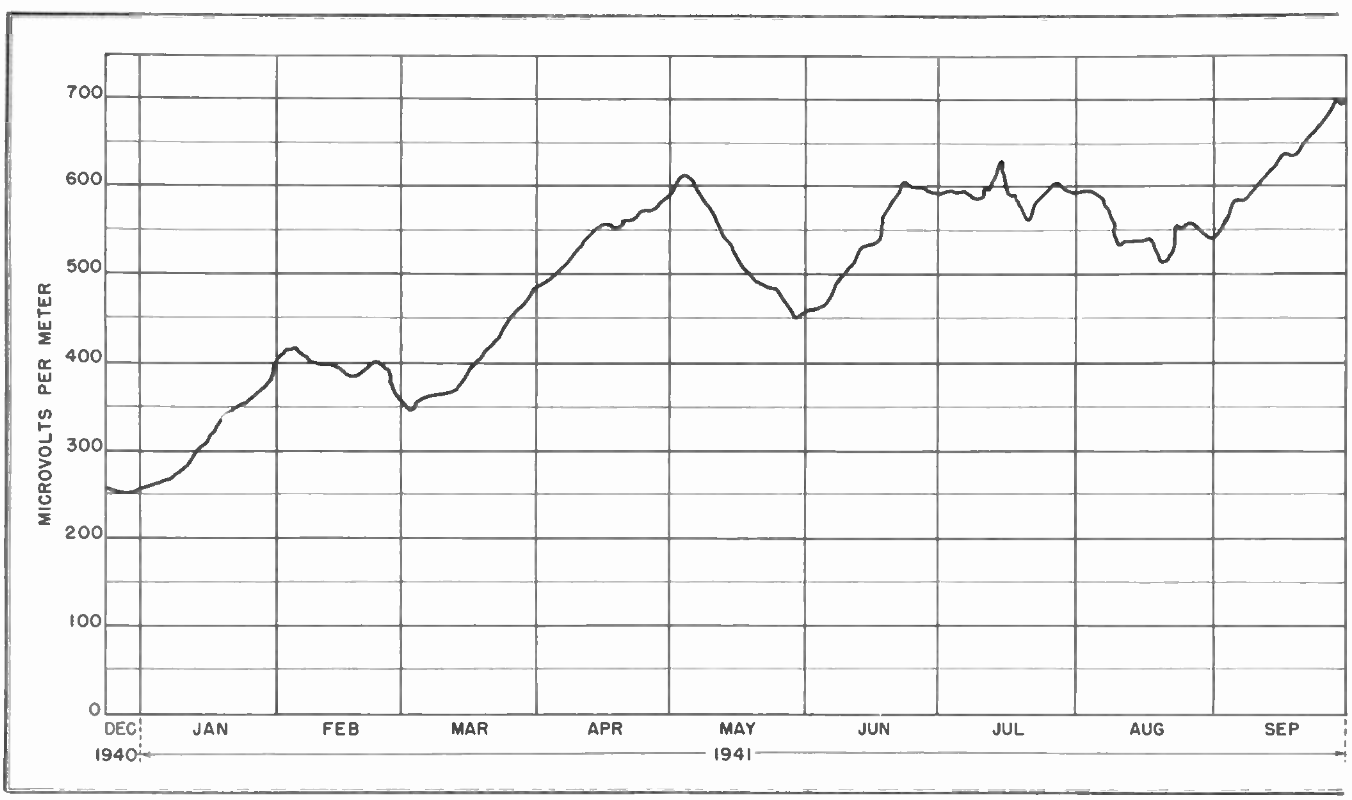


FIG. 2. LONG-PERIOD FLUCTUATIONS OF SIGNAL INTENSITY FROM WGTR, AT PAXTON, MASS., AS RECORDED AT SEABROOK BEACH

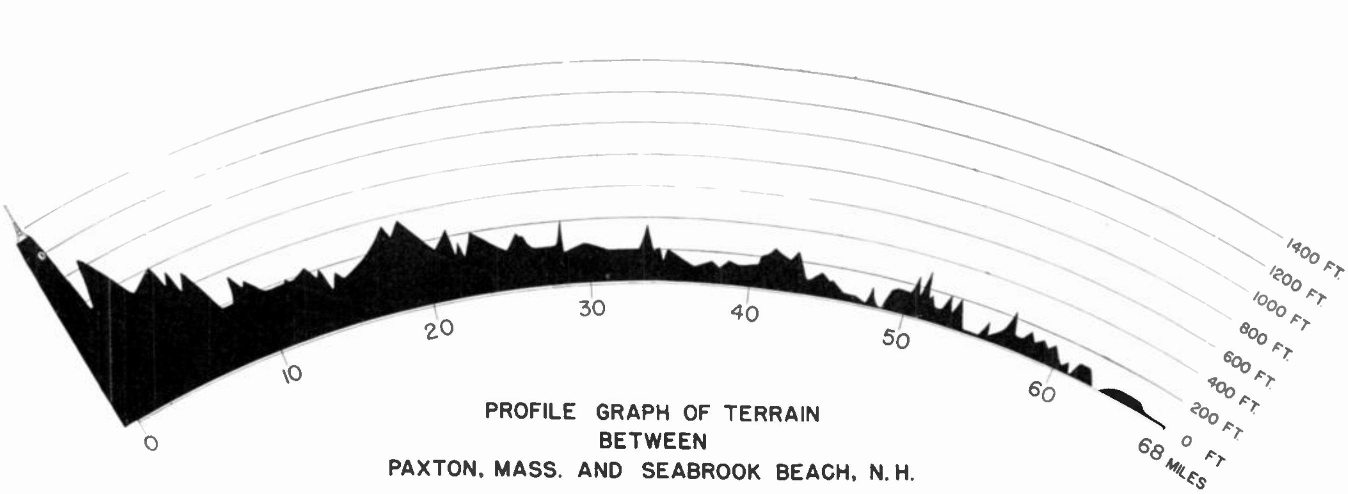


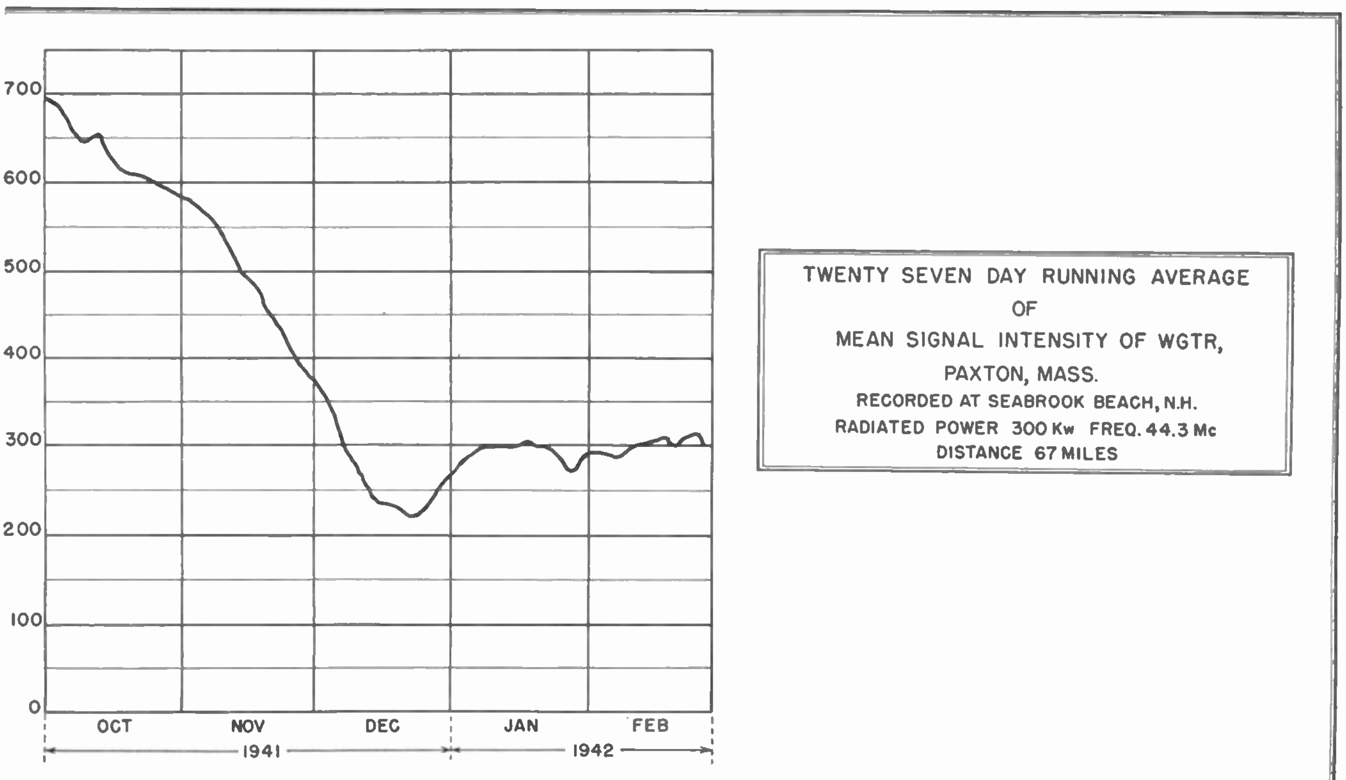
FIG. 3. PROFILE OF THE TERRAIN OVER THE 67-MILE PATH FROM PAXTON TO SEABROOK BEACH, WHERE RECORD IN FIG. 2 WAS MADE

knowledge of the mean annual temperature and wind velocity in Boston, Massachusetts, would furnish adequate information for the architect to design a habitable dwelling is clear to all. Nevertheless, the engineer concerned with building FM's facilities is given no more relatively detailed information by the FCC concerning propagation than the architect in the hypothetical case presented above.

It is important that the definitions established by custom and usage for the terms ground wave and primary service be understood to be as stated in the foregoing since their subsequent use in this series of articles will be in accordance therewith.

Signals Beyond the Horizon ★ The reader's attention is now directed to Figs. 1A to 1F, inclusive, which illustrate how tropospheric phenomena affect VHF signal intensity beyond the horizon. These figures show a field intensity contour which represents the main lobe radiation from an antenna elevated above the earth. They are drawn for the meteorological conditions which account for the principal, known propagation phenomena in the troposphere. It is recognized that these figures constitute an over-simplification of this subject. They are presented with the belief that what they portray will assist the reader to understand the dependence of VHF propagation on the weather.

Fig. 1A represents the boundary, at the surface of a smooth earth and in space, of a field intensity contour under the condition of standard atmosphere. Fig. 1B represents the same field intensity contour under conditions of sub-standard atmospheric refraction. It will be noted that the signal intensity at or near the surface of the earth is now propagated to a shorter distance from the transmitter due to less bending of the radio waves than with average or standard atmosphere. In a similar manner, Fig. 1C represents the boundary of the same signal intensity contour for a super-standard atmosphere, that is, for the conditions that result in the average refractive index of the atmosphere being greater than with standard atmosphere. In this case the field intensity at or near the surface of the earth is found at a greater distance from the transmitter than under standard or average conditions. Figs. 1D and 1E represent the boundary of the same signal when low-level and high-level temperature inversions, respectively, are present. Fig. 1F shows the same signal intensity contour boundary when there is present at high level a marked air mass discontinuity.



N. H., A DISTANCE OF 67 MILES. THE PAXTON TRANSMITTER HAD AN EFFECTIVE RADIATED POWER OF ABOUT 300 KW., ON 44.3 MC.

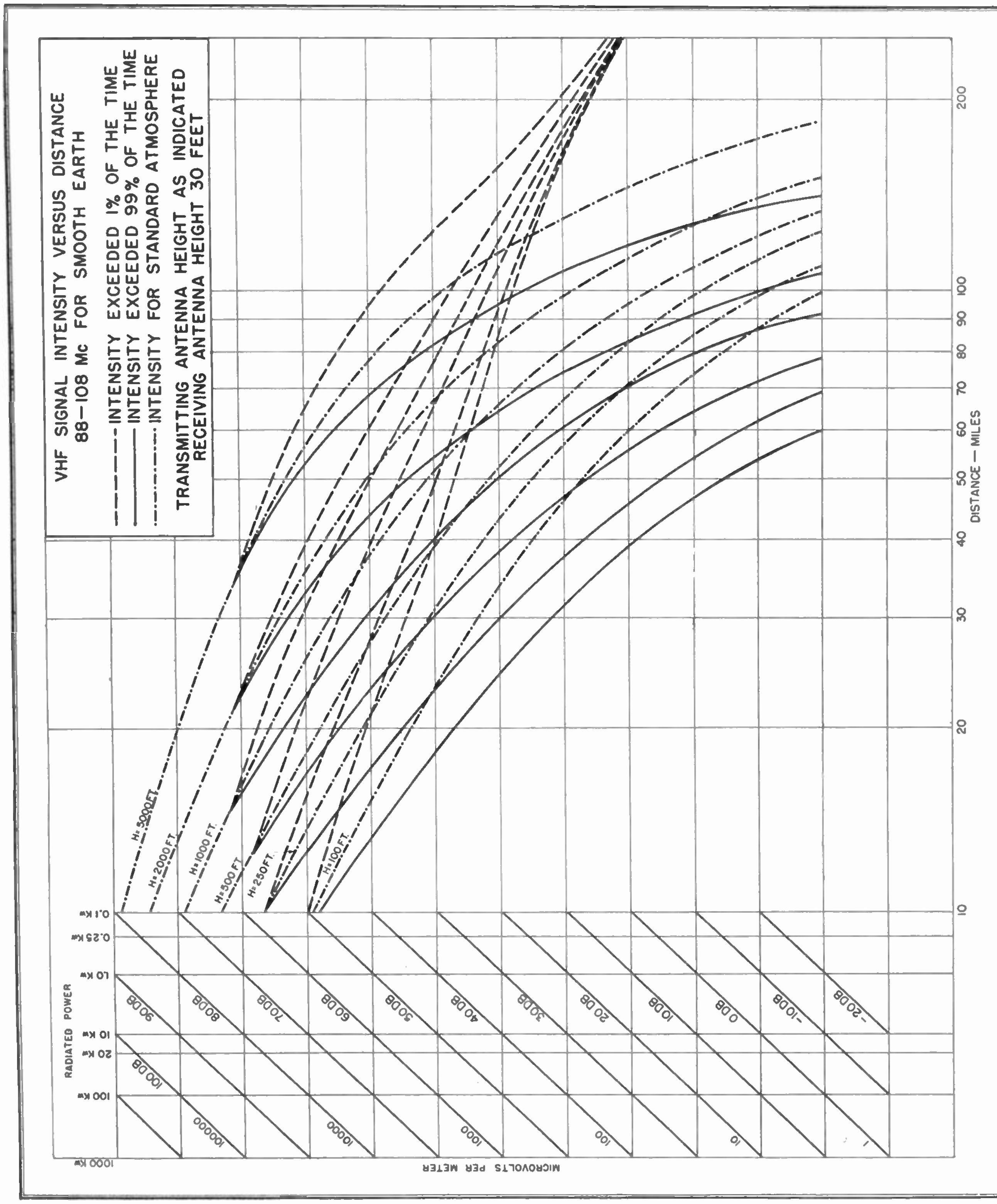


FIG. 4. THESE CURVES CAN BE USED IN PLACE OF THE "FIG. 2" REFERRED TO IN THE FCC'S FM STANDARDS, BUT WHICH HAS NEVER BEEN PUBLISHED

The presence and movement of air masses over the surface of the earth, which produce the general and local weather phenomena, result in the effects on signal intensities shown in Figs. 1A to 1F, inclusive, and in an infinite variety of variations thereof.

Theoretical treatment supported by observations establishes that useful signals would be propagated beyond the horizon by diffraction around the bulge of the earth's surface. Except for irregularities in terrain, this diffraction effect is invariable for a given frequency and is fixed by the radius of the earth. Practically, over distances near and beyond the optical horizon, and exclusive of the effect of terrain, the troposphere contributes the major component of the received signal. In practice, the idealized conditions represented in Figs. 1A to F are seldom realized for long periods of time although in certain localities local meteorological conditions provide notable exceptions. In general, conditions affecting VHF propagation are as variable as the weather. In fact, in the FM band and higher in the spectrum, signal intensities near or beyond the horizon are more sensitive to conditions in the troposphere than the manifestations of weather that affect our senses. The resulting fluctuations in instantaneous signal intensity are similar in character and magnitude to those received at lower frequencies from transmission via the ionosphere.

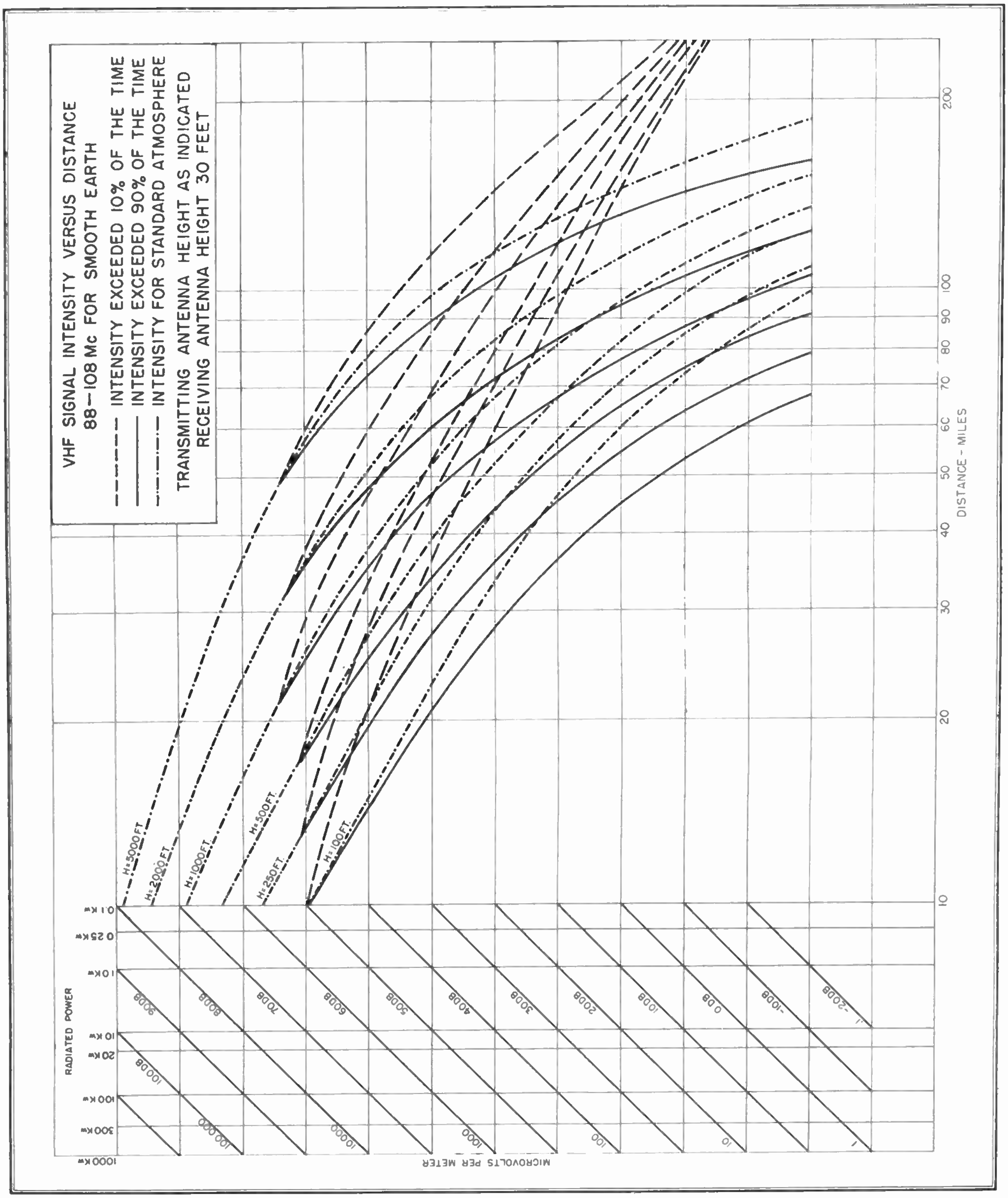


FIG. 5. THESE CURVES, SHOWING SIGNAL INTENSITY EXCEEDED 10% AND 90% OF THE TIME, ARE RELATED TO CORRESPONDING CURVES IN FIG. 4

Field Intensity Fluctuations ★ Measurements of instantaneous field intensities from transmitters radiating from antennas at varying heights disclose that field intensity fluctuations over wide ranges occur from minute to minute, hour to hour, day to day, and season to season.

Long-period fluctuations of signal intensity are graphically illustrated by Fig. 2 which shows the signal intensities in microvolts per meter of Yankee Network's broadcast Station WGTR in Paxton, Massachusetts, recorded at Seabrook Beach, New Hampshire, for a fourteen-month period from December, 1940, through February, 1942. Station WGTR at that time operated on a frequency of 44.3 mc. with an effective radiated power estimated at 300 kw. The airline distance from the transmitter to Seabrook Beach is 68 miles. The center of WGTR's antenna is about 1,550 ft. above sea level. The topography of the Paxton-Seabrook Beach path is shown in Fig. 3.

The signal intensities plotted are average values obtained by plotting the running average for 27 days. It will be noted that with 27-day smoothing, the seasonal effect of atmospheric refraction is very clearly indicated. The predicted signal intensity using the ground wave signal range curves adopted by the Federal Communications Commission would be about 400 microvolts per meter. The actual measured signal intensities are found to be distributed above and below this value, indicating that the tropospheric effects produce both super-standard and sub-standard propagation conditions. The seasonal trend indicated in Fig. 2 is quite characteristic of VHF propagation. A recognized diurnal variation produces increasing signal intensities in the afternoon, reaching maximum value during the evening and night hours, with decreasing intensities in the morning, and minimum values during the middle of the day. The Seabrook recordings further show that even when 27-day averages are used to obtain mean values, sub-standard propagation conditions exist for long periods, in this case about 40% of the time. Because of the observed physical fact that the variation in signal intensity increases with frequency, a similar curve based upon recordings over the Paxton-Seabrook path on a frequency of 100 mc. would show a greater departure from values predicted on theoretical considerations.

Tropospheric Effects ★ The reader's attention is now directed to Figs. 4 and 5 which present the actual facts regarding the effect of the troposphere on propagation in the FM band. Fig. 4 presents a graphic representation of the signal intensity versus distance 1) exceeded 1% of the time, 2) exceeded 99% of the time, and 3) calculated on the assumption of a smooth spherical earth, uniform ground constants and a standard atmosphere. The effect of terrain is not included in order to simplify this presentation. A scale is provided which permits signal intensities to be evaluated in decibels above 1 microvolt-per-meter and also in microvolts per meter for radiated powers from 0.1 kw. to 1,000 kw. for antenna heights from 100 to 5,000 ft. The theoretical signal intensities were taken from the FCC's so-called ground wave signal range curves for FM broadcast stations in the 88- to 108-mc. band. The curves representing signal intensities exceeded 1% and 99% of the time have been derived from a large number of signal intensity measurements and recordings, many of which were made by the Federal Communications Commission at its own measuring stations. Portions of the curves of Fig. 4 extend beyond ranges to which signal intensities have been measured. The extrapolation has been made in accordance with empirical methods which are believed to yield substantially correct results for the distances shown. Included in the data upon which these curves are based are the values of signal intensities obtained in the tests made by Zenith Radio Corporation which covered a comparison of the fading in the 42- to 50-mc. band and in the 88- to 108-mc. band at a point beyond the horizon.

Fig. 5 presents the same information as Fig. 4 except that the boundary curves of the fading ranges are for signal intensities exceeded 10% and 90% of the time. This will assist the reader in understanding the distribution of signal intensity vs. time.

The qualitative accuracy of Figs. 4 and 5 is well supported by measurements. Furthermore, it is generally conceded that they indicate the probable range of signal intensities in the FM band that will be encountered in practice. The FCC chart designated "Ground Wave Signal Range for FM Stations" is, ipso facto, misleading. Mistaken conclusions are inevitable from the use of such data unless its limitations are recognized.

Examination of the effect of the troposphere presented in Figs. 4 and 5 discloses several facts of vital importance with respect to coverage from FM stations and FM frequency allocations. To illustrate, let it be assumed that a field intensity of X microvolts per meter is required to provide service from a desired station. It is then evident that the inner boundary of the service area is determined by the distance to X microvolts on the solid curves for the radiated power and antenna height under consideration. At the distances obtained from Figs. 4 and 5, the required signal will be exceeded 99 and 90% of the time, respectively. If service is desired 100% of the time, the distance will be less than that obtained from these charts. In considering allocations, let it be assumed that field intensity of Y microvolts per meter constitutes an interfering signal. The distance to the dashed curves is the interference range for the radiated power and antenna height under consideration. Fig. 4 yields the distance at which interference will result 1% of the time, and Fig. 5 the distance at which it will result 10% of the time. Greater separation of desired and undesired stations than that obtained from use of the above charts is required to eliminate all interference.

The FCC "Standards of Good Engineering Practice for FM Broadcast Stations" present, in section 4, entitled "Interference Standards," the procedure for estimating the extent of interference within the ground wave service area of a station. Pertinent to the subject under consideration, the Standards state ". . . the tropospheric signal intensity (from co-channel and adjacent channel stations) existing for 1% of the time shall be employed. The 1% values for 1 kw. of power and various antenna heights are given in Fig. 2, and values for other powers may be obtained by the use of the sliding scale as for Fig. 1. The values indicated by Fig. 2 are based upon available data, and are subject to change as additional information concerning tropospheric wave propagation is obtained." A footnote with reference to the above states that "Fig. 2 expected to be available approximately November 1, 1945."

While the above references indicate that the FCC recognizes the existence of signal intensities greater than those predicted by the FM ground wave chart, and has established values exceeded 1% of the time as interference, the promised Fig. 2 has never been published. Furthermore, the "Standards" do not recognize that another effect of the troposphere is to cause fluctuations of signal intensity *below* as well as above those shown on the ground wave chart (FCC Standards, Ground Wave Signal Range for FM).

The Fig. 2 referred to in the "Standards" corresponds to the curves of Fig. 4 of this article, showing the signal intensity exceeded 1% of the time.

A twofold advantage which results as the antenna height is increased is clearly indicated by Figs. 4 and 5. First is the well known fact that with a given amount of power, the service area increases as the height of the antenna increases. The second fact, which is not so well known, is that the range of fluctuation of signal intensity at a specified distance decreases as the antenna height increases.

The attention of the reader is directed to the fact that for a given amount of power, the interfering signal intensities at distances of 200 miles or more are nearly independent of antenna height. The following generalization is justified: Antenna height is the most important factor in determining the primary service area of FM stations, and radiated power is the most important factor that determines the interference from FM stations.

The authors believe that the foregoing treatment of the effect of the troposphere will give those interested in coverage and allocation in the VHF band in general, and the FM band in particular, a better understanding and permit a more practical analysis of their coverage and interference problems than has been possible from information hitherto published. In the two succeeding parts of this paper, the effect of terrain will be dealt with, and some analyses of practical allocation problems will be presented.

G. E. PLANS FOR TELEVISION SALES

The first showing of the new G. E. television receivers was held at Bridgeport, Conn., on March 17. At this time, G. E. plans were announced for two types of television dealerships. First will be the servicing dealer, who must have complete shop facilities approved by G. E. television engineers and, even more important, technical personnel adjudged competent to handle the installation and servicing of television receivers.

Second, there will be the non-service dealer, who will act solely as a sales agent. Such appointments will be made where there is a factory-approved servicing agency to carry out the terms of the consumer service contract.

FIELD ALIGNMENT OF MOBILE EQUIPMENT

A Simple Instrument Used for Field Alignment by the San Antonio Transit Company

BY GEORGE ING*

THE simple, inexpensive unit to be described has been used successfully during the past 18 months for field alignment of mobile FM receivers and transmitters.

The unit was designed by the author and Vic Gallagher, to meet the problem of servicing FM equipment in the field for the San Antonio Transit Company.

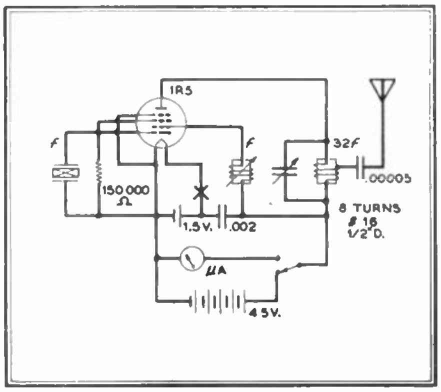
Prior to the construction of this test set, it was either necessary to ask the central station operator to turn on the carrier to furnish a crystal-controlled signal for mobile receiver alignment, or to drive the cars and trucks from their assigned stations to the repair shop in another part of the City, where an AC operated signal generator was available. It was decided that a portable, battery-operated test set would make it possible to align transmitters and receivers at any location, and make it unnecessary to bother the central station dispatcher who already has his hands full with routine communications.

The test set furnishes a crystal-controlled output on the exact assigned frequency. In this respect it has advantages over the regular service type of oscillator wherein the crystal, if any, is used merely to calibrate the dial at certain spots.

This particular set was built to check the Motorola equipment used by the San Antonio Transit Company, but it can be modified to check other makes of mobile units. In this installation, as is common with many police, fire, and utility systems, both transmitter and receiver operate on the same frequency, and the units are mounted side by side in the rear of the car. The operating frequency is 39.860 mc.

It was not necessary to purchase a separate crystal for the test set. The crystal socket and clamp were designed to accommodate the crystals used in the transmitters. Since the transmitters operate on the same frequency as the receivers, it is possible to use a transmitter crystal to align the receiver. Also, a flip of a switch on the test unit puts the tube in a diode rectifier circuit for checking relative field strength of the mobile transmitter.

The crystal for the Transit Company installation is ground for 1245.63 kc. This frequency is multiplied 32 times in the transmitter to attain the final carrier frequency of 39.86 mc. In the test set, as the accompanying diagram shows, the crystal is operated at its fundamental frequency in a triode oscillator circuit consisting of grids No. 1 and No. 3 tied together, the filament, and the screen grid of a 1R5 pentode. Grids No. 1 and No. 3 are connected to tube prongs No. 4 and No. 6 respectively. The screen grid acts as a triode plate. This triode oscillator is then electron-coupled to the plate circuit of the 1R5, which is tuned to the 32nd harmonic of the crystal frequency. This arrangement provides both oscillator and harmonic amplifier within one envelope, and also effectively prevents any fundamental-frequency signal from reaching



CIRCUIT OF THE FIELD ALIGNMENT UNIT

the 3-foot whip antenna mounted on top of the small metal case which houses the test circuit. If a different multiplication factor is used in the transmitter, the corresponding harmonic should be selected. Some manufacturers use a frequency multiplication as high as 48. In this case, the output circuit of the 1R5 would be tuned to the 48th harmonic of the crystal.

As can be seen from the diagram, the circuit is extremely simple. The oscillator grid leak is chosen to have a high value in order to increase harmonic content. The oscillator tank circuit in the screen grid lead is chosen to have a high L/C ratio for the same reason. It consists of a small permeability-tuned coil, resonating with the inter-electrode and distributed capacity at the crystal frequency. The plate circuit of the 1R5 consists of an 8-turn air-core coil ½ in. in diameter, resonated to the 32nd harmonic of the crystal frequency by a midget 3-plate condenser. Some care must be taken that the proper harmonic is selected, because the higher harmonics fall quite closely together. An accurately-calibrated short wave receiver with a carrier meter was used to tune this particular test set.

A single-pole, double-throw toggle switch allows the set to be used as a field strength meter. With the switch thrown to the microammeter position, we have a simple diode rectifier consisting of the plate-to-filament circuit of the 1R5. The test set is placed ten to fifteen feet away from the transmitting antenna. The microammeter reading accurately reflects changes in the transmitter output during the tuning process, and also gives a quick check on the efficiency of the transmitting antenna.

No mechanical details of construction will be given here because they will vary greatly with parts available. All wiring should be short and direct. The set described was constructed from old salvaged parts, and the only new expense involved was purchase of the tube and batteries. If there is no microammeter available to mount in the test set, the meter furnished with the equipment by the manufacturer can be used. In this case a plug jack should be connected in the circuit instead of the meter.

Now a word about alignment procedure. For initial bench alignment, or when changing to a new frequency, the method outlined by the manufacturer should be used. This generally involves tuning the RF, the low- and high-frequency IF, and the discriminator circuits separately, by using an all-wave signal generator set to the different frequencies. A microammeter is usually plugged into the limiter grid return or the discriminator circuit for use as a tuning indicator. For field touch-up tuning, some manufacturers suggest using noise picked up by the antenna as a signal. While this is satisfactory for tuning the RF and IF stages, it is useless for checking or tuning the discriminator circuit. Another disadvantage of using noise is that the amount of noise may vary from moment to moment.

The portable test set described here is excellent as a signal source for routine touch-up tuning through the entire receiver. In touch-up tuning, a signal is induced into the antenna from the test set, and all tuning controls through the antenna and RF to the limiter stages are tuned for maximum readings on the tuning microammeter. The signal from this test set can be used also to align the discriminator according to the manufacturer's procedure.

This procedure varies with the type of discriminator circuit used. In the circuit used by Motorola, one discriminator secondary is tuned to a higher frequency than the center IF, and the other secondary to a lower frequency. By Motorola tuning procedure, the frequency adjustments are

(CONCLUDED ON PAGE 55)

*Chief Engineer, Station KONO, San Antonio, Texas.

SPOT NEWS NOTES

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

FM Allocations: Acting quickly to rearrange FM broadcast frequency allocations so that stations in the same area will be spaced 3 or 4 channels apart, the FCC will probably have the modified assignments ready in time for publication next month. Meanwhile, the following changes have been made in Syracuse, N. Y.: WSYR-FM has been shifted from 93.5 to 94.5 mc.; WAGE-FM, now in process of installation, will go to 96.1 mc.; while WFBL-FM will remain at 93.1 mc. Properly engineered antennas are not affected by slight changes in frequency. It is not expected, therefore, that stations now operating will have to go off the air.

KKLA: New FM station at Los Angeles is preparing to go on the air with a 10-kw. Collins installation. Owned by the Echo Park Evangelistic Association, KKLA will have an effective radiated power of 48 kw. on 93.7 mc.

Admiral William F. Halsey, Jr.: Now retired from the U. S. Navy, has been elected a director of International Telephone and Telegraph Company.

California: Santa Maria Valley, one of the country's richest areas in natural resources, now has daily 10-hour FM service from KRJM, operated by the Daily Times. Summary of live-talent shows indicates better FM program service than most anything being aired on the east coast. Owners are R. K. and S. C. Hancock; Kent B. Young is chief engineer.

George P. Adair: Has resigned as Chief Engineer of the FCC, to enter private consulting practice. He has opened offices at 1833 M Street N.W., Washington, D. C. Comment from FCC: "Mr. Adair has done a magnificent job in a most trying and difficult post. . . . The Commission expresses its appreciation of Mr. Adair's services, and wishes him every success for his future." George E. Sterling, assistant chief engineer in charge of the Field and Research Branch, succeeds George Adair.

Montreal: Insuline Corporation of Long Island City, New York, has opened a Canadian plant to manufacture radio components, accessories, and car antennas. It is located at 9500 St. Lawrence Avenue, Montreal.

A Suggestion: During some 30 years of attending radio meetings that range all the way from small luncheons to dinners which filled the large ballrooms of the Waldorf and Palmer House, we have heard hundreds of speakers introduced, but not one speaker in fifty introduced correctly.

The No. 1 rule of introductions is that the last word uttered by the chairman should be the speaker's name. All the information should be given about the speaker, including his company connections, his title, and degrees, and then: " . . . I present, John Henry Nothcott," or whatever his name may be.

The practical reason for this rule is that the speaker is prepared to rise as soon as his name is mentioned, and further words of introduction after the mention of his name are an anti-climax to both the speaker and the audience.

Leo L. Helterline, Jr.: Has been appointed chief engineer for Sorenson & Company, Stamford, Conn. He was formerly with Sylvania, as quality control engineer.

CONTINENTAL FM NET

GREATEST thrill to FM listeners in the east, and convincing evidence of FM's superiority over AM, is the broadcast of the AAF Band on Wednesday nights from Washington by the Continental Network.

The broadcasts started on March 26th with an 8,000-cycle line from WASH-FM to WBAL-FM at Baltimore and to Major Armstrong's W2XMN and W2XEA, with WDRC-FM, Hartford, rebroadcasting from W2XMN. By the second night, the system was extended through WBCA Schenectady to WIBX-FM Utica. Subsequently, plans were being laid to extend the net to New York stations as far as Buffalo.

Anyone who thinks that FM can offer no advantages over AM in metropolitan areas should listen to the Continental FM net on Wednesdays, 8:30 to 10:00 P.M.

Commissioner E. K. Jett: Commenting on wider separation of FM channels assigned to any one area: "While it is true that the existing plan for assigning alternate channels in the same area may require some readjustment, I do not feel that there is any insurmountable problem, or any problem at all in so far as transmitter drift is concerned. . . . The problem (of allocations) is not as serious as many AM interference problems we have dealt with in the past."

Detroit: Ford Industries has been granted a C.P. for a television transmitter to operate on Channel No. 2. This company also holds a television C.P. for Toledo, Ohio.

Employment Opportunities: The latest issue of the Scientific Personnel Bulletin contains a 76-page listing of vacancies, requirements, and salary scales for technicians and scientists needed by the U. S. Navy. Basic pay rates range from $1,822 to $9,975. Copies of the Bulletin can be obtained from the Office of Naval Research, Scientific Personnel Branch, Navy Department, Washington 25, D. C.

Push-Buttons for FM: Motorola is using push-button for FM with motor-drive to operate permeability tuning. The system is described as being entirely free of frequency drift.

John J. Glauber: Formerly of Federal Telecommunications Laboratories, has been appointed chief engineer of United Electronics Company, Newark, N. J.

WCFC: FM station at Beckley, W. Va., has upped its power from 250 to 1,500 watts. Later, it will go to 3 kw. As a result of FM service in this area, the Montgomery Ward store sold its first shipment of ten $200 FM-AM models in 24 hours, and without advertising them. The Ramey Music Company reports that calls for FM sets average over 100 per week.

Set Production: January RMA figures show 1,564,171 FM, AM, and Television sets produced, an increase of 7% over December production of 1,454,687. Of the radio receivers, 3.3% were FM-AM models, amounting to 51,318. About 10% of these FM-AM sets were table models. This is nearly double the November FM figure, indicating a rapid and healthy gain. Consoles accounted for 10% of the total set production, compared to 90% for FM-AM models. Of the television sets, 647 were consoles, and 4,790 were table types. Total of 5,437 is up from 3,561 produced in December.

Purchase: The E. F. Johnson Company has purchased from Gothard Manufacturing Company the latter's dies, tools, and inventory of pilot lights. This line will now be manufactured in the Johnson plant and sales will be handled by the Gothard Division.

John H. Miller: Has been appointed vice president and chief engineer of Weston Electrical Instrument Corporation. After 12 years as chief engineer for the old Jewell Company, he joined Weston as assistant chief engineer in 1931. He succeeds W. N. Goodwin, Jr., who, although retired, has been retained as an engineering consultant.

Low-Cost Television: DuMont Laboratories has developed a transmitter for televising movies that will be offered at a price of about $90,000. It is understood that this figure does not include the antenna nor the installation cost.

Aluminum Solder: According to Michael P. Walker of the Aluminum Solder Corporation, 10 E. 52nd Street, New York City, a report from the New York Testing Laboratories shows that Prolyt, made in

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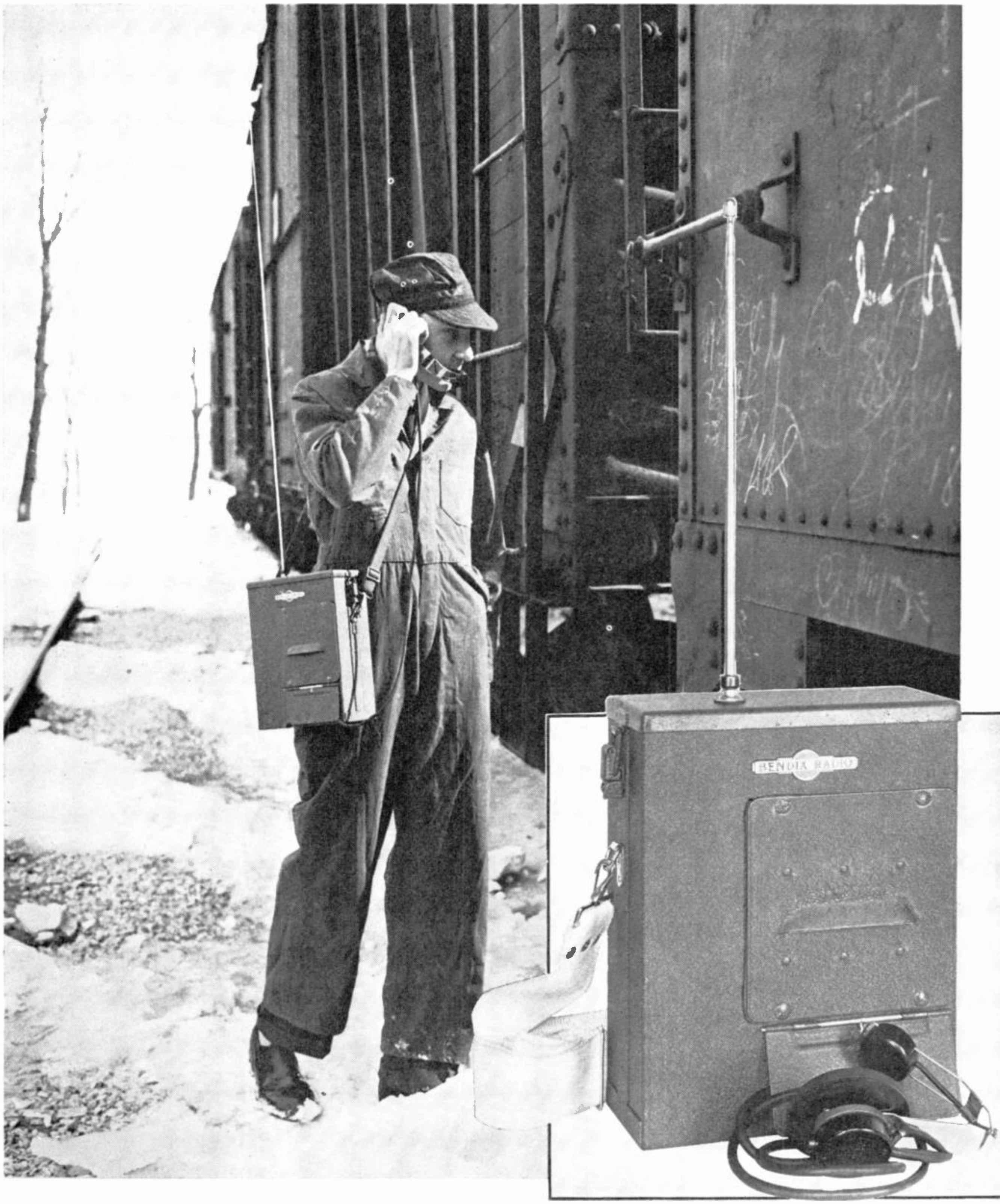


NEWS PICTURE

A HIGHLY useful addition to FM communications facilities for railroads is the new Bendix pack set, operating in the 158- to 162-mc. band. It can be used for communicating between the engineer or conductor and a flagman on the ground or a member of the crew who is inspecting the train.

Track crews can give information to a passing train without stopping it. In yards, car numbers can be received by a man on foot and reported to the yard office, or he can talk with the switching engines. Reliable range to a mobile or fixed station is rated at 1 mile.

Using a 36-in. antenna, this unit, complete with a combination 1-hand microphone and ear-piece, weighs only 15 lbs., including the power supply. The transmitter employs 3½ miniature tubes, and the receiver, 5½ tubes. Both are crystal-controlled.

An innovation is the power supply, comprising a 6-volt, non-spillable storage battery and a dynamotor of 100 volts output. The equipment is switched on or off by extending or retracting the antenna.

WEAW-FM TAPS LOCAL TALENT

Evanston Station Has 40 Sponsors Buying 65% of 60-Hour Schedule

BY GEORGE GRUENWALD*

NORTHWESTERN UNIVERSITY now has a static-free, high-fidelity voice. Its students are cooperating in a unique training arrangement with the first post-war radio station to be allotted a frequency in northern Illinois: Evanston's WEAW-FM.

Working under professional conditions, Northwestern students, particularly those of the Speech and Journalism Schools, are heard regularly by the estimated 27,000 FM receiving set owners along the North Shore and in Metropolitan Chicago. The station's 275 ft. antenna projects newscasts, the a cappella choir, dramatic shows, and special events from lines which link Northwestern studios with the WEAW transmitter.

President of the station is Edward A. Wheeler, a twenty-three-year-old Marine Corps veteran, and former Stanford University engineering student.

Three student radio majors, Bob Bassindale, Bill Butler, and Bob Urban, each work twenty-two hour weeks as salaried announcers. Medill's energetic assistant professor Baskett Moss, formerly of NBC, serves as the station's director of news and special events, and Dean Kenneth E. Olson represents the School of Journalism. Dean James McBurney and Instructor Donald Federson of the Speech School have charge of the drama productions and the student version of the Northwestern Reviewing Stand on WEAW.

Speech School radio playshop performers, Music School's a cappella choir, and members of both the Speech and Journalism Schools are heard regularly on WEAW broadcasts. The 60-time weekly newscasts are prepared and announced by Medill students, who have set up a big-time newsroom, complete with a United Press radio wire, a staff of local reporters, and a city editor. With the recently-acquired wire recorder, Medill's newscasters can cover any news event at a moment's notice, and rebroadcast the on-the-spot account as soon as air time is available.

Assisting in supervising the news programs originating from the campus studios are Arthur Holch, morning news editor of NBC, Chicago, and Benjamin Baldwin, member of WGN-Mutual's news staff.

The Journalism and Speech Schools maintain studio equipment and remote lines which connect them with WEAW.

Broadcasting to an area which fans out about 40 miles to the north and west of the station, WEAW programs can be picked up clearly in Waukegan, Aurora and Oak Park. Chicago's tall Loop buildings cut down the station's southward coverage. The lake is to the east.

Among the outstanding policies inaugurated by WEAW are two features which will gladden the ears of many listeners: no newscasts are interrupted by commercials, no spot announcements are made between 5:00 P.M. to 10:00 P.M.

Biggest stumbling block for many such projects, most people believe, is getting federal permission to undertake them. Ed Wheeler wants it known that he ran into absolutely no politics nor red tape when he flew to Washington, sans attorney, sans consulting engineer, and sewed up his FCC permit in just 10 hours.

Right now, most shows are phonograph record selections, radio transcriptions, and special events. However, Norman Ross, Jr., is already programing an evening disc jockey spot, and a pair of aviation authorities are building a show for the air-minded.

Special service programs are offered by the Council of Social Agencies, U. S. Social Security, U. S. Employment Service, and the Health Department.

Although there are other Chicago FM stations — WDLM, WGNB, WBBM-FM, WEFM, WEHS, to name a few — WEAW is the only one which is specifically dedicated to service newspaperless Evanston and the North Shore.

As an example of what can be done by a new FM station to build revenue quickly, it is interesting to note that WEAW went on the air with 25 sponsors. Now, 6 weeks later, that number has increased to 40, and the station is operating 60 hours per week, with 65% sponsored time. All accounts have been signed on 52-week contracts, with current rates guaranteed for 2 years. An advantage which sponsors were quick to recognize was the availability of favorable time.

*Northwestern University, % Station WEAW-FM, Evanston, Ill.

PART OF THE STUDIO FACILITIES AT STATION WEAW-FM, EVANSTON, ILL.

TELEVISION HANDBOOK

CHAPTER 1—Part 2: Characteristics of Images—3. Contrast and Gamma, 4. Brilliance and Flicker, 5. Size and Shape

BY MADISON CAWEIN

3. Contrast and Gamma ★ Detail in an image, which has been discussed at some length in the last section, is representative of one form of information conveyed by a picture. Detail-information is a form of information which concerns focus, or sharpness in the image. There is another form of information contained in an image which is somewhat, although not entirely, independent of detail.

This second form of information is called *contrast*. The term contrast[1] relates to the range in intensity between the lightest and darkest portions of the image. An image having only a few details may convey a variety of information by variation of the contrast, or of the light intensity within each detail.

By way of clarification, the difference between contrast and detail can be illustrated by a very simple example: Suppose an image field to be divided into nine parts as shown in Fig. 17. There are only nine details in this image. However, by varying the intensity of illumination of the central, grey square between white and black, as represented by the other eight squares, a variety of different images can be obtained. Each of these images will contain the same number of details, but each will convey different information. If only three levels of intensity are considered, that is white, half-white, and black, there are said to be three levels of contrast information in the picture. Three different images can be obtained by changing the central square from grey, to black, to white. A very large number of different images can be obtained by changing the other squares, singly or in groups, in the same way.

Obviously, although all these images will be composed of only nine details each, a large amount of information can be transmitted by variation of the contrast pattern within the detailed areas. If ten levels of contrast are considered, the number of different patterns is enormous.

It is apparent, then, that contrast constitutes a form of information conveyed by a picture. The transmission of contrast information within the detailed regions of a picture, therefore, requires the use of frequency bandwidth. The dependence of bandwidth on contrast has not been established as rigidly as that of bandwidth and detail in a television image, however. This whole subject is related to grain-size, or noise in the picture.

A noisy television picture is illustrated in Fig. 18. In Fig. 19, the same picture is illustrated as relatively noise-free, for comparison. Noise in a picture is constituted by the salt-and-pepper appearance in Fig. 18. It will be noticed how the noise reduces the effective contrast of the picture by increasing the intensity of the black areas and decreasing the intensity of the white areas. When the noise level becomes comparable with the contrast levels in the detailed regions of the picture, then detail as well as contrast will be erased.

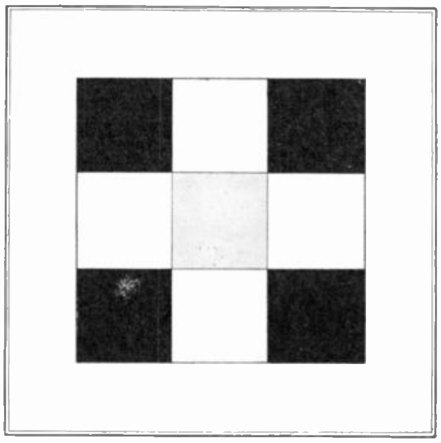


FIG. 17. CONTRAST CONVEYS INFORMATION

Thus, fine-structure noise interferes with the transmission of information in a picture just as hiss-noise interferes with the transmission of sound. The masking effect of noise on contrast in a video program is similar to the masking effect on tone in an audio program.

Neglecting noise, as a first approximation it can be stated that in order to transmit five levels of contrast in the detailed regions of picture will require about 2.3 times the bandwidth required to transmit only two levels, that is, white and black.

A picture which is lacking in contrast is said to be *flat*. Flatness in a picture is illustrated by Fig. 20, as compared to Fig. 21, which is said to be *contrasty* because of the large range of intensity from white to black. Fig. 22 shows the optimum setting of the contrast control. The ratio of white to black is termed the contrast-range of the picture. Good, present-day television pictures are capable of a contrast range of approximately 50 to 1 in the coarse regions of the picture, but only of about 2 to 1 in the regions of fine detail. For finer detail than the system will resolve, the contrast range disappears, and for this reason the wedges of resolution charts run together into a monotone gray at the point where resolution vanishes, as can be seen in Fig. 13.

In photography, the term *gamma* refers to a functional relationship between transmission and density. Gamma refers, in essence, to linearity of reproduction of contrast. Each time a negative or a positive reproduction of a scene is made, the contrast range can be contracted or expanded. In case of expansion of this range, the gamma of the process is said to be greater than unity. In case of contraction, the gamma is less than unity.

Reproduction of a picture in which all the processes have a gamma less than unity will result in a *flat* print. This means that the contrast range in the reproduction is less than that of the original. In the motion picture industry, the gamma of the negative with respect to the original is always greater than unity, and that of the positive with respect to the negative is less than unity, but the overall gammà is unity. It is a rule of photography that the product of the gammas of each process should be maintained at unity.

Television systems utilizing the iconoscope as a pick-up tube develop a camera output signal with gamma less than unity relative to the televised scene. The gamma can be corrected at the cathode-ray picture tube by utilizing a grid characteristic with gamma greater than unity, or in the amplifiers by use of a so-called *gamma expander*, a non-linear tube which amplifies the white excursions of the signal more than it does the black. Curve A in Fig. 23 is representative of the less-than-unity gamma of the iconoscope, and curve B shows the compensating gamma-expansion characteristic of some forms of cathode-ray picture tubes.

[1] Chambers' Technical Dictionary: *Contrast* is "The conflict between light and shade . . . in the composition of a photographic image".

The Farnsworth image dissector has a gamma of unity. That is, the relation between electrical output and light intensity is unity. Non-linearity can be introduced in the dissector circuits, or the video circuits, however, to either expand or compress the whites or blacks, depending upon the type of reproducer tube which is used.

This flexibility of contrast range can be introduced at any point of an electrical system used to reproduce a television image. Some pictures can be improved by expansion of whites or of blacks. When such a control is provided, it is usually called a *gamma control*.

FIG. 18. NOISE INCREASES INTENSITY OF BLACK AREA, DECREASES THAT OF WHITE AREAS

FIG. 19. SCENE SIMILAR TO THAT IN FIG. 18, WHEN NOISE HAS BEEN REDUCED

4. Brilliance and Flicker ★ *Brilliance* may be defined as the brightness, or intensity per projected-unit-area, of the light flux from a luminous surface. The usual unit of brightness is defined as one lumen per square foot per steradian.

The whole subject of light flux, brilliance, and illumination is rather unfamiliar to most radio engineers. Hence, there is considerable confusion on the subject of quantitative measurements of light and the interpretations thereof. The purpose of this section is to provide a working reference in this field, and to interpret some specifications in regard to television which have been obscure insofar as most engineers are concerned.

DEFINITIONS

1. Light is analogous to electric current from the standpoint that the use of the term *light* implies a flow-of-radiant-energy. The rate of flow is sometimes called *flux*. Flux could be evaluated in terms of radiant power at all wave lengths, expressed in watts. The unit of radiant power, or flux, however, over the visible spectrum (which is the more usual interpretation of light) is the *lumen*, which is equivalent, on a power basis, to:

$L = .00161$ watts of green light (of wavelength $\lambda = 5{,}550$ angstroms) (20.)

2. Intensity applies to flux from luminous *point-sources*. Intensity is the flux per unit-solid-angle *from a point source*. The unit of intensity is the *candle*, which is an intensity of 1 lumen per steradian, or solid-radian. The intensity in all directions is 1 candle when 4π lumens are radiated from a point into all of the surrounding space. There are 4π steradians of solid angle in the complete space which surrounds a point. The formula for intensity is:

$I = L/\Omega$ lumens per steradian (2.1)

3. Brightness applies to flux from luminous surfaces. Brightness, in a given direction Θ from the normal to a surface, is the intensity per projected-unit-area of the surface, the projection of the unit area being in a plane normal to the direction considered. The equation for brightness is:

$B = I/A \cos \Theta$, where A is area (2.2)

Since intensity (of reflection or emission) for many substances varies with the cosine of the direction Θ, the brightness of many surfaces is uniform in all directions. Lambert's law states:

$I = I_o \cos \Theta$ (for many surfaces, such as snow for example) (2.3)

where I_o refers to intensity along the normal to the surface. Therefore, brightness can be expressed as:

$B = I_o/\text{Area}$ lumens per unit area per steradian (2.4)

4. Illumination of a surface is light per unit-area. The unit of illumination is a-lumen-per-square-foot, commonly called a foot-candle. This unit is dimensionally incorrect and should be abhorred by all scientists, since it implies that illumination is the product of candle-power and distance, which is untrue. The formula for illumination is:

$E = (I \cos i)/d^2$ (lumens per unit area) (2.5)

where d is distance and i is the angle between the normal-to-the-illuminated-surface, and the direction-of-the-point-source from the center of this surface.

5. The f/-Number of a lens system is the ratio of the focal length to the diameter of the entrance pupil (approximately: focal-length/aperture).

It can be shown from (2.2) and (2.5) that *image* illumination is

$$E_i = \frac{\pi B}{4} \frac{1}{(f/\text{-number})^2} \qquad (2.6)$$

which defines the illumination of an image in terms of the brightness B of the object surface, and in terms of the f/-

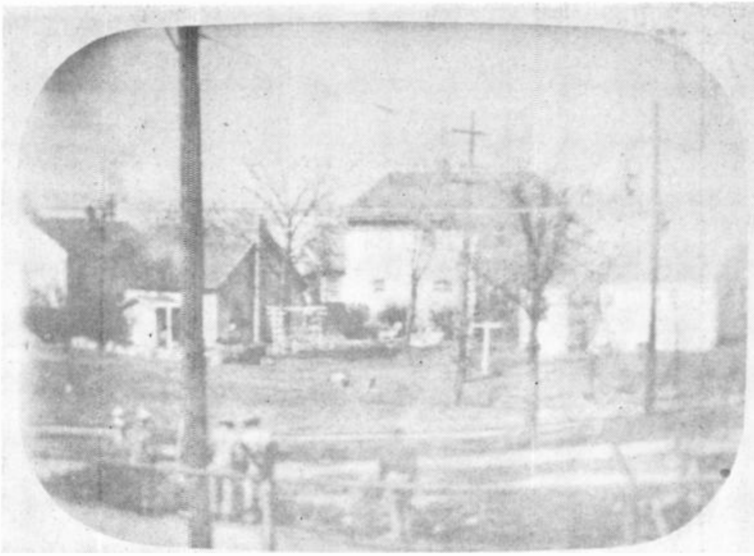


FIG. 20. PICTURE IS "FLAT" BECAUSE IT LACKS CONTRAST BETWEEN BLACK AND WHITE

number of the lens which is being used.

6. DISCUSSION: The concept of intensity is confusing, because of the point-source limitation. In the case of an illuminated scene (surface) which is normal to the axis of a lens system, equation (2.4) shows how the brightness is related to the *normal* intensity, if it be assumed that the radiation from the scene obeys Lambert's Law (intensity of radiation in any direction is proportional to the cosine of the angle of that direction with the normal to the scene). Since a scene radiates over only 180° of solid angle (2π steradians) the intensity at great distances (scene can be treated as a point) is, from equation (2.1), the ratio of the total number of radiated (or reflected) lumens to the angle of radiation, or:

$$I = L/2\pi \text{ lumens per steradian} \quad (2.7)$$

For most camera shots, the distance to the scene is great enough so that 1 square-foot of area can be considered as a point (20-ft. distance is sufficient). Using Lambert's Law, and a square-foot for unit of area, the brightness is, from equation (2.5):

$$B = I/1 = L \text{ (per square-foot)}/\pi \text{ (illumination per steradian)} \quad (2.8)$$

Since lumens/square-feet is a unit of illumination, equation (2.8) establishes a working relationship between *brightness* and *illumination:* brightness can be treated as illumination per steradian.

Substitution of (2.8) in (2.6) shows that the illumination of an image is:

$$E_i = \frac{L/\text{square-foot}}{4(f/\text{-number})^2} = \frac{E_o}{4(f/\text{-number})^2} \quad (2.9)$$

where E_o is the object illumination multiplied by a reflection factor, R.

Using the common, but incorrect term, foot-candles, a scene having a total, reflected illumination of $E_o = 200$ ft.-candles has a brightness of 31.8 ft.-candles per steradian. The illumination of a camera-tube photo-surface from such a scene, through an f/2.5 lens, is:

FIG. 21. EXTREME CONTRAST WHEN BLACKS ARE TOO BLACK, AND WHITES TOO WHITE

$$E_i = \frac{200}{4 \times 2.5^2} = 8 \text{ ft.-candles (8 lumens per square foot)} \quad (3.0)$$

Using an f/4.5 lens, a scene illumination of 200 ft.-candles is sometimes specified as the minimum permissible for substantially zero noise with an iconoscope. This tube, then, should show a noise-free picture at an illumination level on the mosaic, of value:

$$E_i = \frac{200}{4 \times (4.5)^2} = 2.5 \text{ ft.-candles} \quad (3.1)$$

7. PHOTOMETRIC UNITS: An attempt to set forth the rather intricate relations between photometric units may be ill-advised, but should prove useful to some students.

One of the difficulties is that the logical,

FIG. 22. HERE THE VALUES OF BLACK AND WHITE AREAS APPEAR IN THEIR TRUE RELATIONSHIP, THEREBY CONVEYING MORE INFORMATION THAN EITHER FIG. 20 OR 21

fundamental conception concerns the concept of light flux, whereas the practical units are based on a certain standard value of intensity. This is similar to the condition in an electrical laboratory which has a standard resistor, whereas, the fundamental quantity is the ampere or coulomb. But the main difficulties lie in the geometric relations between bundles of elementary rays.

Starting from the conception of *light flux*, L, which is energy per second and could be expressed in watts, the fact that not all radiations are equally visible, and some are quite invisible, makes it imperative to have a unit for white light. This is called the *lumen*. The connection of the lumen with color and watts will be discussed later on.

Light falling on an area gives rise to a certain *illumination* E, (lumens divided by the area on which they fall). The unit is 1 lumen per square foot, called illogically a *foot-candle*. If the area is inclined by an angle θ against the flux (θ is the angle between flux direction and surface normal, see Fig. 24), then one foot-candle on A′ will correspond to cos θ foot-candles on A″. Thus, the general formula for an area A is

$$E = \frac{L}{A''} \cos \theta \qquad (3.2)$$

Illumination is thus the incident flux density.

The idea of a *point source*, which does not exist but is generally agreed to be a light-source smaller than 1/20 of the distance from which it is viewed, is important to the discussion. The point source radiates flux equally in all directions. Into a certain *solid angle* Ω, the radiation is proportional to Ω. The unit solid angle is called a *steradian*, which is the solid angle subtended by unit area at unit distance from a point.

The flux-per-steradian characterizes the point source and is called the *intensity*, I. The unit of intensity is one lumen per steradian and is called a *candle*. Thus, an ideal point source of intensity, I candles, radiates $4\pi \times I$ lumens into all space. Actually, the unit candle is maintained in the Bureau of Standards, and the lumen, as well as all other units, are derived from it on the basis of their definitions.

Two light sources which have the same intensity may have different surface areas. The one with the smaller surface will appear brighter. The brightness has been defined as intensity per unit-area in a given direction. The unit of brightness is 1 candle per square-foot.

Inasmuch as the dimension of a solid angle is a pure number, brightness has the same dimensions as illumination. But conceptually, the two are quite different, first of all because area in the definition of illumination is the area on which light impinges, while area in the definition of brightness is the area from which the light emanates; and secondly, because the solid angle is involved. This is expressed by giving to the unit of brightness the name *candle* per square-foot, while the foot-candle, which is the illumination unit, means one *lumen* per square-foot.

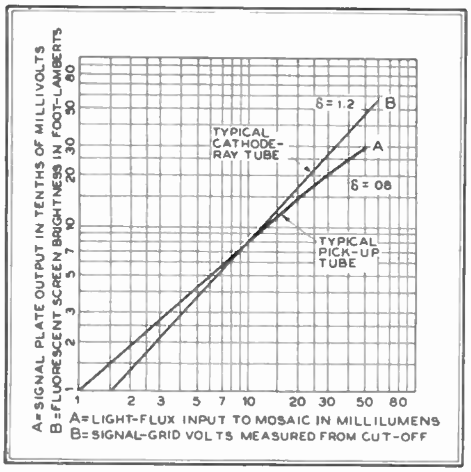


FIG. 23. GAMA CONTRACTION IN ICONOSCOPE IS OFFSET BY EXPANSION IN PICTURE TUBE

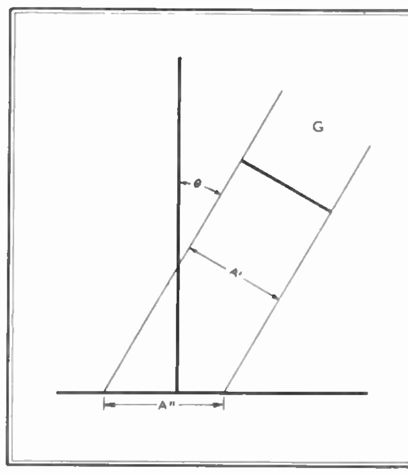


FIG. 24. SHOWING THAT ILLUMINATION IS THE INCIDENT FLUX DENSITY

The units described so far are often changed by introducing metric units instead of the square-foot. In some countries, the practical basis is the Hefner-candle: this is defined as 1 H-candle = .90 international candle.

Special units for illumination are

1 lux = 1 lumen per square meter
1 phot = 1 lumen per square centimeter = 10,000 lux

A special unit of brightness is: 1 stilb = 1 candle per square centimeter.

Definitions for brightness require some discussion of diffuse radiators, for clarity.

8. Diffuse Radiation from Surfaces: A surface is a diffuse radiator if it obeys Lambert's Law, i.e., if the radiation emitted at an angle θ against the normal is proportional to cos θ.

Thus, referring back to Fig. 24, if the surface element A″ of an area has a brightness B, it will radiate into a narrow angle dΩ in the direction of its normal a flux BA″ dΩ, and in the direction θ, according to Lambert's Law, BA″ cos θ dΩ. But A″ cos θ is its apparent area as seen under an angle θ. Thus, its brightness, seen from G in Fig. 24, will be judged as

$$\frac{BA'' \cos \theta \, d\Omega}{A'' \cos \theta \, d\Omega} = B \qquad (3.3)$$

Therefore, a diffuse radiator looks equally bright from all directions.

Sometimes the total flux emitted into the half-space of 2π steradians (a hemisphere) from a surface is called the *specific radiation* S:

$$S = \frac{L}{\text{area}} \qquad (3.4)$$

S has the same dimensions as illumination, but again the surface referred to is an emitting area, and not an illuminated area.

The unit of specific radiation is the Lambert = 1 lumen per square centimeter. Usually, the foot-Lambert or *Rumford* is used. A foot-lambert refers to the specific radiation (from a surface) of one lumen per square foot. If a surface is irradiated with E foot-candles, its brightness is $\frac{RE}{\pi}$, and its specific radiation is RE, where R is the reflection coefficient. Thus, the relation between specific radiation and brightness is

$$S = RE = \pi B \qquad (3.5)$$

Since B = L (per unit-area)/π, see (28),

$$S = L \text{ (per unit-area)} \qquad (3.6)$$

The foot-lambert unit of specific radiation is thus expressed in the same units as illumination, that is, in lumens per-square-foot, or in foot-candles. Using this relation, the lambert is used to measure cathode-ray tube screen brightness, but this can hardly be recommended.

9. Spectral Distribution: All the definitions given can be used for white light or for colored light. If, however, filters are inserted with a specified spectral response curve, the spectral distribution of the light source will affect the result. The definitions given and the relations between them remain valid for monocrhomatic light (one color), and if the spectral distribution for the source and all elements are known, the final result is found by summing over all colors. One example will be sufficient:

A point light source of intensity I sends a flux $\frac{A\,I}{d^2}$ into an area A, facing the source, at a distance d. Assume that this area is the cathode of a photocell, and that a light filter is introduced. What is the photocurrent generated by the source under these conditions? The light source has now to be characterized by the candles I(λ) dλ, within the very small wavelength interval dλ. This means the energy, of wavelength λ, per unit solid angle. Thus, I(λ) has the dimension

$\frac{\text{power-radiated-per-solid-angle}}{\text{wave-length-interval}}$. The filter has a transmission coefficient $T(\lambda)$ varying with the wavelength; this is a pure number. The photocell is characterized by a response curve $R(\lambda)$, defined as $\frac{\text{photocurrent in amperes}}{\text{incident power at wavelength } \lambda}$. The total photocurrent is then

$$\sum_{d^2}^{A} R(\lambda)\, T(\lambda)\, I(\lambda)\, d\lambda$$

In this way, it has been found that 1 lumen corresponds to 1.61 milliwatts of radiant power. A source emitting 1.61 milliwatts in a narrow wavelength interval, around 5,550 angstroms, into the pupil of the eye will excite the eye as much as one lumen of light flux coming from the standard lamp, and containing all colors.

The normal screen brightness in modern cathode-ray tubes is shown for the average 10-in. cathode-ray tube in Fig. 25. This brightness is usually expressed in foot-lamberts, although this unit is really a unit of specific radiation. A light meter calibrated in foot candles, thus, will measure screen brightness in foot-lamberts, as should be clear from the discussion on diffuse radiators.

In making brightness measurements on cathode-ray tube screens, it is usual to hold the cell of the meter, equipped with viscor filter, directly against the screen, and thus to gather almost all of the light emanating from the area in contact with the photo-cell. This area is usually of the order of two square inches. Although the scanning spot which is producing the lighted raster on the screen scans a larger area and is present only part of the time, the meter reading is accurate and represents what the eye would see. This is light flux, or energy per unit time, emanating from all areas equally when rectilinear scanning is used as under RMA standards.

The brightness of the moving spot itself is many times greater than the average measured by the light meter, because the area of the spot is quite small. With a high-light brightness of 50 foot-candles, the spot brightness (10-mil spot) will be

$$\frac{2}{.010 \times .010} \times 50 = \text{one million foot-lamberts}$$

The ratio of spot area to the unit area of one square-foot is approximately $144/(.010)^2 = 1,440,000$, so that this seemingly enormous spot-brilliance can be achieved with considerably less than a candle in the spot. Present day fluorescent-screen efficiencies are from 2 to 5 candles per watt of input power. A beam current of the order of 200 microamperes at 8 thousand volts supplies 1.6 watts of power to the fluorescent screen, so that spot brilliances of several million foot-lamberts can be attained.

Very bright television pictures, such as those described for modern tubes, will produce flicker even at 60 cycles. Perception of flicker is a function of brightness. It can be said, therefore, that RMA standards of 60 fields per second are none too high from the standpoint of flicker, although they may seem wasteful of bandwidth. All proposals to decrease the field-scanning rate below 60 cycles have been rejected, and will probably continue to be rejected from the standpoint of flicker. Other aspects of flicker were discussed under Sections 2 and 3 of Part 1 and will not be repeated here.

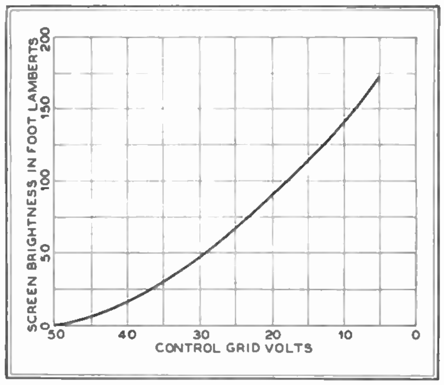


FIG. 25. NORMAL SCREEN BRIGHTNESS OF AN AVERAGE 10-IN. CATHODE RAY TUBE

A considerable amount of experimental data has been gathered by various experimenters [1] on the subject of flicker as a function of image brightness. Although this data is too voluminous to enter in these pages, it has been summarized in part as shown in Fig. 26. This curve shows the functional relation between the frequency at which flicker is perceptible and the brightness of the raster on a television screen. The data of Fig. 26 is for image field presentations which endure for only one-sixth of the cycle. On the average, considering persistence of fluorescence of usual cathode-ray tube screens and the method of presentation of image fields in television practice, this may be considered as representative.

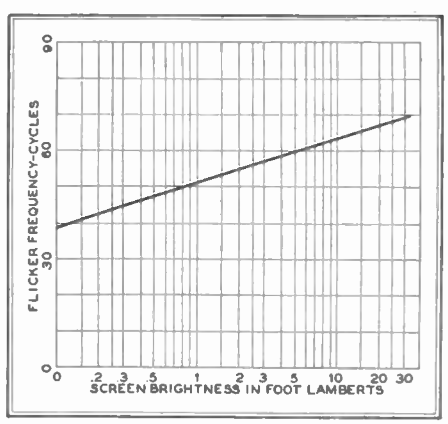


FIG. 26. RELATION BETWEEN VISIBLE FLICKER AND BRIGHTNESS OF THE RASTER

[1] E. W. Engstrom, "A Study of Television Image Characteristics," Part 1, *Proc. I.R.E.*, Vol. 21, pp. 1631–1651, December, 1933.

5. Size and Shape ★ The sizes of television images vary quite widely, depending upon whether the image is an optical image on the photo-sensitive surface of the pick-up tube at the transmitter, an extended electron image, or a reproduced image on the raster of the fluorescent screen at the receiver. Before discussion of the various sizes in general use, a word will be said in regard to shape.

Various shapes of television pictures have been given consideration in the past number of years. The most important of these shapes, and the most pleasing to the eye, is that of a rectangle. Greek geometrists believed that the most pleasing rectangle was one in which the ratio of width to height was the square root of 2, or 1.41. The most pleasing right triangle was believed to be one with its sides in proportion of 5 to 4 to 3. A rectangle which has a ratio of width to height in the order of 4 to 3 has the proportions of this most pleasing triangle. The ratio of width to height is termed the aspect ratio of the rectangle. The NTSC recommended in 1940 an aspect ratio of 1.333 (4 to 3) and the RMA has adopted this as a standard aspect ratio of television pictures. This ratio is suitable also for transmission of motion pictures.

The symbol A is usually chosen to express aspect ratio. Since cathode-ray tubes usually have circular faces, it is useful to have a formula from which the area of the television raster can be calculated in terms of the radius of the tube face and the aspect ratio. The formula for this area is:

$$\text{area} = \frac{4r^2A}{1 + A^2} \qquad (4.0)$$

This area is a maximum at a value of A equal to unity, but since A actually is equal to 4/3, the area is not quite the maximum which could be obtained but does not depart therefrom by a large amount.

The aspect ratio has quite an effect on the bandwidth required for transmitting television pictures, since it enters into the frequency formula (see equation 2.0). Some telemetering systems utilize an aspect ratio of only 0.5 in order to conserve on frequency bandwidth required to transmit certain types of simple information.

As to the size of images, it is usual to operate with as large an image as it is possible to obtain at the pick-up tube, but the size of this image is limited by the construction of the pick-up tube and the availability of lenses. It is usual with an iconoscope to project an image approximately 4 by 3 ins. onto the mosaic. In a dissector, an image size of 1.6 by 1.2 is usual. With an orthicon the image size is approximately 2 by 1.5 ins., and in an image orthicon, an image of only 1.2 by 0.9 ins. is usual.

The larger the image, of course, the more careful must be the design of the

(CONTINUED ON PAGE 54)

NEWS ROOM SET UP AT THE MIAMI HERALD FOR DEMONSTRATING FACSIMILE TRANSMISSION OVER STATION WQM-FM

MIAMI HERALD TRANSMITS FACSIMILE NEWSPAPER

Techniques Developed During 2-Week Showing Create Great Public Interest

BY EDGAR H. FELIX*

THE facsimile broadcasting conducted by the Miami Herald Station WQAM-FM, March 10 to 24, differed from all previous demonstrations in several important respects. First, regular facsimile newspaper editions were prepared by a trained news staff; second, programming was designed for entertainment and demonstration purposes, and took full advantage of all opportunities to tie in with special events; third, operation of demonstrating equipment was turned over to local personnel.

The broadcasting schedule adopted called for three 1-hour transmissions daily plus a special events schedule. The hours were chosen principally to support window display demonstrations at times when the maximum street traffic was available. Thus, the regular schedule was set for 11:30 A.M. to 12:30 P.M., 3:30 to 4:30, and 7:30 to 8:30 P.M.

The facsimile news staff drew its subject matter from Associated Press, United Press, and INS news services, and AP Wirephoto Service. Substantially all copy was edited and re-written for facsimile. All solid text matter was typed on an IBM Electromatic proportional-spacing machine equipped with the Edison margin-justifier. Heads were made with Art Type. Make-up was handled by a topflight newspaper artist and photo retoucher. He worked within sight of the monitor recorder, and soon acquired a bag of tricks which put a new light on the whole art of delivering high grade pictures into the home.

The Miami Herald facsimile staff worked under the direction of Facsimile Editor Tim Sullivan. He handled assignments, leading stories, and planned all special events programs. An old hand at newspaper writing and re-writing served as assistant in preparing and editing copy. An expert IBM operator set up the prepared copy in justified column form. The art man turned the material into finished pages for the scanning drum, assembling typed copy, illustrations, captions and art-type heads.

After a few days, this 4-man team functioned like clockwork. When the occasion warranted, such as the unscheduled departure of President Truman for neighboring Key West, wire photos were broadcast in a matter of minutes from the time that their transmission to Miami was completed. Topnotch news items, re-

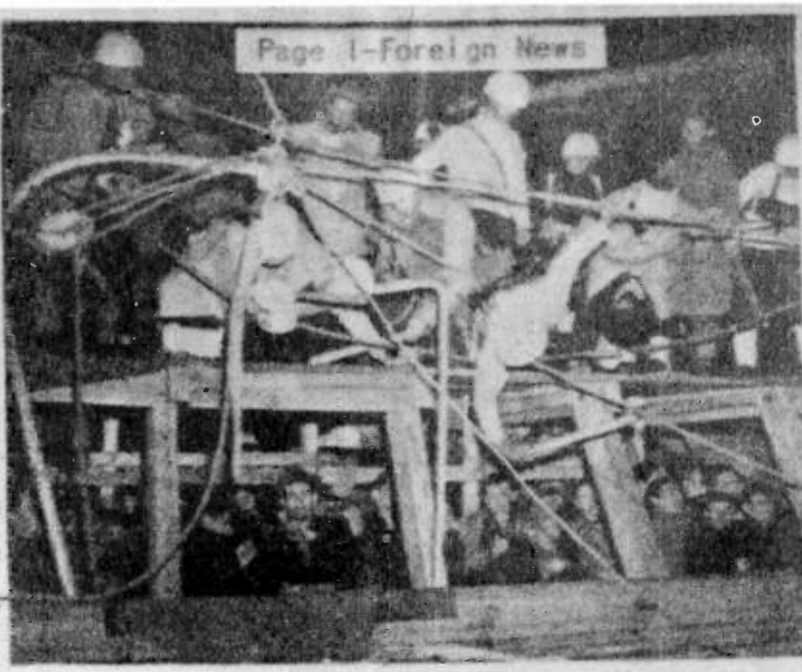
RIGHT: FULL-SIZE REPRODUCTION OF FACSIMILE PAGE, SHOWING NEWS FORMAT

* Director of Station Relations, Radio Inventions, Inc.

-NOW-

the hourly newspaper

Wednesday, March 12, 1947



Trouble at Haifa ——> as British Tommies board small steamer loaded with Jews displaced from European homes, trying to reach Palestine. Note glare of frustrated homeseeker in photo at right.

In Moscow...

Demilitarization of Germany is the first item on the agenda this morning as deputy Big 4 foreign ministers meet in the Kremlin. Their superiors get together again this afternoon.

Yesterday's peace-table session in Moscow saw all four delegates agree on the need for speeding up the disarming of Germany after USSR's Molotov complained that destruction of war potential in western zones of Germany was "not satisfactory."

Molotov withdrew his request that China's internal situation be discussed after US delegate Marshall insisted the conference should not discuss China in the absence of a representative of that nation.

In the Filippines...

Filipinos will give the US special trading rights until 1974 in return for millions of dollars for rehabilitation. The newly independent nation voted nearly 3 to 1 for a constitutional amendment to that effect asked by President Roxas. Voting was orderly, but only about 40 percent of the three million registered voters went to polls.

Meantime, one man died of wounds suffered when a handgrenade aimed at Roxas exploded. It was thrown by a Manila barber who told police he blamed Roxas for the commonwealth's economic plight.

In South America...

Paraguay's government has sent 1000 soldiers to quell a rebellion of army troops at San Pedro, about 100 miles north of the capital, Asuncion.

An infantry division, about 1/3 of Paraguay's entire infantry forces, rebelled Friday during a bloody but unsuccessful try by "armed Communists and members of the Febrerista Party" to seize police headquarters and a military school at Concepcion.

The government has warned Concepcion's 10,000 inhabitants by radio to evacuate strategic spots, which it said would be hit "with bombs of great power."

World Briefs...

Pope Pius XII gave two AP correspondents a special audience on the subject of world peace as he ended his 8th year of reign. He said he hoped for lasting world peace but felt some curtailment of sovereign rights of nations might be necessary to achieve it.

* * *

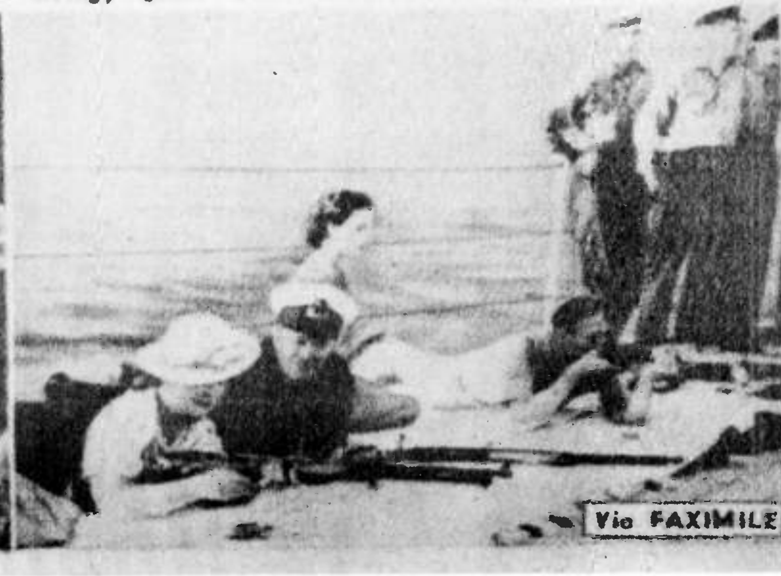
In London, a monkey sculptured by the late Eric Gill, a devout Catholic, has been removed from the alter piece of Westminster Cathedral, says UP. Church authorities claimed the statue might be regarded as "half monkey and half boy" and had it removed to avoid possible identification with the Darwin theory of man's evolution.

* * *

In London, parliament is considering a bill requiring 18 months full-time military service and 5½ years reserve service of each Briton reaching 18.

WHILE London's Central Electricity Board works on the coal shortage crisis by candlelight and wrapped in overcoats against the cold...

BRITAIN'S Royal Family enjoys balmy breezes at sea, en route to South Africa. Picture shows King, Queen and Princess Margaret at play. (AP)

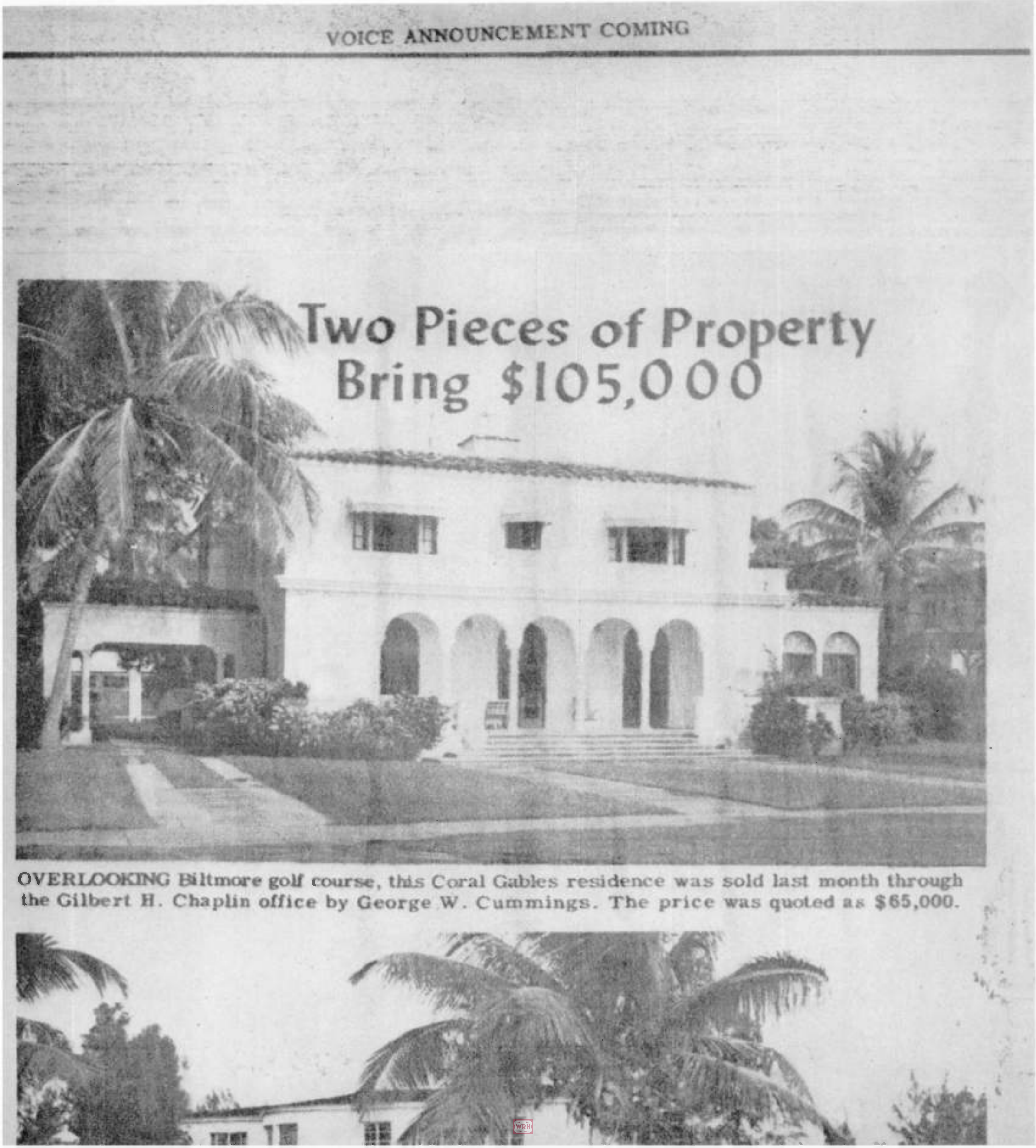


ceived by teletype, were not re-typed but immediately put on the scanning drum as delivered by the news wire service. In many instances, the recorders were showing news within four minutes of the time the ticker completed pounding out the dispatch at the news room.

Newspaper staff photographers covered all the main events at which the facsimile recording equipment was set up. Guests at luncheon meetings were photographed as they entered the banquet hall and talked with their friends before being seated. The resulting pictures began appearing on facsimile recorders before the entrée was served. Signatures on the guest book were reproduced with similar promptness. Such demonstrations of speedy transmission invariably made a profound impression.

The Radio Inventions equipment used

FULL-SIZE REPRODUCTION SHOWING NOTICE OF VOICE ANNOUNCEMENT AND INTERVAL PRECEDING THE NEXT FACSIMILE PICTURE



VOICE ANNOUNCEMENT COMING

Two Pieces of Property Bring $105,000

OVERLOOKING Biltmore golf course, this Coral Gables residence was sold last month through the Gilbert H. Chaplin office by George W. Cummings. The price was quoted as $65,000.

at Miami for these demonstrations consisted of 1) a single scanner unit, 2) an accompanying monitor recorder, 3) two additional display recorders especially well suited to window use, 4) a console home recorder, and 5) a projector for enlarging copy. Two engineers accompanied the equipment, one in charge of scanner and one in charge of recorders. In spite of the limited list of equipment, its judicious location throughout the Miami area and the powerful publicity build-up through the Miami Herald columns and the radio station drew practically every Miami resident to at least one facsimile demonstration.

After some preliminary announcements, the Miami Herald began its intensive build-up about a week before the demonstrations. Mr. John S. Knight, publisher, announced the forthcoming facsimile editions to selected high school students, the winners of a Herald-sponsored essay contest. Every step in the development of the demonstration installations, beginning with the arrival of equipment and engineers, kept the subject alive with increasing tempo until the Sunday preceding the first showing. On that Sunday, papers and radio station both went all out to warm up public interest in the new medium.

A streamer across page one, a 2-column front page news story, and a full-page illustrated feature story constituted the newspapers' contribution to the final pre-event publicity. The radio station set aside a choice 15-minute spot on Sunday for a three-way interview concerning facsimile with the station's top news commentator as narrator. Radio and newspaper support continued to the end of the showings.

The first two days' showings (Monday and Tuesday, March 10–11) were entirely private, the first being in the largest high school auditorium in Miami, in keeping with Mr. Knight's original announcement at the conclusion of the essay contest. One of the preliminary events was a luncheon given by the Miami Herald to leaders in industry, finance, and to local and state government officials at the Biscayne Room of the Columbus Hotel. Mr. Lee Hilles, Managing Editor, was chairman. He occasionally interrupted the speakers to call attention to news bulletins flashed on the projector, including pictures and descriptions of events which had occurred minutes before in various parts of the world. Mr. Kent Cooper, President of the Associated Press, sent a reply to Mr. Knight's invitation to attend the luncheon by Wirephoto from New York, and it was seen by guests within 17 minutes of the time that its transmission was concluded at Miami.

As the demonstrations developed, it became evident that an increasing proportion of voice announcement to pictures heightened the effectiveness of the demonstrations. An announcer's description of

JOHN V. L. HOGAN, PRESIDENT OF RADIO INVENTIONS, INC., AT WQAM-FM MIKE

the copy being prepared for the drum increases interest in the subject matter as it appears.

One of the accompanying reproductions of actual facsimile recording shows how the voice announcements worked out. The words "Voice announcement coming" were put on the copy at the transmitting scanner. During voice transmission the recorder continued to run, accounting for the space following the horizontal line, and the horizontal pattern preceding the top of the picture. Then, as the microphone was cut off, the output of the scanner was cut in again and recording was resumed at the receivers.

RECORDERS USED BY WQAM-FM WERE DESIGNED FOR PUBLIC DEMONSTRATIONS

The whole operation was not only a build-up for facsimile, but it was an immense boost to interest in FM reception in the Miami area. The possibility of interesting Miamians in FM reception because low-priced facsimile recording attachments would later be available is being plugged by dealers who were invited to a special private showing.

Sidewalk counts made at the demonstrations showed that many of the spots gave a view of the recorder to 100 to 150 people. The turnover of the crowds increased when loudspeaker systems were installed, explaining what was taking place. The turnover estimate was placed at 5 to 8 per hour so that, in the course of the 14-day demonstration, easily 150,000 people saw facsimile in action.

The Miami Herald is scheduled to receive its General Electric scanning and recording equipment in September, and will make its stock of recorders available to local merchants for display purposes in order to assure maximum public contact with its broadcasting until low cost home facsimile recorders are available through the regular channels of trade.

The Radio Inventions engineer trained the entire FM staff of WQAM-FM in the operation of the facsimile scanner during the first week of the demonstration. Recorders were turned over for operation to students selected from the student body of the technical high school. They proved entirely competent to operate the recorders and to answer questions after a half-hour indoctrination.

One of the amazing features of the first demonstrations of facsimile is the amount of public interest and curiosity which well-run demonstrations are accorded. The writer was in charge of the first public demonstration of facsimile by AT & T in 1923 and of many a demonstration in the intervening years, so the operation of a facsimile machine is hardly a novelty. Therefore, it was somewhat of a surprise to observe that the public viewed facsimile as one of the new wonders of the world and as evidence of the magic of radio progress. Facsimile demonstrates a great deal better than television because it works in full daylight and produces clear, black, permanent copy with sufficient speed and detail to be interest-holding.

The second outstanding point proved in Miami is the capacity of an able news staff to produce attention-compelling copy, taking full advantage of the high transmission speed and instant visibility of copy.

MAGNETRON: GENERATOR OF CENTIMETER WAVES

The Theory of the Magnetron, and Its Development as a Practical Means for Generating Centimeter Waves—7th Installment

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

It is known, however, that an increase of cathode diameter, although it is accompanied by a decrease in electronic efficiency, does reduce the difficulty with *moding* resulting from failure to start in the π mode.

Associated with the rate of buildup of RF oscillation in determining magnetron starting behavior is the rate at which the DC voltage is applied. From the discussion of the electronics of the magnetron, it is clear that oscillation is not possible at all values of V, but only for a limited range near that which provides synchronism between the electron motion and the rotating field pattern. If the pulser can apply a voltage which rises to a value in this region and which can remain at substantially this value regardless of the current drawn, no difficulty is encountered. However, should the pulser regulation be such that to secure operation at a given voltage and current it is necessary to apply a voltage which on no load would rise to a value considerably higher than the operating value, the rate at which the voltage passes through the range of possible operating values and the relation of this rate to that of RF buildup are extremely important. Should the pulse voltage rise so rapidly as to pass through the region where oscillation is possible before the RF oscillation can build up and cause the magnetron to pass current, which by modulator regulation keeps the DC voltage from rising further, the magnetron fails to start. Clearly, the more rapid the oscillation buildup, the more rapid a voltage rise is permissible. Conversely, for a given rate of DC voltage rise, failure to start should appear at greater load and longer wavelength as relation (48) implies. Experience has corroborated both of these conclusions. It is also clear by equation (48) that the equalization of loading of the doublet modes of the same periodicity, which is achieved by proper location of strap asymmetries, equalizes their starting times and makes possible interference with π mode starting less likely.

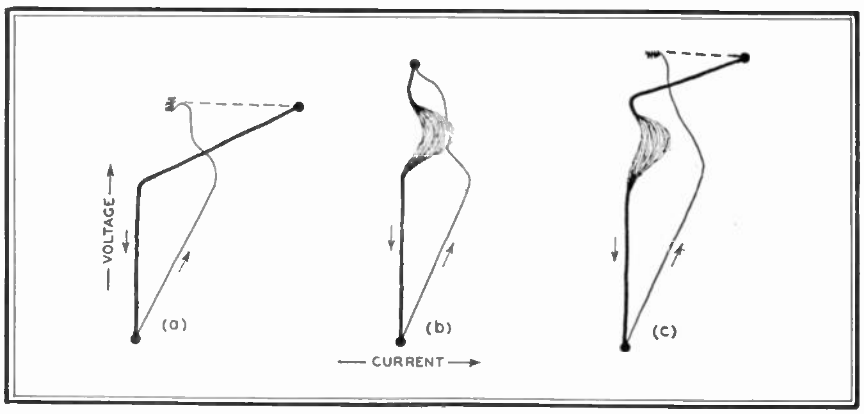


FIG. 38. Three so-called dynamic V-I plots or dynamic performance charts illustrating the mode skip phenomenon. The plots are copies of presentations obtained with an oscilloscope whose vertical deflection is proportional to DC voltage and whose horizontal deflection is proportional to DC current. On any plot the heaviness of the lines is roughly inversely proportional to the rate at which the coordinates are traversed, and the large dot at the upper extremities represents the operating point at the top of the pulse. (*a*) Shows normal operation in the π mode; (*b*) shows failure to oscillate in any mode, the π mode being skipped; and (*c*) shows oscillation in a harmonic of a mode of smaller n.

When oscillation in the π mode fails, the magnetron may fail to oscillate at all or may oscillate in another mode for which the operating voltage in a harmonic is higher than but close to that of the π mode. In this case, as has been seen, $\frac{2\pi f'}{|k'|} > \frac{2\pi f}{N/2}$, and the Hartree line of the *second* or *primed* mode lies just above that of the π mode. This case in which oscillation in the π mode is skipped for oscillation in another mode represents the most common type of moding encountered in pulsed magnetrons. If, on the other hand, $\frac{2\pi f'}{|k'|} < \frac{2\pi f}{N/2}$, and the Hartree line of the harmonic of the second mode lies just below that of the π mode, as in Fig. 16, the magnetron is observed to oscillate first in the second mode, before oscillation at low currents in the π mode commences. When the mode driven during the interval at the top of the pulse is the π mode, oscillation in the second mode occurs only momentarily on the rise and fall of each pulse as the voltage passes through the range of operating values for this mode.

The starting behavior of pulsed magnetrons can be shown by the so-called dynamic performance chart or V-I plot on which the course in time of the voltage and current is shown. In Fig. 38 are shown three V-I plots of this type. The initial current rise is the charging current of the cathode-to-anode capacitance. The current rise when oscillation commences is very rapid and is shown as a dashed line. After remaining for the major part of the pulse at the operating point, indicated in Fig. 38 by a large dot, the current and voltage fall during which they follow closely a constant B line of the static performance chart. See Fig. 17.

In Fig. 38 (a) is shown the dynamic V-I plot for normal operation in the π mode. In Fig. 38 (b) is shown a dynamic plot after the voltage control has been raised above the point of π mode failure. Here the magnetron does not oscillate at all. As seen in Fig. 38 (c), further increase of the voltage control of the pulser makes possible oscillation in the $k = -5$ ($p = -1$) harmonic of the $n = 3$ mode ($N = 8$). In both (b) and (c) of Fig. 38, it is of interest to note how the magnetron tries to oscillate in the π mode as the voltage at the end of the pulse falls through the range of permissible values. These attempts at oscillation are indicated by the magnetron drawing in this region small amounts of current which vary from pulse to pulse.

10.7 *Magnetron Cathodes:* One important component part of the magnetron oscillator which to this point has not been discussed in detail, but which has been assumed present and operating satisfactorily, is the cathode. Its duty is to supply the electrons which serve as the intermediaries between the DC and RF fields. In terms of the usual requirements of vacuum tube cathodes, the number of electrons demanded of a magnetron cathode is little short of prodigious. Magnetron cathodes may be required to deliver current densities of the order of 50 amperes per square centimeter as contrasted with the 0.5 amperes per square centimeter emitted normally by oxide cathodes in high-vacuum tubes.

How oxide surfaces are capable of emitting such enormous currents is not yet entirely clear. It is certain, however, that the RF oscillation in the magnetron is responsible for the fact that such currents can be attained. This is made evident experimentally by measuring the current that can be drawn when the magnetic field is reduced so that oscillation is impossible and comparing it with the current drawn during oscillation. At temperatures even in excess of the operating temperature, such pulsed emission currents of excellent magnetrons may run as low as 1% of the currents flowing during oscillation. Furthermore, the fields at the cathode during these measurements may actually exceed those present during oscillation because of the absence of the dense space charge clouds in the interaction space.

In the process of phase selection of electrons, previously discussed, those electrons starting from the cathode in a phase such as to gain energy from the RF field are removed from the interaction space and driven into the cathode. They impart to the cathode the energy they have gained, causing secondary electrons to be emitted and the cathode temperature to increase. In most magnetrons the amount of this returned energy is about 5% of the input, though in some cases it may become as high as 10%. This means that the average energy of back bombardment may run as high as 75 watts per square centimeter of cathode surface. This amount of energy must be dissipated under equilibrium conditions by radiation and conduction. In general, the short-wavelength magnetrons are run with no heater power supplied to the cathode, the cathode temperature being maintained by back bombardment. In many cases, cathode overheating by this process is actually the limitation on the operating capabilities of the magnetron.

There is some experimental evidence that the large current drawn from the magnetron cathode is not primarily made up of secondary electrons but may result from an *enhanced* primary emission. This is supported by the fact that the secondary electrons emitted at the return to the cathode of the out-of-phase electrons are themselves, assuming negligible emission time, largely out-of-phase electrons later to return to the cathode. However, the emission of large numbers of secondary electrons may lead to an enhanced primary emission by a process not now understood. As possible processes may be mentioned field emission or an actual lowering of the cathode work function, each brought about by the fields in the cathode coating which result from the charge loss attendant upon the secondary emission. Ionic conduction or electrolytic action in the coating may also contribute in some manner to a lowered work function and to the enhanced emission, although such ionic processes would generally involve time intervals longer than a microsecond. The actual mechanism involved, however, is still speculative.

A word about the relation of magnetron scaling to magnetron cathode problems will be in order here. It has been seen earlier that, in scaling all magnetron dimensions by a factor α, the magnetic field changes by a factor 1/α while the current and voltage remain unchanged. That this places severe requirements on the cathode can be seen by considering the scaling of a 10 cm. magnetron down to 1 cm. The operating current may be 20 amperes in both cases. If this corresponds to a current density of 5 amperes per sq. cm. at 10 cm., 500 amperes per sq. cm. will be required at 1 cm. What is more, the back bombardment in watts per sq. cm. is increased by a factor of 100. Both of these requirements are completely unreasonable and preclude direct scaling in this instance. Consequently, an attempt is made in such cases to decrease the current density by increasing both the cathode length and diameter. Increasing the latter usually involves increasing the anode diameter and the number of resonators. Even so, current densities may exceed 50 amperes per sq. cm., as stated earlier.

The pulsed magnetron cathode at the shorter wavelengths (less than 10 cm.) in the centimeter band is a limiting factor in magnetron design. In CW magnetrons, the small size of the interaction space has made the cathode an important and difficult design problem throughout the centimeter wave-length region. Considerable effort has been expended in a number of laboratories not only to understand the physics of the operation of the magnetron cathode but to find suitable materials and constructional designs. It has become clear that a good magnetron cathode which will meet the special conditions of high current density and high voltage gradient and the considerable electron back-bombardment are these: (1) sufficient primary emission to enable the magnetron to start and to supply a part of the required operating current; (2) sufficient secondary emission to supply the remainder (it may be practically all) of the required current density through whatever mechanism is involved; (3) sufficient active material to permit satisfactory life; (4) some mechanical means of holding the active material on the cathode surface; (5) sufficiently low electrical resistance of the coating to permit large bursts of current without undue local heating and high back-bombardment without excessive coating temperature; and (6) satisfactory over-all heat-dissipation characteristics, conductive and/or radiative, to keep evaporation of active material to a minimum.

In pulsed magnetrons of 10 cm. wavelength or greater, it has generally been possible to use plain oxide-coated cath-

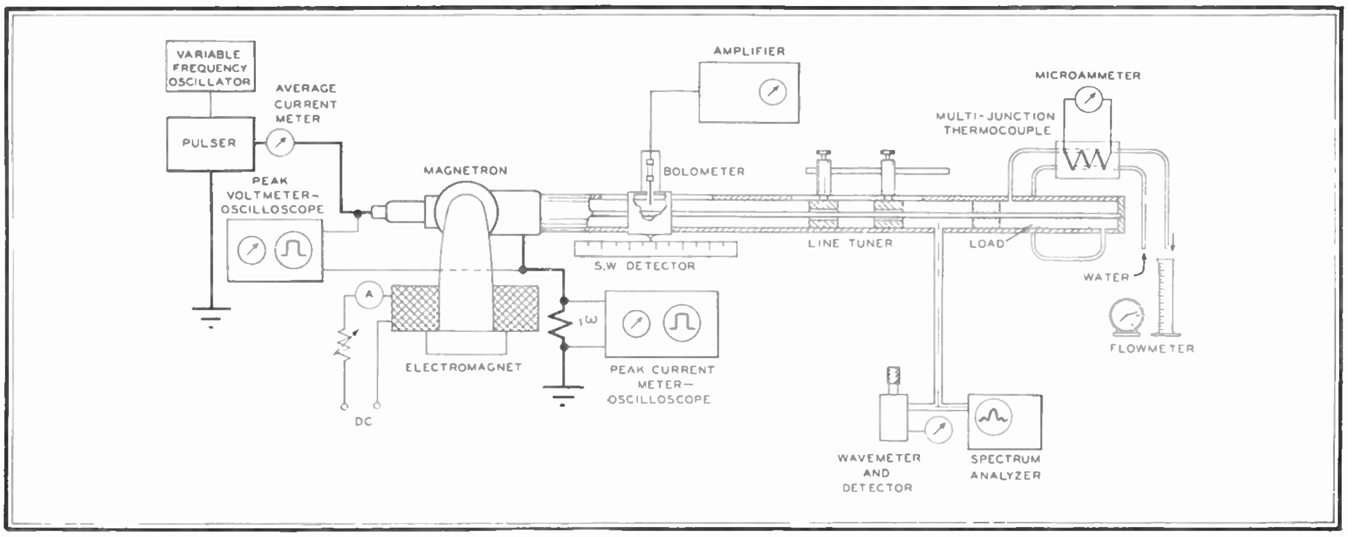


FIG. 39. A diagram showing the arrangement of apparatus generally used in making measurements on an operating magnetron in the laboratory.

odes. Nickel-base material is generally used, and the active material is the usual double carbonate coating (reduced to the oxides during activation). At wavelengths of 3 cm. and shorter, the development of satisfactory pulsed magnetrons would have been impossible without the development of special cathodes. In the main, these have been aimed at meeting requirements (3) to (5) above. The constructions have made use of wire meshes and of sintered nickel matrices both to reduce the coating resistance and to hold sufficient material on the cathode in a manner such that it can be dispensed gradually during life.

10.8 *The Magnetic Circuit:* The magnetic field required for operation of the magnetron oscillator is generally obtained, except in laboratory experiments, by means of a permanent magnet. At long wavelengths and in early models at shorter wavelengths, the magnetron and permanent magnet are separable. Building the magnetic pole faces into the magnetron structure itself and attaching the magnetic material to it has made possible the reduction of the over-all magnet gap, and hence total magnet weight, as well as the use of mechanically superior axial cathode mountings. The resulting so-called *packaged* magnetron design has been used at shorter wavelengths where the magnetic fields are high but need not extend over a large area. The total magnet weight under these conditions is much less than that required in a separate magnet. Needless to say, the possession of good permanent magnet material and the work done on magnet design have contributed materially to the success of the centimeter-wave magnetron.

10.9 *Magnetron Measurements:* The fundamental measurements made on the magnetron oscillator have already been discussed or alluded to where the performance characteristics of the magnetron and its circuit theory are described. Here will be described briefly the technique of measurement:

Magnetron measurements are of two general types. One is made on the oscillating magnetron and the other on the non-oscillating magnetron. The latter can be made at any stage in the fabrication of the magnetron after its anode structure and output circuit are completed. Figs. 39 and 40 illustrate schematically the apparatus employed in these tests.

Perhaps the best way of describing the techniques of magnetron measurements is to list all of the parameters, quantities, or characteristics associated with such measurements, and for each to give the definition, method of measurement or calculation, or the way it is put together from other data, as the case may be. In any event, the list given below permits of ready reference. Although the text applies directly to pulsed magnetrons, the simplifications for CW magnetrons are obvious.

The *DC magnetic field B* in which the magnetron operates is generally supplied in the laboratory by an electromagnet, the field in the gap generally being calibrated in terms of the current passed through the magnet coils.

The *peak DC voltage V* applied to the magnetron cathode is measured by means of a peak voltmeter or by observing a known fraction of the voltage pulse on the calibrated screen of an oscilloscope. In a simple but suitable peak voltmeter it is arranged to charge a condenser through a diode to the peak voltage which then can be measured with a high-resistance DC voltmeter.

The *peak DC current I* drawn by the magnetron is measured by passing the current through a known resistance, usually 1 or 2 ohms, and determining the peak voltage developed across the resistance by means of a peak voltmeter or calibrated oscilloscope.

The *average DC current* drawn by the magnetron is the current measured on a DC meter connected in one leg of the pulsing circuit, as shown in Fig. 39.

The *pulse duration* τ, as its name implies, is the length of the time during which the voltage, usually measured near the top of the pulse, is maintained across the magnetron. It can be determined from the pulse presentation on an oscilloscope having a calibrated sweep, or it can be calculated as indicated below when other parameters are known.

The *pulse recurrence rate pps* is the repetition frequency at which the voltage pulse is applied, and is determined by the frequency of the calibrated primary oscillator driving the pulser or modulator circuit.

The *duty cycle*, defined as the fraction of time the pulsed magnetron operates, can be determined as the ratio of average to peak DC current, or as the product of the pulse duration and the pulse recurrence rate.

The *peak input power* is the product of the peak DC voltage and the peak DC current.

The *average input power* is the product of the peak input power and the duty cycle.

The *voltage and current pulse shapes* as observed with oscilloscopes are of importance in studying the spectrum and moding characteristics of the magnetron under test.

The *dynamic V-I plot*, or *dynamic performance chart*, is viewed on an oscilloscope in which, at any instant, the vertical deflection is proportional to peak DC voltage, and the horizontal deflection proportional to peak DC current. Three such plots are shown on Fig. 38, and their usefulness is indicated in the corresponding text.

The *average output power* is the average centimeter-wave power delivered to the useful load. The simplest and most foolproof method of measuring this power is to absorb the energy in a column of water. From a determination of the rate of water flow and its temperature rise, the power can be calculated readily. The water column terminating the coaxial line or wave guide of the test apparatus is made reflectionless either by tapering it or preceding it by a quarter-wavelength matching plate of proper dielectric constant, analogous to the optical quarter wave plate.

The *peak output power* can be calculated as the average output power divided by the duty cycle.

The *over-all efficiency* of operation is the ratio of the peak output to peak input powers or the ratio of average output to average input powers.

The *frequency of oscillation* of the magnetron is determined by feeding a small amount of the RF power into a calibrated variable-frequency resonant cavity of high Q and, by means of a detector, observing the frequency at which the cavity absorbs or passes power.

The *load impedance* into which the magnetron operates is determined by measurement in the output line of the voltage standing-wave and its phase with respect to some previously chosen reference point. This measurement is made with a *standing-wave detector* in which it is arranged to move an electrostatic probe along a section of slotted line in which it samples the RF energy in the line. The energy picked up by the probe is detected after sufficient attenuation either by a crystal

(CONTINUED ON PAGE 52)

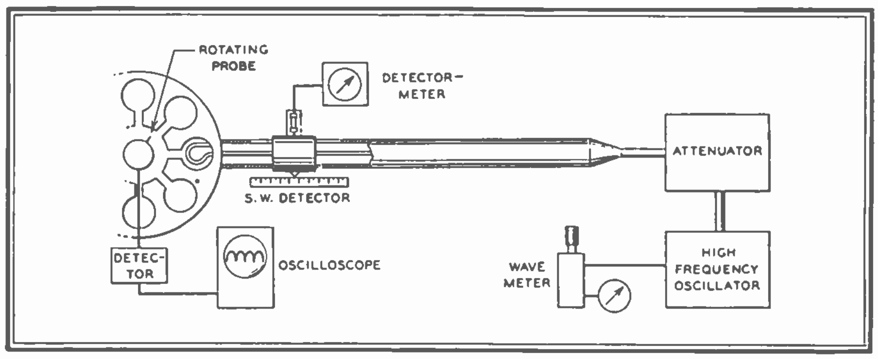


FIG. 40. A schematic diagram showing the arrangement of apparatus used in making measurements on a non-oscillating magnetron or magnetron resonator block.

INSURANCE NEEDS FOR RADIO STATIONS

Analysis of Insurance Requirements of Radio Stations, and Types of Coverage Available—Part 3

BECAUSE broadcast stations and communications systems present unusual and very special insurance problems, this analysis, prepared by the Fidelity & Casualty Company, is of great importance to radio station managers.

Part 1, concerning protection of investment in real property, and Part 2, covering protection of other assets, appeared in the January and February, 1947 issues, respectively. Copies of those issues are still available for those who need them.

DIVISION 3—PROTECTION AGAINST CLAIMS

A. Indispensable Insurance ★ Every radio station, whether it be a broadcasting station, experimental installation, laboratory or other type of operation, has a responsibility for bodily injury to persons and damage to property of others that is inescapable and of great importance. The hazards that are created by the existence or operation of any enterprise present risks involving more than the mere capital invested. If injuries to persons or damage to property are found to have been the result of negligence on the part of the radio station, the resultant monetary damages may exceed the amount that could be obtained or realized by the sale of the entire equipment and assets of the radio company.

Liability insurance is, therefore, of primary importance and, as indicated in the beginning of this article, should be carried with limits of sufficient amount to meet every possible contingency. There are many forms of this insurance, designed to meet various types of exposures, and some or all of them will be on the station's "must" list. This type of insurance is the only way in which the present and future assets, as well as the anticipated earnings, can be protected against loss by reason of liability under the laws of negligence.

Defense costs and all other legal expenses incurred by the insurance company arising out of an accident are included as a part of all public liability policy provisions, and are not limited by the stipulated policy limits. This feature of every liability policy is extremely important since it applies even if the legal action is fraudulent or groundless.

Liability insurance will pay (with respect to the hazards or exposures insured), up to the limits stated in the policy, any judgment that may be awarded for bodily injuries or death to persons or damage to property of others that may result from negligent acts of the company or any of its employees or officers. Injuries to employees which would be covered by a Workmen's Compensation Act or law are specifically excluded.

Damage to property owned by the broadcasting station or in its custody or control is also excluded.

PREMISES AND ELEVATORS — OWNED OR OCCUPIED: Any premises which are occupied by a radio broadcasting company should be insured under a liability policy covering loss by reason of negligent acts causing bodily injuries to persons or damage to property.

It is important to note that in connection with the use and existence of studios certain types of performers may not be legally considered employees of the broadcasting station, but rather considered as independent contractors or even members of the public. In this event, they would not be considered employees with respect to Compensation Laws of the various states and, if there is the possibility of having guest stars or performers on the premises, high limits of liability insurance should be carried. It is obvious that a high-priced and well-known musician, for example, would obtain a judgment in a sizable amount for accidental injury due to negligence.

Transmitter stations and towers and also other similar types of installations should be insured whether on premises owned or leased.

Premises which may be owned by the radio station and not presently occupied by but are leased to others for their use should be insured also, since the mere ownership of premises creates a liability exposure to loss which may result from negligence in maintenance or operation. For the same reason, elevators in premises owned by the station or under its entire control should be adequately insured.

OPERATIONS — RADIO: Liability insurance is important with respect to radio broadcasting operations which do not originate at a fixed location, such as a studio or transmitting station. This would include roving microphones and television cameras used by employees in connection with broadcasts of special events, such as parades, baseball games, ship launchings, fires, and other noteworthy occurrences.

OPERATIONS — CONSTRUCTION: Specific insurance must be carried in connection with the construction of additional radio transmitting stations, towers, studio buildings or any other type of new construction. If the construction work is to be performed by employees of the radio broadcasting company, a distinct exposure will exist with respect to bodily injuries or death to members of the public, as well as with respect to damage of property of others. The limits of liability for both bodily injury and property damage must be commensurate with the exposure involved, as determined by the traffic and activity in the adjacent neighborhood.

ASSUMED LIABILITY: It is important to note that the ordinary public liability policy does not, unless specific provision is made, cover more than the insured's own legal liability. In other words, if by the nature of some contract or lease, the radio station has assumed the liability of another, proper insurance must be specifically arranged under what is known as "Contractual Liability". Such assumptions are not unusual and may be found in leases, easement agreements, or any contracts between two parties that gives the right to occupy, maintain, use, operate, or construct on the property which is the subject of the contract. This may be in connection with a roof top for the construction and maintenance of a tower, vacant property for a similar purpose, rights of way for transmission lines, easement agreements, or similar types of contracts.

Many of these assumptions of liability appear innocuous on the surface but have great potentiality of causing financial loss to the radio station. It is, therefore, recommended that an attorney be employed in connection with the signing of every contract, and that he be requested to pay particular attention to this phase of the document. For example, it will probably be found that every lease with a building owner for the use of his roof top to construct and maintain a tower will have a provision whereby the station assumes the liability of the building owner for any bodily injuries or damage to property that such owner may have because of the existence, use, maintenance and construction of the tower. It can easily be seen, therefore, that liability insurance with high limits is an important form of protection in connection with all such exposures. This liability will be in addition to any liability the radio station may have on its own part.

The contracts under which one party assumes the liability of another are fre-

(CONCLUDED ON PAGE 49)

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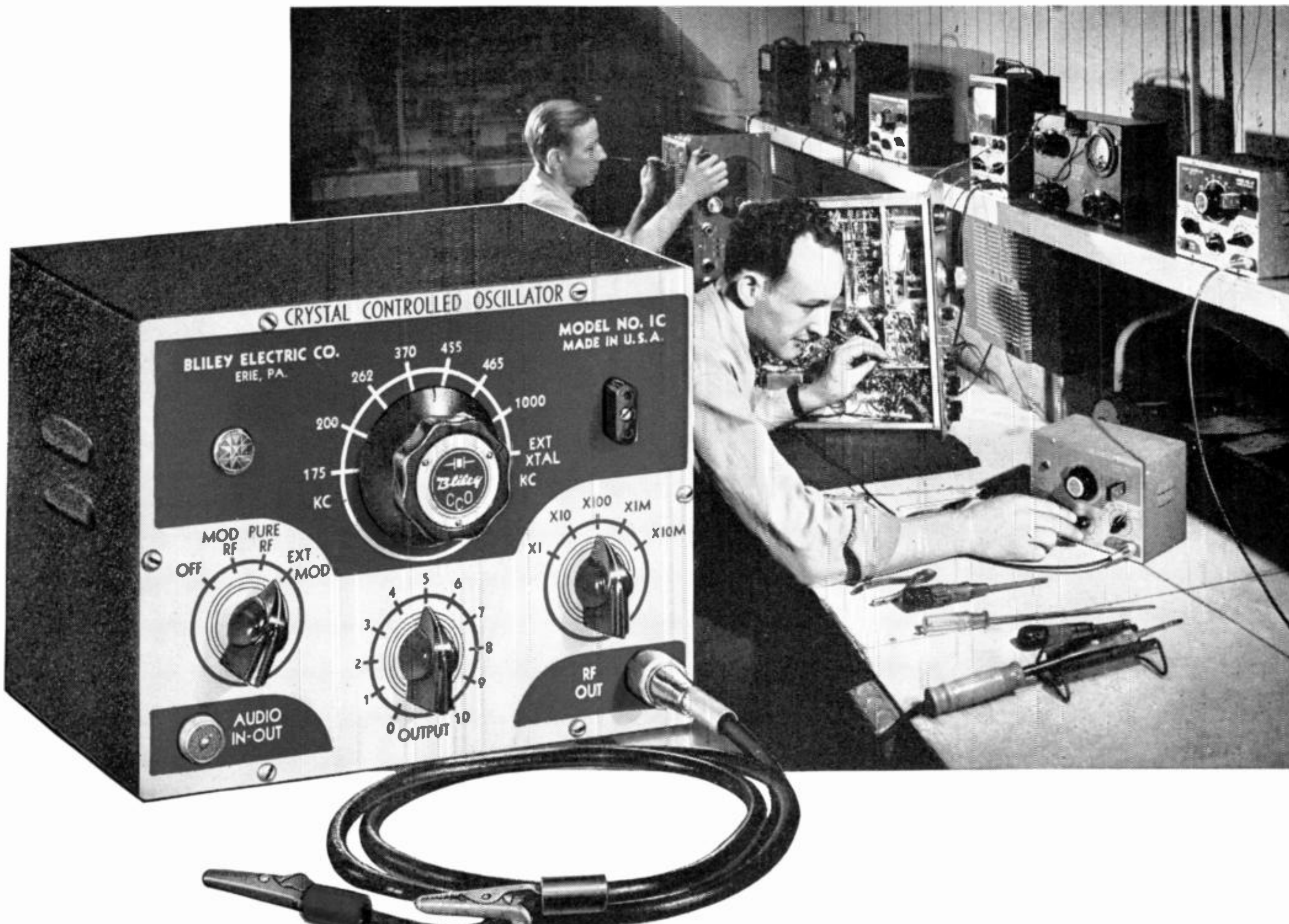

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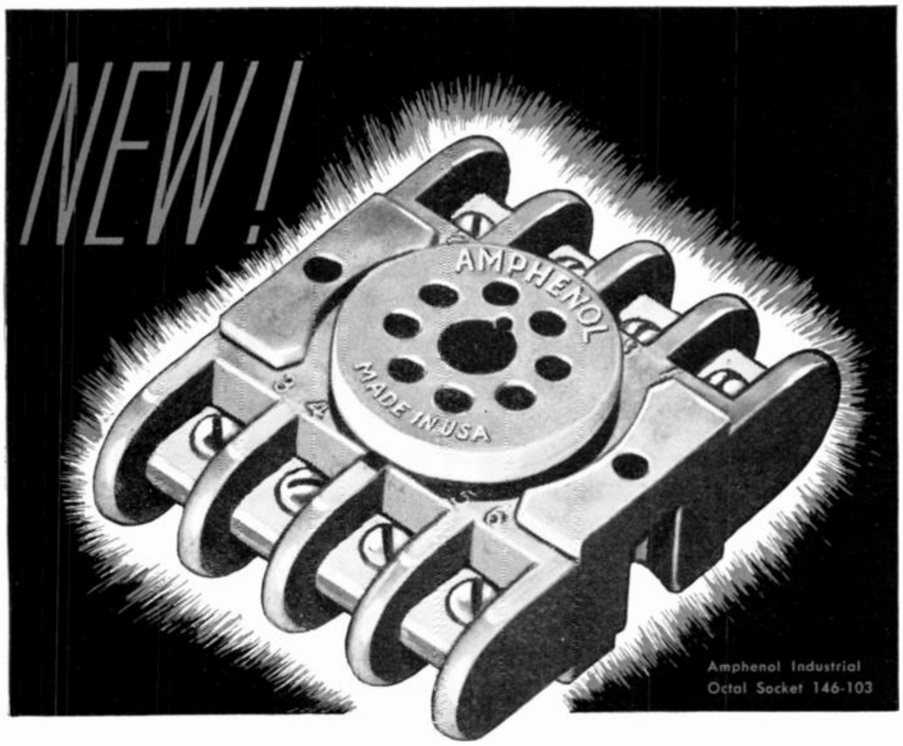

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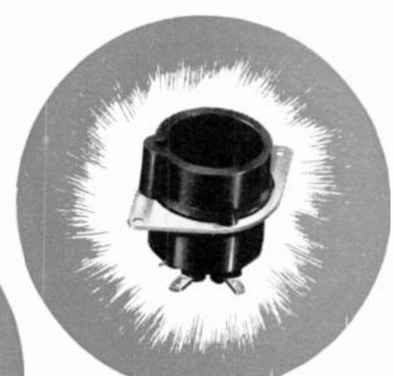

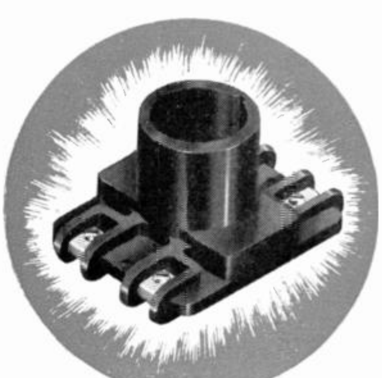

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- Gearing is such that only 3 turns of the selector wheel will run the entire length of the 6¼ foot chart.
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An independent testing laboratory recently reported of the Simpson Model 330, "It does every thing you claim for it. We have never tested a finer instrument." And, just as there has never before been a tube tester to equal this one, so there has never before been a Roll Chart to offer the mechanical perfection of the new Simpson "No-Backlash" Roll Chart. Read *its* story in the panel below.

The Simpson Model 330 RC tests tubes in terms of percentage of rated dynamic mutual conductance—a comparison of the tube under test against the standard rated micromho value of that tube. It tests tubes with voltage applied automatically over the entire operating range, reproducing more completely than ever before the actual conditions under which a tube functions in a radio receiver. The colored zones on the dial coincide with the micromho rating or the percent of mutual conductance, indicating that the tube is good, fair, doubtful, or definitely bad. Thus you check against manufacturers' ratings.

Equally revolutionary is the switching arrangement. The circuit is so arranged that, even though numerous combinations are possible, very few switches require moving to test any one tube. Many popular tubes are tested in the "normal" position without moving any of the nine circuit switches. Only a few settings of the rotary and push button switches are necessary for the most complicated tube. The "No-Backlash" Roll Chart is arranged for quickly identifying the tube and setting the controls.

When you have finished a test, just press the Automatic Reset button and instantly all switches, *both push button and rotary,* return to normal automatically. This not only saves time but prevents the possibility of error due to previous settings being left in position at the beginning of the new test. The Reset mechanism, in whose design and tooling many thousands of dollars have been invested, is Simpson patented.

This beautifully cased instrument has a panel of heavily molded bakelite of handsome satin grained finish, and a 4½" rectangular meter of modern design.

Size, 15½" x 12" x 6¼". Weight 11 lbs.
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INSTRUMENTS THAT STAY ACCURATE

quently called "hold harmless" or "save harmless" agreements.

Automobile — Owned: The ownership or operation of automobiles, trucks or other motor vehicles creates a responsibility for the radio station to members of the public for injuries or death sustained as well as for damage to property of others. The automobile policy covers liability, up to the policy limits, for the operation or use of such automobiles.

Comprehensive Liability: A very broad form of liability insurance has been written into the so-called Comprehensive Liability Policy. This policy is a combination of all of the various liability coverages commonly purchased under separate policy forms. It also includes additional service hitherto not available, since it grants automatic coverage on unforeseen and unpredictable exposures. The radio station would therefore have complete protection in connection with all unknown hazards other than those specifically excluded at the request of the insured. This protection against unknown exposures is of great importance since new and unusual types of loss arise from time to time, and the various forms of liability insurance policies formerly written may be entirely inadequate to cover these risks.

The policy form itself has been greatly simplified and the exclusions common to public liability policies have been correspondingly reduced. For example, the principal exclusions pertain to injuries to employees or obligations under any Workmen's Compensation Law; watercraft away from the premises; aircraft; and assumed liability other than certain specific types such as leases, easements and agreements required by municipal ordinance. In certain states, automobile accidents are also excluded if they occur away from the insured premises but in most instances automobile exposure can be included in this broad comprehensive policy.

Libel and Slander: A broadcasting station may be liable for broadcasting an untruth even though it did all it could to verify the accuracy of the statement made, and it may also be liable for defamatory material broadcast by it, even though such material is received by wire from another station and even though the originating station has, by examining the script and otherwise, taken precaution to prevent the broadcast of untrue material. There is even the possibility that a broadcasting station may be held liable for the acts of a person on the air in one of its own studios who suddenly departs from the prepared script and interpolates defamatory remarks ad lib. Courts and legal authorities have differed as to the correct rules to be applied in the foregoing cases, but the desirability of insurance against such liability for libel and slander is evident. As indicated in the beginning of this division, the costs of defense are included in this insurance, and are a very important part of this protection.

Patents and Copyright Infringement: Infringement of patents and copyrights renders the infringer liable to the owner of the patent or copyright. This is also true where use of a patented device or copyrighted material is licensed but the licensee may infringe the patent or copyright by violating the terms of his license. The radio station should consider the purchase of insurance for this form of liability. The costs of defense are an important part of this insurance.

Workmen's Compensation and Employers' Liability: All states in the Country, with the single exception of Mississippi, have enacted Workmen's Compensation Laws for the protection of employees. The laws of the various states differ with respect to the category of employment and operations which are brought under their jurisdiction. Every radio broadcasting company should make careful inquiry in connection with this point since responsibility under the law is a very definite and clear-cut one if employees are brought within the scope of the Compensation Law.

The workmen's compensation policy issued where applicable must, by law, cover awards to employees who may be injured while in the performance of their duties. Failure to secure compensation insurance on employees, if this is required under the law of the state, provides for stated penalties, in addition to any awards to employees.

In certain instances employees may be specifically exempt from the provisions of the Workmen's Compensation Law. In this event, the standard compensation policy provides protection under common law for injuries or death of employees due to the employer's negligence.

The payment of compensation awards made according to the laws of the various states may be guaranteed in one of several ways, primarily the purchase of insurance in a private insurance company, the filing of self-insurer's statement and certain collateral with the state authorities, or in some states by carrying the insurance with the State Compensation Fund. There are some states in which the State Compensation Fund has a monopoly and private carriers are not permitted to write this form of insurance.

In the State of Mississippi, Employers' Liability insurance covers liability under common law for injuries or death of employees which may be sustained while they are performing their duties within the scope of their employment. This insurance is written with stipulated limits similar to those in a public liability policy.

B. Insurance of Secondary Importance ★ Automobile — Non-Owned: Special automobile insurance should be carried as a protection in the event that employees or officers use their own automobiles on business for the broadcasting station. It has been definitely established by various court decisions that it is not the ownership of the automobile which makes the employer legally liable, but the relationship of master and servant and the fact that the automobile is being operated for business purposes. This insurance should be written to provide protection with respect to all employees regardless of whether they regularly use their own automobiles or not.

Motor vehicles hired by the radio station or those operated by independent contractors in connection with business for the radio station also present an exposure to loss and should be insured in connection with the so-called "non-ownership automobile policy."

Owners' Protective: New construction work, whether the construction of new buildings, additions to existing buildings, or major alterations or structural changes in existing buildings, are not covered by the ordinary public liability policy. If this work is performed for the radio station by an independent contractor this insurance will protect the station's interest in such work.

The contractor who is performing the work for the radio station will be primarily liable, but owners of property where work is being done have a contingent liability particularly if a contributing cause of the accident may be some inherent hazard in the property itself, such as the erection of towers on high buildings. If the work is being performed by contractors, it is important to secure certificates of insurance from all independent contractors providing evidence that they carry both public liability and Workmen's Compensation insurance, because if the contractor does not carry such insurance himself the station may be obligated to make compensation payments to his employees if they should be injured on the station's premises.

Property of Others: Musical instruments, scores, and special equipment of performers and employees may be insured against the risk of fire and theft while such property is within the premises. Damage to privately owned equipment and other property would also be insured if such damage is caused by employees or by the operation of the radio station.

Occupational Diseases: The compensation policy covers only awards made for injuries under the Workmen's Compensation Law. There may be an exposure to other occupational diseases not covered by state laws for which the employer might be liable at common law. Insurance against loss by reason of claims arising out of such occupational diseases may be covered by an extension of the compensation policy.

WHAT'S NEW THIS MONTH

(CONTINUED FROM PAGE 4)

wards the development of low-cost television receivers . . . The objective of television heretofore mentioned of bringing news, education, culture, and entertainment to large numbers of people cannot be carried out unless television receivers are manufactured and sold at a price which the average family can afford to pay.

"Secondly, further experimentation should be conducted along the line of finding methods of transmitting color television over narrower channels . . . It should be emphasized that narrowing the band width should not be at the expense of picture brightness, picture detail, color fidelity, or other features of television performance. The objective should be a narrower band width while retaining and even improving the quality of television performance.

"Before approving proposed standards, the Commission must be satisfied not only that the system proposed will work, but also that the system is as good as can be expected within any reasonable time in the foreseeable future. In addition, the system should be capable of permitting incorporation of better performance characteristics without requiring a change in fundamental standards. Otherwise, the danger exists that the standards will be set before fundamental developments have been made, with the result that the public would be saddled with an inferior service, if the new changes were not adopted, or if they were adopted, receivers already in the hands of the public would be rendered useless.

"Judged by the foregoing test, the Commission is of the view that the standards for color television proposed by Columbia Broadcasting System should not be adopted. In the Commission's opinion the evidence does not show that they represent the optimum performance which may be expected of a color television system within a reasonable time."

SPOT NEWS NOTES

(CONTINUED FROM PAGE 28)

Switzerland, can be used with great success as a solder for joining aluminum parts, and for joining aluminum to copper. The report covers electrical, vibration, and salt-spray tests.

Frank H. Barnett: Who has been in charge of production at the Westinghouse plant at East Springfield, Mass., since 1937, is now manager of manufacturing for the home radio division at Sunbury, Pa.

New FM Models: Stewart-Warner has announced two FM-AM consoles and three table models. The third Farnsworth FM-AM phonograph combination has been started in production. Hallicrafters has entered the home radio field with two FM-AM phonograph models.

Chicago: Raytheon's broadcast equipment division is being moved to the Company's main plant at Waltham, Mass., near Boston.

WBT-FM: At Charlotte, N. C., is coöperating with FM set distributors by giving 7 hours of FM daily from studios open to the public. Distributors rotate FM set displays at the studios on a weekly basis, and visitors hear the broadcasts over the sets displayed. Dealer representatives are on hand to answer questions and demonstrate the sets. The plan is proving highly effective in promoting FM set sales.

Communications Mike: A new noise-cancelling hand microphone has been introduced by the Turner Company, Cedar Rapids, Ia. Intended for use in cars, planes, locomotives, and factories, it accepts only close-talking speech, and cancels out ambient noise.

Austin C. Lescaboura: Already the recipient of the French order of Officier d'Academie and the decoration of Academic Palms, has been awarded the order of Officier de L'Instruction Publique, in recognition of technical services over a period dating back to World War I.

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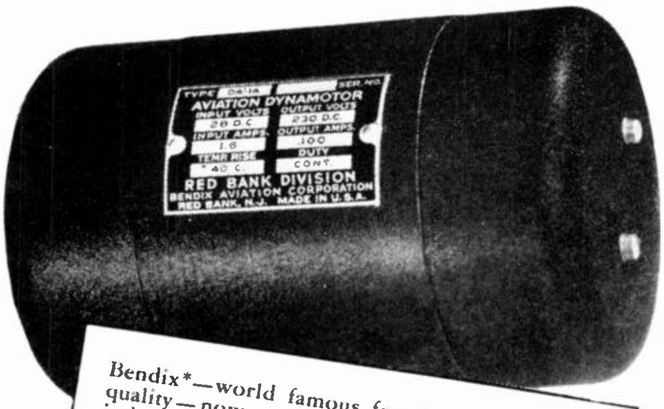

Bendix*—world famous for top-flight aviation quality—now makes available to the radio industry these low-cost D.C. Transformers.

- **Specially designed for long life, light weight, and low ripple.**
- **Standard diameters run 2¾, 3⁷⁄₁₆, 4, 4½, 5 and 5¼ inches.**
- **From 12 to 1100 volts and from 15 to 500 Watts output.**
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- **Single, dual, and triple output.**
- **Regulated and unregulated.**

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STANDARD RATINGS

Model	Frame Size	Input Volts	Output Volts	Output Watts	Approx. Weight
DA58A	2¾"	14	250	15	2 lb. 12 oz.
DA1A	3⁷⁄₁₆"	14	230	23	5 lb.
DA77A	4"	5.5	600	104	9 lb. 12 oz
DA1F	4½"	25	540	243	11 lb. 8 oz.
DA7A	5¼"	26.5	1050	420	26 lb. 10 oz.

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MEMO to Purchasing Agents and Chief Engineers: New circuits and higher frequencies, obsoleting the old familiar types of coils, call for completely new production facilities, methods, and standards of precision. In this connection, we'd like to point out something of special interest to you.

When you select a source of supply for your coil requirements, you are naturally concerned with picking an experienced organization. But what kind of experience do you want? There are two kinds, you know.

One is experience that develops into the habit of always doing the same thing in the same way. It wears a groove that becomes a rut which offers resistance to progressive thinking.

The other kind is experience that points the way to better, less expensive ways of doing familiar jobs, and develops the ability to originate ways of doing new jobs successfully, without delays.

At ARTTED, when we talk about our experience in coil winding, we refer to the second kind. We're talking about an 8-year record of continuous improvement in skills, methods, and equipment, of success in meeting new coil production problems.

We'd like to show you tangible evidence of this, whether it's on a standard type of coil, or an entirely new design. If you're in a hurry, call Springfield, Mass. 3-3944. Remember, ARTTED is only a few hours from New York and Philadelphia, and overnight from Chicago. — *Arthur Demers* and *Theodore Klassanos.*

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RF FILTERS • IF COILS • DISCRIMINATOR COILS • RF CHOKES • RF FILTERS

MOTOR-DRIVEN ANTENNAS

Rotating dipole antennas which can be oriented by the operation of a simple switch at the receiving set are proving highly effective for both FM and television at locations where signals are weak, or where television ghosts interfere with reception from stations in different directions.

Antennas of this type, priced very reasonably, are being manufactured by Kings Electronics, 372-F Classon Avenue, Brooklyn 5, N. Y., and by The Workshop Associates, Inc., 66-M Newton Highlands, Mass. Literature is available on request.

MAGNETRON OSCILLATOR

(CONTINUED FROM PAGE 42)

or by a small bolometer whose resistance is a function of the energy fed into it. The voltage standing-wave ratio and its phase can be translated into impedance, admittance, or reflection coefficient in the manner already discussed. The magnetron load impedance can be varied from the match presented by the terminating water column by means of a *line-tuning section* or *tuner*. In one such line-tuning section, two sleeves constituting in effect quarter-wavelength lines of low characteristic impedance can be moved relative to one another to vary the magnitude, and moved together to vary the phase of the standing wave.

The *Rieke diagram* is a plot of constant output power and frequency on a reflection coefficient plane. Its construction thus involves the measurement of output power, frequency, and load impedance as the line tuners are moved over a wide range of positions. The operating parameter maintained constant is usually chosen to be the peak DC current. Such a diagram is shown in Fig. 33.

The *pulling figure PF*, defined as the maximum frequency excursion of the magnetron as the load reflection coefficient traverses the $\rho = 0.2$ circle, may be obtained from the Rieke diagram. It can be measured directly by two simple wavemeter measurements taken at the frequency extrema occurring as the standing wave of 1.5 voltage ratio is moved up and down the line. Various types of *standing wave introducers* have been devised to produce a reflection coefficient of $\rho = 0.2$ for the specific measurement of pulling figure.

The *performance chart* is a plot of constant magnetic field, peak output power, and over-all efficiency contours on a *V-I* plane. Its construction thus involves the measurement of peak DC voltage, peak DC current, and peak output power at several magnetic fields. Sometimes frequency, pushing figure, and spectrum appearance are also determined. Figs. 17 and 20 are examples of this chart.

The *frequency spectrum* is the distribu-

(CONCLUDED ON PAGE 54)

The trade marks, FAX and FAXIMILE have been applied for registration by Faximile, Inc., and the trade mark, FAXPAPER has been applied for registration by Radio Inventions, Inc.

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MAGNETRON OSCILLATOR

(CONTINUED FROM PAGE 52)

tion of energy with frequency for a pulsed magnetron and is displayed on a so-called *spectrum analyzer*. This analyzer is a very narrow band tunable-radio receiver whose pass band is varied periodically twenty or so times per second over several mc. The response of the receiver to the frequency distribution of energy appears on an oscilloscope whose sweep is synchronized with the pass band frequency variation.

The *pushing figure* is the instantaneous frequency change in mc.-per-ampere change in peak DC current at constant load. It can be obtained by measuring the frequency shift on a spectrum analyzer as the pulse current is changed by a known amount. The current change must be executed rapidly enough to avoid frequency shifts arising from temperature changes.

Impedance measurements on the non-oscillating magnetron involve the use of a variable frequency RF oscillator feeding power through an attenuator and a standing-wave detector into the output circuit of the magnetron. See Fig. 40. These measurements determine as a function of frequency the impedance Z_c discussed in the text.

Mode frequencies are determined from the impedance measurements on the non-oscillating magnetron by noting the frequencies at which the input standing wave is observed to go through a minimum. They can also be determined by the observation of energy maxima with a pickup loop or probe placed in the resonator system.

Mode identification is made by observing the periodicity of RF field in the interaction space of the resonator system. This is done by sampling the field with a rotating RF probe placed in an axial cylinder corresponding to the cathode as shown in Fig. 40. The probe response is detected and displayed on an oscilloscope with sweep synchronized to the rotation of the probe.

Next month, beginning Part 2, Development Work on the Magnetron Oscillator.

TELEVISION HANDBOOK

(CONTINUED FROM PAGE 35)

optical system to avoid aberrations. This is particularly true of tubes requiring a long focal length of projection lens, as in the dissector tube. There is some point in keeping the size of the image as small as possible in pick-up tubes which utilize magnetic focussing fields for extended images, in order to minimize a type of distortion known as S distortion. On the other hand, it is desirable always to operate over the maximum amount of focal surface possible in order to obtain maximum sensitivity.

At the receiver, it is usual to reproduce

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TELEVISION HANDBOOK

(CONTINUED FROM PAGE 54)

a picture approximately 8 by 6 ins. on a 10-in. tube. This means that the corners of the image have to be rounded and cannot be square because there is actually not a 10-in. diameter of the tube face which is useful. Designers usually take advantage of the fact that there is not much information in the corners and, therefore, they make the rectangle slightly larger than would be allowable. This corner cutting is illustrated in Fig. 22.

One of the problems of television reception is to obtain a very small, bright image on the end of a projection tube so that a reasonably-priced lens can be used to project this image. Projection images of the 35-mm. variety would be ideal on the face of the projection tube because projection lenses for such images would not be too costly. The trend of the television art seems to be in this direction as of today. At present, however, it is more usual to encounter images approximately 4 by 3 ins. on projection tubes. This requires either an expensive projection lens or a Schmidt optical system.[2]

Optimum sizes of pictures for various types of cathode-ray tubes can be calculated by the aid of formula (4.0) by assigning to the radius of the screen, r, a value which will allow some corner cutting. It has been usual in projection television to produce pictures having a size of 24 by 18 ins. There seems to be some tendency lately, however, to reduce the size of this picture to 16 by 12 ins. in order to obtain greater screen brightness. It is expected that projection receivers will be manufactured which produce pictures only 12 by 9 ins. in the future.

[2] See "Lens System for Projection Television" by John P. Taylor, *FM* AND TELEVISION, June, 1945.

To be continued next month

FIELD ALIGNMENT

(CONTINUED FROM PAGE 27)

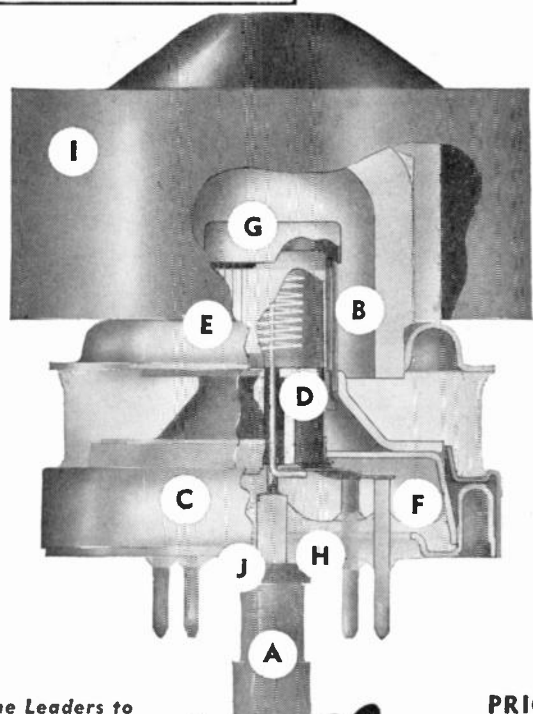
made by detuning the two secondaries in opposite directions, as far as frequency is concerned, until the rectified diode currents drop to two-thirds of the resonance reading. This automatically puts each secondary tuned circuit approximately 25 kc. away from the center.

When tuning the antenna, RF, and IF stages, the test set should be placed some distance from the receiving antenna. The distance should be such that noise just starts to come in along with the oscillator signal. If the receiver is out of tune, it will be noticed that proper tuning will decrease the amount of noise coming from the speaker. In fact the quieting effect of the tuning is a good check on the accuracy of alignment.

This simple test set should prove of value to others who maintain the hundreds of police, fire, and utility systems now in operation.

UHF tetrode

Eimac 4X150A Power Tetrode		
Electrical Characteristics		
Heater voltage	6.0	volts
Heater Current	2.7	amps.
Grid-screen amplification factor (approximate)	4.	
Direct interelectrode capacitance (typical)		
Grid-Plate	0.02	μμf
Input	12.0	μμf
Output	4.6	μμf
Maximum Ratings		
DC Plate voltage	1000	volts
DC Plate current	200	ma.
Plate dissipation	150	watts
DC Screen voltage	300	volts



The 4X150A, a new Eimac tetrode, extremely versatile—diminutive in size, will fill the bill in all types of application and at all frequencies up to 500 mc. Performance characteristics include — high transconductance, low plate voltage operation, low grid drive, high plate dissipation, and traditional Eimac-tetrode-stability. Physical features include:

- **A** Low inductance grid lead.
- **B** Close element spacing for UHF and high transconductance.
- **C** Screen grid, mounting, and ring connector design effectively isolates input and output circuits.
- **D** Heater isolated from cathode.
- **E** Indirectly heated cathode.
- **F** Low inductance cathode terminals, (four separate paralleled pins).
- **G** Controlled primary and secondary grid emission, by specially processed grids.
- **H** New molded glass header, precision pin alignment.
- **I** Forced air cooled (vertical finned).
- **J** Simple installation, adaptable to standard loctal socket.

You will find the 4X150A suited to your requirements, whether for wide-band low-efficiency service such as television video and audio or conventional application. For further information on this new, versatile, Eimac tetrode, type 4X150A, write to:

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10,000 watt FM
Broadcast Transmitter

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Operating reliability and efficiency are your assurance of economical operation. In Collins FM transmitters each stage has been carefully designed for maximum efficiency. The requirements of every component were determined and generous safety factors allowed. You can depend on a Collins transmitter to give you continuous efficient performance.

Lasting Economy

The 10 kw 734A (shown above) consists of a type 732A 1 kw transmitter to which have been added a 10 kw amplifier and an amplifier power supply bay. The economy of thorough engineering is apparent in the initial cost of the transmitter and in the low operating expense. Each stage functions with high efficiency, thus a minimum number of stages is required. Only 34 tubes are utilized in the entire transmitter, *with only ten different tube types.* Low maintenance costs are assured by the use of highest quality components operated conservatively.

Advanced Circuit Design

Frequency stability is within $\pm$250 cps. All circuits are metered. Exciter and power amplifier stages utilize motor tuning. Forced air ventilation is provided for each cabinet. The vertical chassis can be tilted forward for servicing the rear side. Fuseless circuit protection is provided in both a-c and d-c power channels.

Distortion is less than 1% at 100% modulation over the range of 50-15,000 cps. The frequency response is flat within 1.0 db over the same range.

Twenty-five or fifty kw operation is accomplished simply by adding amplifier bays. Write us for a complete, descriptive bulletin giving detailed information.

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THE 15 chapters of the *FM* HANDBOOK were written by 14 outstanding FM engineers. This book, of 174 pages, 8¾ by 11½ ins., is equal to 300 pages of the ordinary handbook size. There are 218 photographs, wiring diagrams, and charts to illustrate the latest FM equipment and circuits. Here is a resume of the chapters:

1. Background of FM: as told by Major Armstrong to the Senate Interstate Commerce Committee in December, 1943. Also, excerpts from his log in 1934, '38, and '39.

2. Theory of FM: by Rene Hemmes. This is the most complete and understandable explanation of FM theory ever written. By using charts and diagrams, the functions of FM circuits are shown clearly, without recourse to mathematics. This chapter explains all the special features of receiver design, including AFC; and transmitter design, including the Armstrong dual-channel modulator.

3. Business of FM Broadcasting: by Milton B. Sleeper. Answers questions from those planning to enter FM broadcasting.

4. FM Studio Techniques: by D. W. Gellerup. Explaining fundamental differences between AM and FM techniques.

5. Coaxial Lines for FM Transmitters: by C. Russel Cox. A complete exposition, with working charts and mechanical layouts.

6. Audio Distortion and Its Causes: by Jerry Minter. A study of cross-modulation and its effect on tone quality.

7. High-Fidelity Reproduction: by John K. Hilliard. Describing the operation and design of coaxial speakers and high-fidelity amplifiers.

8. Antennas for Communications Frequencies: by James A. Craig. Covering all types of antennas for 30 to 44, 72 to 76, and 152 to 156 mc.

9. Selective Calling Methods: by Milton B. Sleeper. Explanation includes a call-number chart for individual and group calling.

10. Maintenance of Communications Systems: by Frank Bramley. How Connecticut State Police handles the maintenance of 332 cars and 11 main stations.

11. Alignment of FM Receivers, by Bernard J. Cosman. The fast, visual method for aligning FM broadcast and communications receivers.

12. WWV Signals for Frequency Checking, by Arthur Fong. Describing a receiver for checking circuits, meters, and modulators from WWV transmissions.

13. Railroad Radio Installations: by Arnold Nygren. Presenting factual data on their operation and performance.

14. Notes on Facsimile Equipment, by Frank R. Brick. Outline of progress for commercial and broadcast services.

15. FCC Standards of FM Engineering Practice, corrected to January 1, 1947.

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